A tracer tool to map reservoir blending ratios, water travel times, and incursion/persistence of stormwater in tap water under extreme weather events in north-central Texas

Funding Opportunity No. R23AS00446 WaterSMART-Applied Science and Technology and Other Research and Development

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1. Executive summary

Date: September 26, 2023
Applicant Name: University of Texas at Arlington
City: Arlington
County: Tarrant
State: Texas

Persistent droughts and extreme convective storms coupled with increasing water needs are shaping the co-evolution of Texas's socio-economic assemblages, water laws/regulations, and future water supply allocation. The main goal of this project is to implement a tracer tool within the Tarrant Regional Water District (TRWD) of north-central Texas to improve the ability of water suppliers to ensure drinking water reliability and security under extreme weather events. **Across this region, there is an urgent need to quantify a) blending ratios from drinking water reservoirs, b) the arrival time of such water blends to drinking water treatment plants, and c) the incursion and persistence time of recycled stormwater in the tap water distribution system after large convective rainfall events.** By establishing a spatiotemporal (from the source to the end-user) monitoring method, water managers will be better equipped to i) improve drinking water treatment strategies (e.g., more accurate surface water blending estimations) and ii) understand the net effects of large convective rainfall events in the urban water cycle and potential transport of emerging contaminants into the tap water distribution system. Elucidation of emerging patterns (in time and space) will advance the understanding of water movement and mixing and the tap water supply systems' reliability and vulnerability in light of inter-annual climate variability. It is important to emphasize that this tracer tool can be used in other urban settings across the United States that also rely on surface water reservoirs for their drinking water supply.

Length of Time and Completion Date: This project will take approximately two years with completion by March 31st, 2026. **Federal Facility:** This project will not be located on Federal Facilities.

2. Technical project description

2.1. Applicant Category

The Department of Earth and Environmental Sciences, University of Texas at Arlington is a Category B applicant. Our key Category A partner for this proposal is the Tarrant Regional Water District (TRWD). As part of several technical team meetings (2022 and 2023) and 1.5 years of preliminary tracer data, we have identified and delineated current issues and urgent needs for the water district (See Section 2.2). Continuous feedback between TRWD water managers/engineers and environmental teams and the Tracer Hydrology Group at UTA is expected throughout the project. The feedback will be on topics related to (but not limited to) the analysis of spatiotemporal trends in water supply and movement, improving sampling strategies, coordinating field sampling campaigns, and the use/dissemination of tracer-informed spatiotemporal tools.

2.2. The Problem

Drinking water quality can be adversely affected by extreme weather events such as droughts and rainstorms, particularly in areas where drinking water is sourced from a combination of surface sources. In many cases, the individual sources are not equally susceptible to the adverse effects. At water treatment plants, ***timely*** adjustment of the amount of water from each source (blending) can assure the quality of the drinking water and reduce the cost of subsequent treatment steps. Because of the complex geometry of large water delivery systems, simple flow and volume calculations may not always be sufficiently accurate for determining optimal treatments. A better method for determining the volume and timing of the water flows is needed.

In Texas, complex interconnections between geographical features with oceanic and atmospheric large-scale processes make it a water deficient-state extremely susceptible to prolonged/severe droughts and prone to large convective rainfall events and flash flooding episodes (Cavazos, 1999; Banner et al., 2010; Schmidt and Garland, 2012; Okumura et al., 2017; Ray et al., 2018). This climatically vulnerable region is home to roughly 30 million people with a near two-fold increase in population expected by 2070 (US Census Bureau, 2022). Additionally, it is the second biggest economy in the U.S. (Texas Economic Development Corporation, 2021). However, Texas' population and economic growth are imposing a large stress on water availability and urban tap water allocation. For example, state-wide water needs in 2020 represented 18.6% of the existing water supply. Water needs are expected to increase up to 49.6% by 2070 (Texas Water Development Board, 2022).

Across north-central Texas water districts, there is an urgent need to quantify a) blending ratios from drinking water reservoirs, b) the arrival time of such water blends to drinking water treatment plant facilities, and c) the incursion time of recycled stormwater into the tap water distribution system after large convective rainfall events. These data are needed to effectively select water treatment procedures (e.g., dissolved organic carbon removal). Preliminary tracer data (2022-2023) in the Dallas-Fort Worth metroplex (DFW) confirmed that recycled stormwater from extreme convective rainfall events can reach the tap water system in <7 days (i.e., precipitation→urban/rural runoff→reservoir storage→drinking water treatment plants→tap water). Therefore, knowing the incursion and persistence time of recycled surface stormwater becomes critical for drinking water emergency assessments, particularly for emerging contaminants with a large potential to bypass treatment systems in a relatively short timeframe.

