texaswaterjournal.org

An online, peer-reviewed journal published in cooperation with the Texas Water Resources Institute and the Bureau of Economic Geology

Texas Water Journal

Volume 15 Number 1 | 2024

Texas Water Journal

Volume 15, Number 1
2024
ISSN 2160-5319

texaswaterjournal.org

THE TEXAS WATER JOURNAL is an online, peer-reviewed, and indexed journal devoted to the timely consideration of Texas water resources management, research, and policy issues. The journal provides in-depth analysis of Texas water resources management and policies from a multidisciplinary perspective that integrates science, engineering, law, planning, and other disciplines. It also provides updates on key state legislation and policy changes by Texas administrative agencies.

For more information on the Texas Water Journal as well as our policies and submission guidelines, please visit texaswaterjournal.org. As a 501(c)(3) nonprofit organization, the Texas Water Journal needs your support to provide Texas with an open-accessed, peer-reviewed publication that focuses on Texas water. Please consider donating.

Texas Water Resources Institute
make every drop count

Bureau of Economic Geology

The Texas Water Journal is published in cooperation with the Texas Water Resources Institute, part of Texas A&M AgriLife Research, the Texas A&M AgriLife Extension Service, and the College of Agriculture and Life Sciences at Texas A&M University and the Bureau of Economic Geology in the Jackson School of Geosciences at The University of Texas at Austin.

DOAJ seal

The Texas Water Journal is indexed by Scopus, Google Scholar, and the Directory of Open Access Journals.

Cover photo:
The Narrows on the Blanco River.

Texas Water Journal
Volume 15, Number 1, October 2, 2024
Pages 104-139

Addressing Challenges to Ensuring Justice and Sustainability in Policy and Infrastructure for Texas Water Resources in the 21st Century

Margaret A. Cook[1], Darrel M. Tremaine[2], Briana M. Wyatt[3], Jay L. Banner[4], Joni Charles[5], Matthew Berg[6], Tianna Bruno[7], Yael R. Glazer[8], Coy Callison[9], Robert E. Mace[10], Valerie Miller[11], Ryan Bare[12], Rosario Sanchez Flores[13], Jonathan Seefeldt[14], Amanda Fuller[15], Dev Niyogi[16]

[1] Deputy Director of Climate Equity & Resilience, Houston Advanced Research Center
[2] Director of Climate, Energy, and Government Affairs, CenTrio Energy
[3] Assistant Professor, Department of Soil & Crop Sciences, Texas A&M University
[4] F. M. Bullard Professor, Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin
[5] Associate Professor of Economics, McCoy College of Business Administration, Texas State University
[6] CEO & Principal Scientist, Simfero Consultants
[7] Assistant Professor, Department of Geography, University of California, Berkeley
[8] Research Associate, Webber Energy Group, The University of Texas at Austin
[9] Professor and Associate Dean for Graduate Studies & Research, College of Media & Communication, Texas Tech University
[10] Professor of Practice, Department of Geography, Meadows Center for Water and the Environment, Texas State University
[11] Industry Expert, Water, Olsson
[12] Research Scientist, Watershed Ecology, Hydrology and Watersheds Program, Houston Advanced Research Center
[13] Senior Research Scientist, Texas Water Resources Institute, Texas A&M University
[14] Senior Communications Manager, Climate Resilient Water Systems, Environmental Defense Fund
[15] Regional Executive Director, South Central Region, National Wildlife Federation
[16] Professor, Department of Earth and Planetary Sciences, Jackson School of Geosciences, and Professor, Department of Civil, Architectural, and Environmental Engineering, Cockrell School of Engineering, The University of Texas at Austin
* Corresponding author: mcook@harcresearch.org

Received 10 September 2023, Accepted 22 April 2024, Published online 2 October 2024.

Citation: Cook MA, Tremaine DM, Wyatt BM, Banner JL, Charles J, Berg M, Bruno T, Glazer YR, Callison C, Mace RE, Miller V, Bare R, Sanchez Flores R, Seefeldt J, Fuller A, Niyogi D. 2024. Addressing Challenges to Ensuring Justice and Sustainability in Policy and Infrastructure for Texas Water Resources in the 21st Century. Texas Water Journal. 15(1):104-139. Available from: https://doi.org/10.21423/twj.v15i1.7169.