2.3. Project location

Texas is divided into 16 regional water plans. Region C in north-central Texas represents over a quarter of Texas's population and almost one-third of the state's economy (Region C Water Plan, 2021) (Figure 1). The Dallas-Fort Worth (DFW) metroplex is the most prominent socio-economic area in Region C. One of the major water providers in Region C is the Tarrant Regional Water District (TRWD). TRWD supplies only raw water to more than 30 wholesale customers. The water is sourced from four major reservoirs (Lake Bridgeport, Eagle Mountain Lake and the Cedar Creek and Richland Chambers Reservoirs), a wetlands system (George W. Shannon Wetlands at Richland-Chambers reservoir), three terminal storage reservoirs (Lake Arlington, Lake Benbrook, and Eagle Mountain Lake), and three balancing reservoirs (Eagle Mountain, Kennedale, and Midlothian).

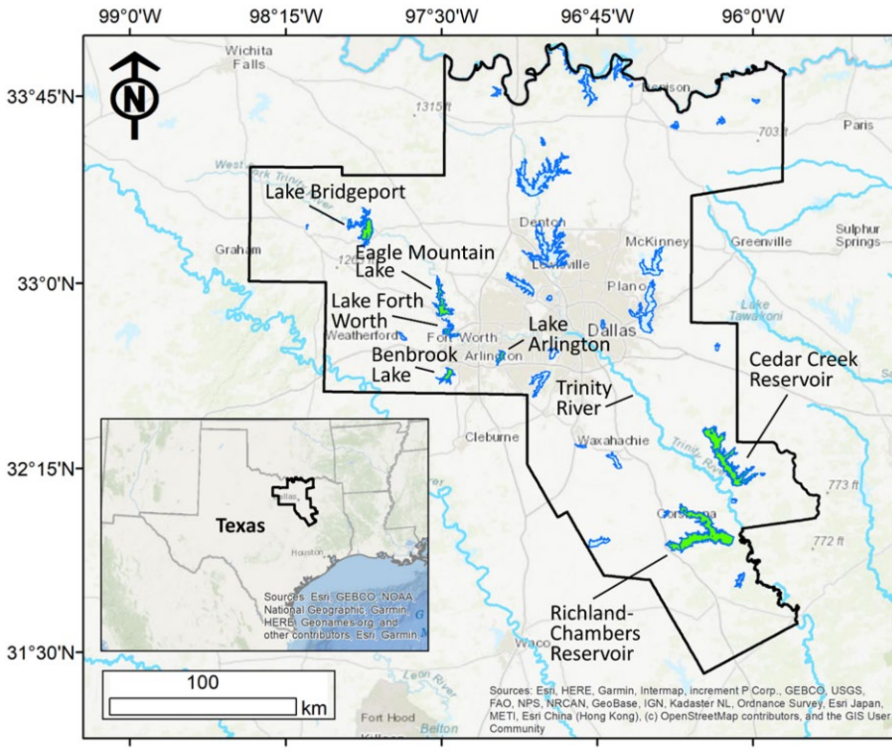

Figure 1: Region C in north-central Texas, including major cities and rivers, existing reservoirs (light blue polygons), and major reservoirs used by the TRWD (blue-green polygons). The inset shows Region C (black polygon) in Texas.

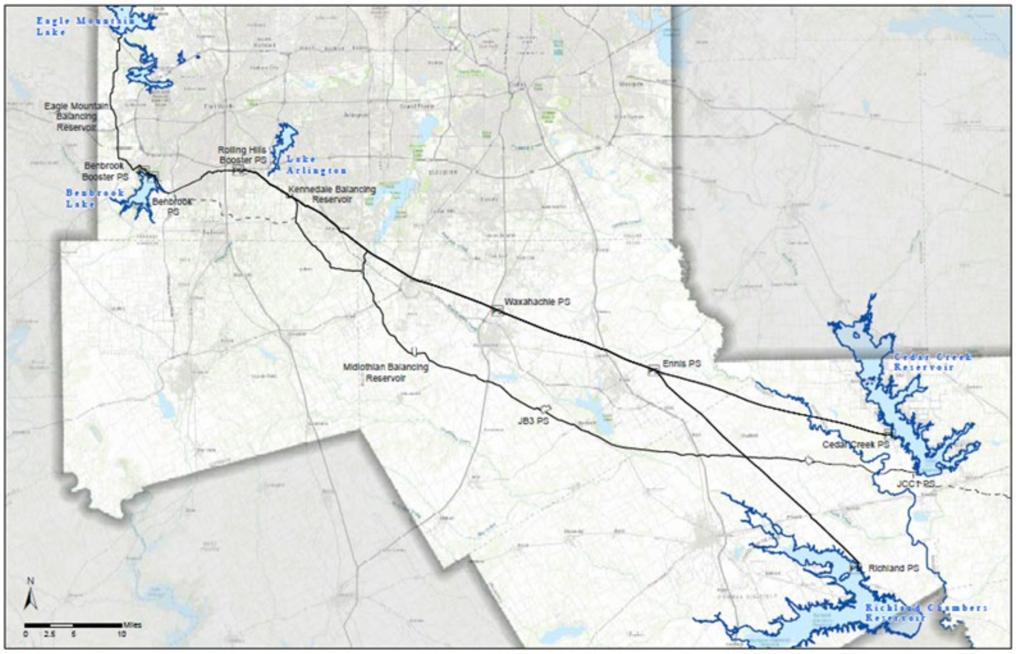

Figure 2: An overview of the main water supply system within the Tarrant Regional Water District that will be studied as part of this project.

Overall, this project will be located within the TRWD operational area and centered on the reservoirs providing water to the City of Arlington (i.e., Cedar Creek, Richland Chambers and Lake Arlington) and will include Arlington's tap water distribution system.

3. Detailed project description

3.1. Goals

The main goal of this project is to implement a stable isotope based tracer tool within the Tarrant Regional Water District (TRWD) of north-central Texas to map reservoir blending ratios, water travel times, and the effects of recycled stormwater entering the tap water distribution system under extreme weather events.

The specific objectives are to:

1. Determine the distinct seasonal and event-based endmember stable isotope tracer compositions of the water sources for the DFW area: precipitation, reservoirs and blends, surface water, and tap water.
2. Estimate blending ratios for water from major reservoirs and the water arrival time of such blends to the drinking water system in the city of Arlington, Texas.

3. Estimate the incursion/persistence time of recycled stormwater into the tap water distribution system after large convective rainfall events.

3.2. Sample collection

Regional daily and event-based (hourly) precipitation samples will be collected throughout the study period using a passive collector installed on the roof of the Geoscience building, University of Texas at Arlington. Two surface water bodies, Rush Creek (urban stream draining in S-N direction across the city of Arlington, Texas) and West Fork of the Trinity River (major river receiving reservoir discharges across the DFW area) will be sampled on a weekly and event-based schedule. Similarly, the main drinking water reservoirs—Lake Arlington, Cedar Creek, and Richland Chambers—will be sampled on weekly basis. In addition, tap water samples in two locations across the City of Arlington (i.e., southwest and northeast sites; a residential location and UTA campus, respectively) will be collected on weekly basis (baseflow conditions) and on a daily basis during large convective rainfall events. All samples (Table 1) will be collected and stored at 5°C in clean 30 mL HDPE bottles and sealed with Parafilm until analysis.

Table 1: Summary of sampling sites, frequency, and personnel responsible for samples collection.

Sites	Sampling frequency	Personnel
Precipitation, Geoscience building UTA	Daily and event-based (hourly)	Tracer Hydrology Group
Rush Creek and West Fork of the Trinity River	Weekly and event-based (daily)	Tracer Hydrology Group
Lake Arlington	Weekly	Tracer Hydrology Group
Tap water	Weekly and event-based (daily)	Tracer Hydrology Group
Cedar Creek and Richland Chambers Reservoirs	Weekly	TRWD
Reservoir water blends	Based on TRWD blending changes	TRWD

3.3. Stable isotopes analysis

Stable isotope analysis will be conducted at the Tracer Hydrology Group facilities of the Department of Earth and Environmental Sciences, University of Texas, Arlington using a water isotope analyzer GLA431-TLWIA (LGR Inc., USA). Two in-house secondary standards will be used to normalize the results to the VSMOW-SLAP scale, while a third standard will be used for quality and drift control. Stable isotope compositions will be presented in standard delta notation δ (‰, per mil) and follow typical reporting conventions.

3.4. Water arrival times and stable isotopes Bayesian blending model

Tracer time series during baseflow and large convective rainfall events will be used to determine water arrival times of reservoir blends to the drinking water system as well as the incursion time of recycled stormwater into the tap water distribution system. The stable isotopes mixing model from the R statistical computing package Simmr (Parnell and Inger, 2016) will be used to partition relative endmember water contributions (i.e., blending ratios) using a Bayesian statistical framework based on a Gaussian likelihood as described by Sánchez-Murillo et al. (2020). The main advantage of Bayesian mixing models over simple linear models is the ability to input isotope data from multiple sources (Ma et al., 2016, Gokool et al., 2018, Correa et al., 2019).

The model requires three sets of input data, as a minimum, to determine the proportions of water used within the reservoir blend or in the tap water supply system: i) $\delta^{2}H$ and $\delta^{18}O$ of the mixture (either reservoir blends or tap water), ii) mean $\delta^{2}H$ and $\delta^{18}O$ for the endmembers, and iii) standard deviations of $\delta^{2}H$ and $\delta^{18}O$ for the endmembers. Source water contributions to the mixture will be determined using a Markov Chain Monte Carlo (MCMC) function (Brooks, 1998) to repeatedly estimate the proportions of the various sources in the mixture and determine the values which best fit the measured mixture data (Parnell and Inger, 2016) (100,000 iterations). The Gelman-Rubin (1992) diagnostic test will be performed to test model convergence using $\delta^{2}H$ and $\delta^{18}O$ values. The test evaluates MCMC convergence (Gelman-Rubin value equal to 1) by analyzing the difference between multiple Markov chains. Median values of source water contributions from the posterior parameter distribution will be used for practical comparisons of the water supply operation.