Abstract: Environmental justice and sustainability have both become major concerns for water resource management, particularly with recent federal emphasis on environmental justice under the Biden administration in the United States. Texas, like many U.S. states, lags behind the federal government in this emphasis. While many localities have made progress in some respects—for example, some major Texas municipalities have included equity and sustainability metrics in their recent climate action plans—others have not. This has left a patchwork of persistent water management and availability issues that are exacerbated by extreme weather and worsening impacts of climate change. We provide a review of many of Texas's water equity and sustainability challenges, both now and in a more extreme climate future. These include water access, affordability, contamination, flooding, drought, and aging infrastructure. For example, many Texas counties rank highest in the nation for flood risk, including coastal counties with high populations of disadvantaged communities and counties containing populations that live in persistent poverty in the Lower Rio Grande Valley. Additionally, approximately 44,000 Texans, or about 0.4% of the state population, lack access to complete plumbing facilities in their homes. The costs of water infrastructure leaks (estimated at about 51 gallons of water per day statewide) are shared across customers of all income levels, though they place a disproportionate burden on low-income customers. We then assess existing statewide and local policy and planning efforts and gaps in addressing these concerns in Texas. We focus particularly on the role of efforts to incorporate community voice—the ideas, concerns, needs, and expertise of impacted community members, dismantle causes of injustice, and improve equity in spending. If communities are not intentional with future development, new water infrastructure could continue to perpetuate existing harms. Thus, we provide a research agenda and recommendations for addressing some of the policy and planning gaps and persistent environmental justice issues. We aim to help water managers and policy makers identify and dismantle sources of inequity, particularly through including community voice.

Keywords: sustainability, environmental justice, equity, aging infrastructure, water insecurity, affordability, flooding, contamination, nature-based infrastructure, one water, community voice, lived experience

Terms used in paper

Acronym / Initialism	Descriptive Name
ARPA	American Rescue Plan Act
ASCE	American Society of Civil Engineers
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
H-GAC	Houston-Galveston Area Council
HUD	U.S. Department of Housing and Urban Development
IBWC	International Boundary and Water Commission
IIJA	Infrastructure Investment and Jobs Act
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
Mgal	million gallons
MWh	megawatt-hour
NCEI	National Centers for Environmental Information
PFAS	per- and polyfluoroalkyl substances
ppb	parts per billion
RCP	Representative Climate Pathways
TCEQ	Texas Commission on Environmental Quality
TDEM	Texas Division of Emergency Management
TWDB	Texas Water Development Board
USDA	U.S. Department of Agriculture

INTRODUCTION

Climate change and humanity are inextricably linked, especially in regions where disparities in wealth distribution and systemic exclusion from decision-making processes engender and perpetuate environmental justice issues. Texas is an exemplary case study, where rapid population increase meets extreme weather events of increasing intensity and frequency, and where policy makers struggle to strike a balance between economic growth and the vitality of its least affluent citizens. We provide a holistic review of historic and current environmental justice issues through the lens of water resources, with a specific focus on water access, affordability, contamination, flooding, drought, and aging infrastructure. The contribution of the article is twofold: First, to provide options to policy makers to implement real, meaningful participation; and second, to provide researchers with areas to explore that contribute to water justice by helping identify and dismantle sources of inequity.

In Section II of this paper, we provide background information regarding environmental justice, climate change, and Texas demographics. We detail and tabulate equity issues including water access, affordability, contamination, aging infrastructure, and flooding in Section III. Then we discuss policy, planning, and regulatory concerns specific to Texas in Section IV. In Section V, we outline challenges and opportunities for using sustainable water management to address environmental justice issues. Next, in Section VI, we provide recommendations for identifying and using funding equitably and creating meaningful stakeholder engagement by incorporating community voice and cultural knowledge. Finally, in Section VII, we propose a research prospectus that will help identify and dismantle causes of inequities.

Water infrastructure development can be improved through better understanding of existing sustainability and environmental justice concerns, including how they could be exacerbated under future climate conditions. This study explores the persistent environmental justice concerns related to Texas water resources, infrastructure, and policy, delving into the tension between justice concerns and sustainable water resources management. For the purposes of this conversation, we define "water sustainability" as a holistic and proactive approach to water planning, management, and consumption that provides every individual access to affordable, clean, and safe water in amounts required for human persistence, while maintaining volumetric balance that also satisfies the needs of ecosystems, industries, and agricultural systems.