3.5. Data Management Practices

The spatial tools and modeling codes generated under this project will follow standard formats that are compatible with Geographic Information System (GIS) platforms and the R language and will be immediately available to the TRWD. Similarly, tracer compositions, blending ratios, travel and incursion times databases will be provided to the TRWD in accessible MS Excel files.

4. Evaluation Criteria

4.1. Evaluation Criterion A—Water Management Challenges

Currently, there are three main water management challenges related to the water supply for tap water operations in north-central Texas. First, there is a need to accurately quantify reservoir water blending ratios (i.e., different proportions of surface water sources), which are critical for the operation of drinking water treatment plants, particularly to evaluate total organic carbon removal treatment procedures (EPA, 2020). Water blends are regularly changed, depending on water consumption and needs, but there is a large uncertainty involved in estimating reservoir blend ratios. **Secondly,** the arrival time of such blends to the drinking water system is still unknown (Personal Communication, TRWD engineering team, 2022). This limits the proper onset time of drinking water treatment procedures. the first and second challenges are related to problems of an engineering nature. **A third challenge** is the rapid incursion of recycled stormwater into the drinking water system, particularly for emerging contaminants with large potential for bypassing treatment systems in a short time frame. The two figures that follow are graphical depictions of some aspects of these challenges.

Figure 3 shows an analysis (U.S. south region, including the Dallas-Fort Worth metroplex area) of 1-day extreme precipitation (90th percentile, 1910-2021) based on the U.S. Climate Extreme Index. Since the 1980s, this region has experienced an average increase of 13.8% in 1-day extreme events, with the largest increase (>20%) occurring mainly during strong El Niño years (Timmermann et al., 2018).

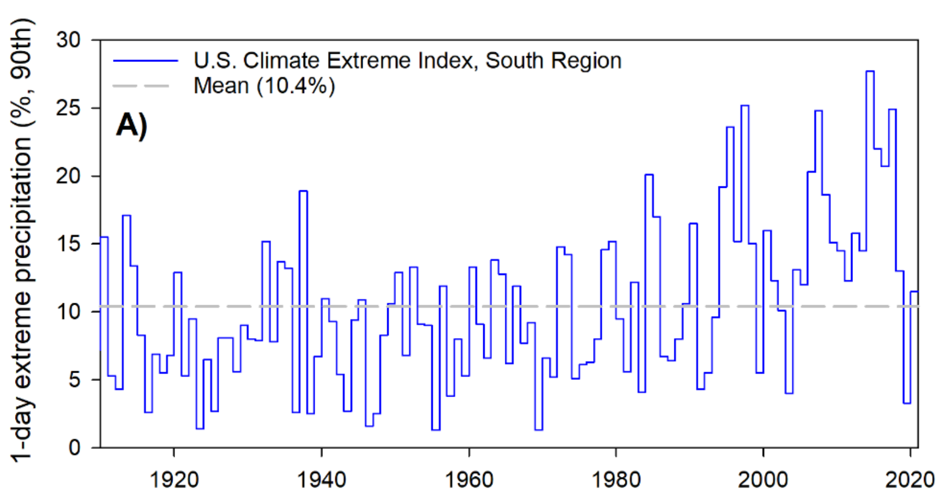

Figure 3: Regional analysis (U.S. south region, including the Dallas-Fort Worth metroplex area) of 1-day extreme precipitation (90th percentile, 1910-2021) based on the U.S. Climate Extreme Index (CEI). The gray dashed line denotes the long-term average (10.4%). The average increase after 1980 corresponds to 13.8%.

Figure 4 shows preliminary tracer evidence of recycled stormwater arriving at the drinking water system in the City of Arlington, after a 1000-yr rainfall event on August 22nd, 2022. Five phases can be distinguished:

I. Tap water in both locations (SW and NE) across the City of Arlington exhibited a strong connection with tracer compositions from Lake Arlington (closest drinking water source).
II. The incursion of fast recycled stormwater into the drinking water system occurred within 7 days after a 1000-yr rainfall event (August 22nd, 2022). At this point, the drinking water system was composed of two distinct water sources, recycled stormwater (NE) and a second source (SW), mostly likely from the reservoirs blend of Cedar Creek and Richland Chambers. The influence of recycled stormwater lasted until the middle of October 2022.
III. Both tap water locations received reservoir-blend water and were fully disconnected from Lake Arlington's water source.
IV. During the spring and summer of 2023, tap waters exhibited a fluctuation between at least two water sources in an 'on-and-off' temporal pattern.
V. At the end of the summer of 2023, both tap water locations were again showing a strong connectivity with Lake Arlington's water source.

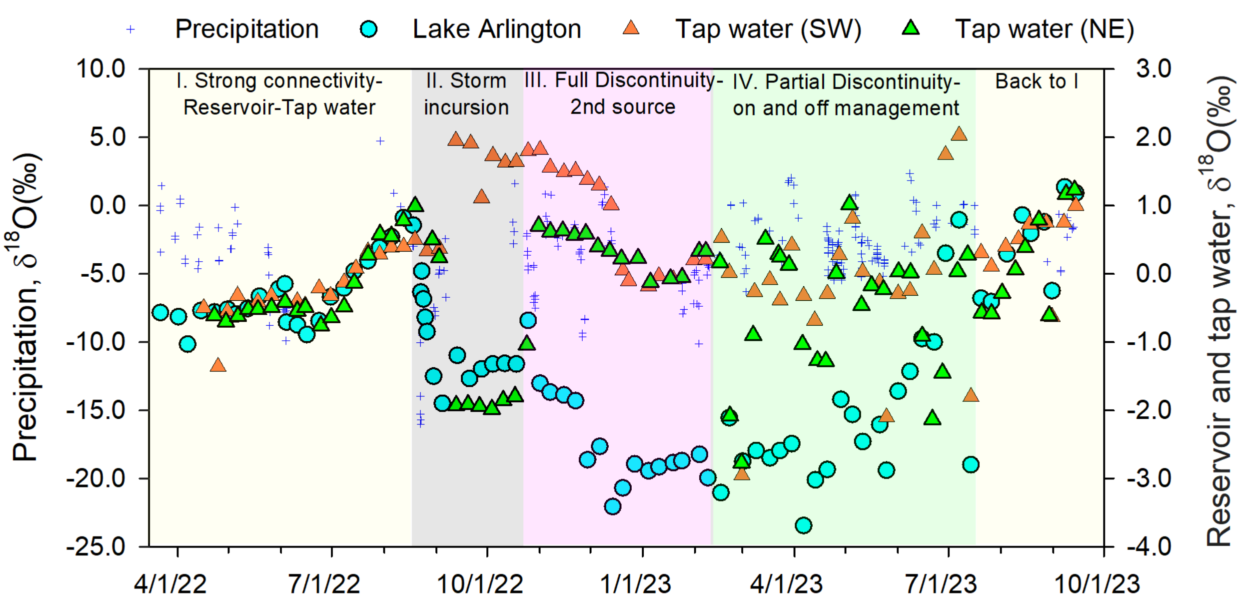

Figure 4: Tracer times series in precipitation (blue crosses), lake water (cyan dots), and tap waters (SW and NE) (green and orange triangles, respectively) locations. Five different phases are distinguished (color coded panels) in the drinking water distribution system.

Failure to accurately assess reservoir blending ratios and water arrival times of such blends, as well as the incursion and persistence time of recycled stormwater could potentially lead to poor water quality, waterborne disease outbreaks, and overall inability to meet customer water demands. In addition, intrusion of recycled stormwater into the drinking water system could violate regulatory standards and requirements for water quality, monitoring, and treatment which, in turn, could put utilities at legal risk.

This project will support and improve the following water management options:

a. water supply reliability for municipal, agricultural, tribal, environmental or recreational water uses: by providing a better understanding of the incursion time of recycled urban/rural stormwater into the drinking water supply system, this project will enhance contingency plans for large convective storm scenarios such as the identification of alternative supply options, establish earlier boil-water advisories, and improve earlier storm response across water departments to prevent waterborne disease outbreaks.
b. management of water deliveries: by providing a new stable isotope tracer methodology to estimate reservoir blending ratios and their respective arrival time to drinking water treatment systems, this project will facilitate the proper onset of treatment procedures to remove prevailing contaminants, such as dissolved organic carbon.

4.2. Evaluation Criterion B—Project Benefits

This project is rooted in an ongoing collaboration between the Tracer Hydrology Group in the Department of Earth and Environmental Sciences at the University of Texas-Arlington and the Tarrant Regional Water District (Fort Worth, Texas). As part of several technical team meetings (2022 and 2023) between scientific, engineering, and technical staff, and after 1.5 years of preliminary tracer data collection (e.g., N=1,004 samples; reservoirs, precipitation, surface waters, and tap water), we identified and delineated current issues and urgent needs for the water district (See previous Section 3.1).

The stable isotope tracer tool postulated in this proposal will be applied on a regular basis (e.g., during reservoir blend changes) to effectively determine reservoir blending ratios, water travel times, and the incursion and persistence of recycled stormwater in the drinking water distribution system (e.g., during extreme rainfall events, 90^{th} percentile). During the two-year project, different blending and storm scenarios will be sampled to refine the sampling methodology, determine uncertainty propagation, and validate the tracer tool under distinct seasonal precipitation patterns. This tracer tool will be used by the Tarrant Regional Water District (See support/partnership letter attached). The main benefits will be the enhancement of tap water supply reliability and security. As explained in section 4.1, a quantitative method to calculate reservoir blends is needed to improve the selection of drinking water protocols in treatment plants across the United States. This management decision has been historically limited due to the inherent complexity of water transmission systems and the large uncertainties involved in calculating water travel times. Similarly, managing drinking water systems during extreme precipitation events is becoming a nationwide problem. Stable isotope tracer data will provide critical information to underpin the incursion time of recently recycled stormwater into the tap water system and the persistence time of such incursions (See Figure 4).