BACKGROUND

History of Environmental Justice in Texas and Nationally

Residents of Texas have been leading efforts to improve environmental justice since the beginning of the movement. In 1979, Black Texan homeowners filed a lawsuit to prevent a landfill from being sited close to public schools in *Bean v. Southwestern Waste Management Corp.* (U.S. Environmental Protection Agency [EPA], 2022a). While the lawsuit failed, the movement brought to light the disproportionate environmental impacts that Black residents experience. A few years after the lawsuit, Dr. Robert Bullard, now known as the "father of environmental justice," published the first study documenting environmental racism in Houston, an analysis of solid waste facilities' proximity to Black communities (Bullard, 1983). The environmental justice movement has since expanded nationally to include many communities who have been systemically under-resourced and impacted by pollution. Today, the climate justice movement takes a similar stance regarding the impacts of climate change.

While the environmental justice movement has roots in Texas, much of the environmental justice policy action first began at the national rather than the state level. Federal environmental regulations began in the 1960s and 1970s, but the federal government did not begin to acknowledge environmental justice issues until the 1990s, after many years of environmental justice organizing across the country.[1] During the Obama administration, federal agencies signed a memorandum of understanding committing to report annual environmental justice efforts. The 2022 Inflation Reduction Act (IRA) was the first federal legislation that recognized that disadvantaged communities experience disproportionate climate change impacts and included major funding for environmental justice (The White House, 2022).[2]

Many environmental justice scholars have highlighted that while there have been several federal environmental justice initiatives over time, underserved communities across the country have seen few environmental justice improvements (Essoka,

[1] In 1994, President Clinton signed Executive Order 12898. This mandate focused on the action of federal agencies, requiring that every federal agency incorporate environmental justice considerations into their actions (Executive Order Number 12898, 1994).

[2] The Climate and Equity Justice Screening Tool identifies "disadvantaged communities" throughout the United States based on multiple criteria, including climate change, legacy pollution, and water and wastewater concerns (Council on Environmental Quality, 2023)..

2010; Pulido, 2017; Pulido et al., 2016).[3] For instance, EPA's Environmental Justice Showcase Communities Project selected one community in each EPA region that was given $100,000 dedicated to a project to "help alleviate environmental and human health challenges" (EPA Office of Environmental Justice and Office of Sustainable Communities, 2010).[4] Though Port Arthur, Texas, served as EPA's Environmental Justice Showcase Community for Region 6, residents still experience poor air quality and related respiratory health impacts (EPA, 2022b). Moreover, outcomes of programs intended for environmental remediation and disaster relief have privileged affluent and White communities while adversely impacting low-income residents and communities of color (Barron, 2017; Bullard, 2020; Holifield, 2004). This disparity has been particularly evident in disaster relief, climate adaptation, and mitigation policies (Bullard, 2020; Marino, 2018; Martinich et al., 2013). Given Texas's trends toward a warmer and drier climate, more expensive weather- and climate-related disasters, and rapid population growth, it is particularly important to address these sustainability and justice disparities.

Texas Population Demographics

Texas is a fast-growing state, increasing in population at a greater rate than any other U.S. state (U.S. Census Bureau, 2019). Between the 2010 and 2020 censuses, the state population increased 16% from 25.1 million to 29.1 million (Redistricting and Voting Rights Data Office, 2023). This growth is predominantly in non-White populations, particularly the Hispanic/Latinx population, and is due to both natural increase (births vs. deaths) and international and domestic in-migration. People of color are now the majority in Texas. Hispanic/Latinx Texans alone make up approximately 39.3% of the population compared to the 39.7% of Texans who identify as White, non-Hispanic (Redistricting and Voting Rights Data Office, 2023). Residents who identify as Black/African American follow at 12.9%, Asian at 5.2%, and American Indian/Alaska Native at 1%.

[3] Underserved communities refers to communities that have been historically and often systemically under-resourced and are generally predominantly made up of individuals who are low-income, Black or Latinx, foreign-born, disabled, elderly, unhoused or in unreliable housing, live in unincorporated rural areas, or have limited English proficiency..

[4] In 2011, under the Obama administration, leaders of multiple federal agencies signed the "Memorandum of Understanding on Environmental Justice and Executive Order 12898" (EPA, 2011) as a symbol of recommitment to Executive Order 12898 that included a commitment to annually report agency efforts regarding the executive order. Furthermore, EPA under the Obama administration also implemented environmental-justice-focused programs, including the Environmental Justice Showcase Communities Project (EPA Office of Environmental Justice and Office of Sustainable Communities, 2010).