Figure 5 shows the overall project workflow from tracer measurements, modeling calculations, and expected benefits. This project will complement the current research activities between the Tracer Hydrology Group at the University of Texas and the Tarrant Regional Water District.

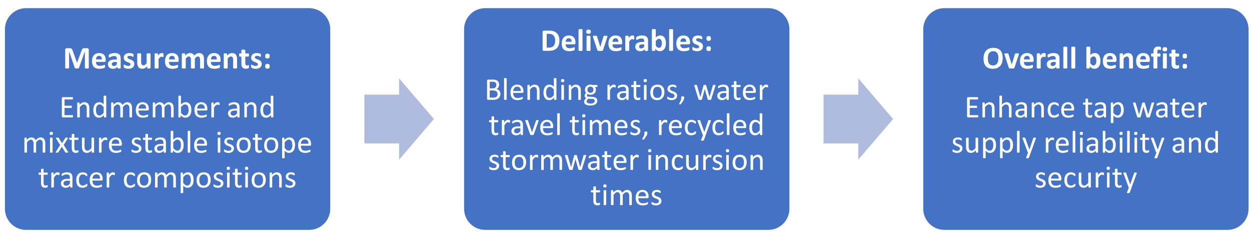

Figure 5: Project workflow including stable isotope tracer measurements, modeling calculations, and expected benefits.

This stable isotope tracer methodology can be transferred to other urban settings across the United States also relying on surface water reservoirs or shallow groundwater reservoirs for their drinking water supply and perhaps experiencing an increase in extreme precipitation events. Applying this methodology will require a baseline of seasonal isotopic patterns during the hydrological year for each particular region.

Environmental isotopes have become a well-established and reliable tool in many fields of hydrology, as isotopes can provide important information to water managers for assessing sources and interactions between water bodies. However, these studies have been heavily concentrated across natural and agricultural landscapes (Kendall and McDonnell, 2012), while research initiatives in water supply systems are limited. There is an increasing worldwide demand to understand water supplies and water dynamics in urban settings (Ehleringer et al., 2016; IAEA, 2018).

Tracer applications of water stable isotopes have proven to enhance the understanding of contrasting urban transmission systems within coastal and semi-arid regions of the US Pacific Northwest (Jameel et al., 2016; Tipple et al., 2017; Fillo et al., 2021), humid tropical and sub-tropical cities (Sánchez-Murillo et al., 2020; de Wet et al., 2020) and continental settings (Wang et al., 2018). These studies have been focused on understanding seasonal and spatial isotope patterns only. However, to the best of our knowledge, no high frequency sampling studies of urban water systems have been conducted in the United States. Therefore, this project builds on existing methodologies, but incorporates a new high frequency sampling and modeling framework to elucidate the unknown spatiotemporal structure of a drinking water distribution system in one of the fast-growing metropolitan areas in Texas.

4.3. Evaluation Criterion C—Project Implementation

Table 2 shows proposed tasks per specific objective, timeframe, and milestones divided into calendar year quarters. Overall, the project will be conducted during two hydrological years 2024-2026. Methodological aspects for each activity are described in Sections 4.3-4.5. Expected budget costs are included in Section 5.1.

Table 2: Summary of project main activities, timeframe, and milestones.

Project activities	2024/25				2025/26				Milestones
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Determine the distinct seasonal and event-based endmember tracer compositions across the DFW area: precipitation, reservoirs and blends, surface water, and tap water.									
Continuous isotope monitoring in precipitation, reservoirs and blends, streams, and tap water									Isotopic timeseries database of precipitation, lake reservoirs and blends, streams, and tap water.
Water stable isotopes analysis									Completion of water stable isotopes analysis
Estimate blending ratios from major reservoirs and the water arrival time of such blends to drinking water system in the city of Arlington, Texas.									
Endmember data preparation									Endmember database in R
Running Bayesian calculations in R and water travel times									Endmember mixing estimates and uncertainties and water travel times
Water blends sampling (depending on blending operation)									Blending ratios estimates and uncertainties
Estimate the incursion time of recycled stormwater into the tap water distribution system after large convective rainfall events.									
High frequency sampling of extreme rainfall events (precipitation, reservoirs, and tap water)									Isotopic database of extreme rainfall events
Water stable isotopes analysis									Completion of water stable isotopes analysis
Calculations of the incursion and persistent time of recycled stormwater									Incursion and persistent time of recycled stormwater into the drinking water system
Communication Strategies									
UTA-TRWD feedback/coordination meetings									Consistent and continuous communication via email and technical meetings
TRWD webinars									Webinars, videos