Texas's suburban areas are the fastest growing, but about 84% of Texans now live in urban areas (Brannen, 2023). Thirty-six areas previously classified as rural in 2010 are now considered urban. Conversely, 114 communities that were previously considered urban are now considered rural, due to a change in thresholds requiring a minimum of 5,000 rather than 2,500 residents or 2,000 housing units to qualify as urban. These changes impact eligibility for federal funding while growth areas can cause issues for affordability and access (described below), the ability to keep up with needed infrastructure, and extraction of resources from rural communities, all of which contribute to continued or worsening social injustice.

In addition to these demographic shifts, the Texas population is also younger and experiences lower wages and higher poverty than the rest of the United States. In Texas, 25.3% of the population was under 18 years old as compared to 22.1% of the national population, and 12.9% of the population was over 65 years old as compared to 16.5% of the national population (U.S. Census Bureau, 2022b). Texans also earn lower median wages and are more likely to live in poverty in childhood and overall. The median household income in Texas in 2022 was $73,035, while the national median household income was $75,149 (U.S. Census Bureau, 2022a). Additionally, in the same year, Texans experienced poverty at a rate of 13.9%, and 19.3% of Texas children under 18 years old and 21.1% of Texas children under 5 years old lived in households with incomes below the poverty level. At the same time, nationally, the poverty rate was 12.5%, and 16.7% of children under 18 years old and 18.1% of children under 5 years old lived in poverty (U.S. Census Bureau, 2022a).

Regional Climate Outlook

There is overwhelming scientific consensus that the planet's climate is changing and that this change is driven primarily by an anthropogenic disruption of the planet's carbon cycle caused by the burning of fossil fuels (Sixth Assessment Report Working Group I, 2021). Globally, this change has led, and will continue to lead, to an increase in atmospheric temperature if drastic actions are not taken to curb greenhouse gas emissions. This increase in atmospheric temperature will have varying effects on different regions of the globe, with wet areas generally becoming wetter and dry areas becoming drier (Sixth Assessment Report Working Group I, 2021). Current projections also indicate that weather extremes such as floods, hurricanes, and droughts are likely to become more frequent and larger in intensity both globally and in the United States (Kloesel et al., 2018).

In Texas, an increase in mean annual temperature of 0.6–1.1 °C (1.08–1.98 °F) has been observed since the early 1900s, leading to expected future increases in both drought and extreme precipitation events (Runkle et al., 2022). Along the

Texas coastline, sea levels have risen 0.13–0.43 meters (0.433-1.41 feet) over the last 100 years. Annual mean temperatures in the Southern Great Plains are projected to increase 2–2.8 °C (3.6–5.04 °F) by the mid-21st century and 2.4–4.7 °C (4.32–8.46 °F) by the late 21st century.[5] Southwestern Texas is projected to experience more than 80 additional days per year above 37.8 °C (100 °F) compared to 2018 by the end of the century, which will lead to increased water stress, reduced soil moisture, and unprecedented drought severity.

These unprecedented risks have yielded unprecedented expenses. Between 2010 and 2022, there were 90 recorded disaster events exceeding $1 billion in damages affecting Texas (66 severe storms, six floods, seven droughts, six tropical cyclones, three wildfires, and two winter storms), resulting in an estimated $200–$250 billion in damages, comprising 60% of all events and 55–67% of damages in 1980–2022 (National Centers for Environmental Information [NCEI], 2022).

Extreme weather events in Texas are increasing in frequency and intensity. By 2100, while the annual volume of rain is expected to remain constant or decrease in some parts of the state, the number of intense rain events (over 10 cm) in these areas is expected to increase (Houston Advanced Research Center, 2022).[6] Tropical cyclones remain the costliest disasters, making up about half of total costs from 1980 to 2022. At the same time, projected drought risks for the southwestern United States and Texas in the 21st century are assessed as unprecedented (Cook et al., 2015; Seager et al., 2018; Kloesel et al., 2018; Nielsen-Gammon et al., 2020a) compared to the past 1,000 years of historic records. With the increase in frequency and intensity of both drought and storm events, the risk of flash floods could also increase.