DISCOVER/ACES College of Science Research Symposium									Poster presentations by students
AGU Meetings									2 Abstracts submitted
Peer-reviewed publications									2 Manuscript drafts

Principal Investigator, Dr. Sánchez-Murillo has over 10 years of expertise in the field of isotope hydrology. He was part of a global initiative within the International Atomic Energy Agency (Vienna, Austria) (2018-2023) to develop global guidelines for tracer applications in the study of urban water supply systems. Dr. Sanchez-Murillo has expertise in the areas of key drivers controlling water tracer variations, geospatial modeling, Bayesian mixing analysis, and statistical applications. A PhD student with GIS and isotope field sampling skills will be part of this project. Undergraduate students with a chemistry background will collaborate with isotope samples preparation. Sampling logistics within the water supply system will be coordinated by Vinicius de Olivera, TRWD water resources engineer.

4.4. Evaluation Criterion D—Dissemination of Results

The communication plan will be generated and supervised by both TRWD and the Tracer Hydrology Group. It will include the following delivery schemes: a) technical meetings to discuss sampling strategies, logistics, and project progress; b) one webinar per year offered to TRWD water managers to explore preliminary results and methodology applicability; c) preliminary results will be also presented during the DISCOVER/ACES College of Science Research Symposium at the University of Texas, Arlington (2024-2025), d) AGU annual meetings, and e) two manuscripts for peer-review publications will be also drafted. The spatial tools and modeling codes generated under this project will follow standard formats that are compatible with Geographic Information System (GIS) platforms and the R language and will be immediately available to the TRWD. Similarly, tracer compositions, blending ratios, travel, and incursion times databases will be provided to the TRWD as MS Excel files.

4.5. Evaluation Criterion E—Presidential and Department of the Interior Priorities

4.5.1. Sub-criterion No. E1. Climate Change

Due to the continuous decline in water table levels (de Graaf et al., 2019) and the vanishing of spring seepages, water managers worldwide have resorted to the exploitation of regional surface water resources, large-scale inter-basin transfer, and water reuse from artificial wetlands. Overall, municipal use accounts for 87% of the water demand in north-central Texas, of which 61% is concentrated in Tarrant and Dallas counties alone (Region C Water Plan, 2021). Surface water sources pose a high water quality risk, since emergent contaminants may have a large capacity to bypass treatment systems. This project will assess the net effects of recycled stormwater entering the tap water distribution system under extreme weather events and the ability to adapt the distribution system to deal with future water stress and needed blends in fast-growing urban areas across Texas.

5. Project Budget

5.1. Budget Proposal

Table 2: Summary of Non-Federal and Federal Funding Sources

Funding sources	Amount
Non-federal entities	
University of Texas at Arlington	**$203,334**
Non-federal subtotal	**$203,334**
Requested Reclamation Funding	**$194,685**
Total Cost	**$398,019**

Table 3: Budget Proposal.

Budget item description	Computation		Quantity type	Sponsor	Cost-share	Total cost
	$/unit	Quantity				
Salaries and Wages						
Employee 1 (PI)	$11,502/mo	2	Salary	$20,383	$23,340	$43,723
Employee 2 (PhD student)	$2,500/mo	24	Salary	$60,900	$0	$60,900
Fringe Benefits						
Full-Time Employee 1	$3,451/mo	2	Salary	$6,115	$7,002	$13,117
Part-Time Employee 2 (PhD student)	$500/mo	24	Salary	$12,180	$0	$12,180
Isotopic Analysis						
δ^2H and δ^{18}O analysis	$50/per sample	1000	Analyte	$0	$50,000	$50,000
Supplies and Materials						
Injection syringes	$400/unit	10	Unit	$4,000	$0	$4,000

Travel						
Gas	$30/sampling	104	Gas	$3,120	$0	$3,120
STEM Tuition						
STEM Tuition	$14,118/yr	2	Tuition	$28,236	$0	$28,236
Other						
Water isotope analyzer depreciation	$25,000/year	2	Depreciation rate	$0	$50,000	$50,000
Total Direct Costs				**$134,934**	**$130,342**	**$265,726**
MTDC				**$106,698**	**$130,342**	**$237,040**
Indirect Costs				**$59,751**	**$72,992**	**$132,742**
Total Estimated Project Costs				**$194,685**	**$203,334**	**$398,019**

5.2. Budget Narrative

The requested salaries/wages and fringe benefits are intended to cover a) 1.0/0.75 calendar months of salary for Dr. Sánchez-Murillo (PI) per year and b) 12-month salary for a PhD student per year. The Tracer Hydrology Group will provide the isotopic analysis of 1,000 samples ($40/per sample) and basic lab consumables as cost-share. However, injection syringes are requested for isotopic analysis ($4,000).

Travel expenses (gas for one vehicle) are intended to cover intense sampling campaigns (weekly and event-based) during reservoir blending and extreme rainfall sampling campaigns. An estimated depreciation of the water isotope analyzer (GLA431-TLWIA; LGR Inc., USA) during the 2-year period is included as a cost-share. STEM Tuition for a PhD student is requested for two years. The negotiated indirect cost rate is based on Modified Total Direct Costs (MTDC) and is 56% for this type of project according to university regulations.

5.3. Environmental and cultural resources compliance

No ground-disturbing activities related to environmental or cultural resources are part of the scope of this proposal. This project only involves sampling campaigns of tap waters, public reservoirs, streams, and precipitation. Water collection implies a 30 mL grab sample under minimal disturbances of air, soil, water, or any endangered species habitat. No changes in any irrigation system or archeological or historical places are part of this project.

5.4. Required permits or approvals

No permits or other approvals are required for the project scope included in this proposal. Access to sampling sites will be coordinated with personnel from the TRWD as described in their letter of support.

5.5. Overlap or Duplication of Effort Statement

There are no overlaps or duplication between this application and any of our Federal applications or funded projects, including in regard to activities, costs, or time commitment of key personnel. Preliminary data has been collected during the last 1.5 years as part of PI-Sánchez-Murillo UTA startup.

5.6. Conflict of Interest Disclosure Statement

We have no conflicts of interest to disclose.

5.7. References

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5.8. Letters of support/partnership

See letters attached to this submission.

October 16, 2023

Bureau of Reclamation
Water Resources and Planning Office
Attn: Ms. Avra Morgan
Mail Code: 86-63000
P.O. Box 25007
Denver, CO 80225-0007

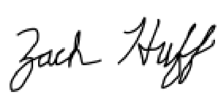
Re: Funding Opportunity No. R23AS00446 WaterSMART-Applied Science and Technology and Other Research and Development
Proposal title: A tracer tool to map reservoir blending ratios, water travel times, and incursion/persistence of stormwater in tap water under extreme weather events in north-central Texas

The Tarrant Regional Water District (TRWD) fully supports the above-referenced proposal for implementing a tracer tool within north-central Texas to a) determine the distinct seasonal and event-based endmember tracer compositions across the DFW area (precipitation, reservoirs and blends, surface water, and tap water; b) estimate blending ratios from major reservoirs and the water arrival time of such blends to the drinking water system in the city of Arlington, Texas; and c) estimate the incursion time of recycled stormwater into the tap water distribution system after large convective rainfall events. The proposed partnership directly serves several goals and objectives of the TRWD Strategic Plan, Texas Water Plan, and Presidential Executive Order 14008: *Tackling the Climate Crisis at Home and Abroad,* where robust statistical and modeling techniques will be used to improve water reliability and security under a changing climate.

Continuous feedback between TRWD water managers/engineers and the Tracer Hydrology Group, University of Texas at Arlington, is expected throughout the project in topics related but not limited to access to sampling sites, the analysis of preliminary spatiotemporal trends, improving sampling strategies, coordinating field sampling campaigns, and use/dissemination of the tracer-informed spatiotemporal tools. TRWD will also assist in collecting samples in several facilities supporting the study as an in-kind contribution. In addition, TRWD will work in collaboration with the Tracer Hydrology Group and will review any public communication regarding the study on different platforms (e.g., peer-reviewed papers, reports, conference papers, and social media communications, among others).

We look forward to working with the Tracer Hydrology Group from the Department of Earth and Environmental Sciences, University of Texas at Arlington, on this vital urban water supply project.

Sincerely,



J. Zach Huff, Director
Water Resources Engineering
Tarrant Regional Water District
800 E Northside Dr. Fort Worth, TX 76102

October 8, 2023

RE: Funding Opportunity No. R23AS00446 WaterSMART-Applied Science and Technology and Other Research and Development

Proposal title: A tracer tool to map reservoir blending ratios, water travel times, and incursion/persistence of stormwater in tap water under extreme weather events in north-central Texas

To Whom It May Concern:

As Chair of the Department of Earth and Environmental Sciences, University of Texas at Arlington, I am writing to express our commitment to support the project proposed for **Funding Opportunity No. R23AS00446 WaterSMART-Applied Science and Technology and other Research and Development** by our full-time Associate Professor, Dr. Ricardo Sánchez-Murillo.

This is to confirm that Dr. Sanchez-Murillo was granted a Rising STARs (Science and Technology Acquisition and Retention) Award from the University of Texas System to help purchase state-of-the-art research equipment, a triple water isotope analyzer and make necessary laboratory renovations for his Tracer Hydrology Group. Similarly, Dr. Sanchez-Murillo was granted a startup grant from the Office of the Provost to establish his research program.

I envision the proposed partnership with the Tarrant Regional Water District to directly accomplish the project's main goal and specific objectives within his strong field of expertise, isotope hydrology applications.

Sincerely yours,

Dr. Arne Winguth
Professor and Chair
Department of Earth and Environmental Sciences
500 Yates St, Arlington, Texas 76019-0049
United States of America
Ph: 817.272.2987/Email: awinguth@uta.edu