Urbanization and rural migration into cities, combined with increasing frequency and intensity of extreme weather events, is expected to increase Texans' vulnerability to the impacts of climate change (Bixler et al., 2021). For instance, urban areas grow hotter than their surroundings due to the roads, buildings, and other surfaces that retain heat, and this "urban heat island effect" has been demonstrated to increase extreme precipitation at the scale of the metropolitan area (Georgescu et al., 2021). In Houston, where the urban footprint grew 63% from 1997 to 2017 (Smiley & Hakkenberg, 2020), urbanization has exacerbated rainfall and flooding (Zhang et al., 2018). Climate change is expected to alter the sustainability of water resources in Texas, impacting infrastructure and communities—in particular, those residents made vulnerable by historic systemic inequities and compounding disproportionate impacts.

MAJOR EQUITY AND SUSTAINABILITY CONCERNS FOR TEXAS WATER RESOURCES

Many studies indicate that underserved communities experience disproportionate negative impacts to water sustainability, as well as systemic barriers to alleviating these inequities. The following sections outline ways in which underserved communities face disparities in water access, affordability, contamination, infrastructure, and flooding as outlined at the end of this section in Table 1. Changing climate is expected to exacerbate many of these impacts.

Infrastructure Degradation

Municipal water networks degrade as they age. This degradation produces significant impacts on water quantity and water quality that pose challenges to ensuring water equity and sustainability. Degradation and corrosion can lead to infrastructure failure, in the form of leakage of supply water and wastewater from the pipe network. Factors leading to infrastructure failure include age, material, construction practices, weather extremes, and excessive forces such as traffic aboveground (Shinstine et al., 2002; Makar & Rajani, 2000). Such losses from water infrastructure also alter water quality, as the leaked municipal water flows into natural groundwater and surface water systems and subsequently interacts with host rock and existing water in these natural systems (Christian et al., 2011; Beal et al., 2020). Contaminants¬¬, including heavy metals, nutrients, and bacteria, can contribute to degradation of streams in urban areas or urban stream syndrome (Walsh et al., 2005). As of 2020, leakage from water distribution systems in Texas has been estimated to exceed 186 billion gallons per year, or an average of 51 gallons of water per service connection per day (Walker et al., 2022). Similar losses are estimated for leaky sewage lines (Lerner, 1986; Sharp et al., 2003; Garcia-Fresca & Sharp, 2005). Water leaks in Texas increased by 3% from 2016 to 2020 (Texas Living Waters Project, 2020), and these costs are shared across customers of all income, though a disproportionate burden is placed on low-income customers.

During drought periods, water leaks may increase as demand and use of municipal water increases. These leaks pose signif-

[5] Compared to the mean annual temperature recorded between the years of 1976–2005.

[6] Multiple climate change scenarios, called Representative Climate Pathways (RCPs), were generated for the major Texas cities and industrial centers of Corpus Christi, El Paso, San Angelo, Dallas, Lubbock, McAllen, Fort Worth, Victoria, San Antonio, Houston, College Station, Lufkin, Tyler, Beaumont, Sherman, Amarillo, Abilene, Port Arthur, and Midland. RCPs describe changes between the year ranges of 2011–2100. Over those year ranges, the range of days per year with precipitation over 4 inches in the aforementioned communities is expected to increase from 0.05–0.41 in the first decade to 0.05–0.49 in the final decade under RCP 4.5 and from 0.05–0.38 to 0.06–0.66 under RCP 8.5. In the same communities and year ranges, the precipitation range expected on the wettest 3 days of the year is expected to increase from 1.8–5.9 inches to 2.1–6.4 inches under RCP 4.5 and from 1.9–6.2 inches to 2.2–6.9 inches under RCP 8.5.

icant costs to water systems. In early 2023, the Texas Water Foundation and the Houston Advanced Research Center conducted a survey of 270 water practitioners from across the state (including academic researchers, scientists, utility staff, and those responsible for educational outreach). Data revealed that nearly 80% of respondents rated extreme weather and aging water infrastructure as a medium to high risk. Water and wastewater leakage volumes can in some cases exceed natural groundwater recharge to urban aquifers beneath impermeable land cover (Sharp et al., 2003), providing aquifer recharge when there would be little otherwise. Indeed, water and wastewater leakage may provide a positive unintended impact on urban riparian ecosystems by helping to maintain baseflow during extended droughts (Banner et al., 2024).

Water losses also correspond to significant economic costs to a municipality and its households. These costs include lost revenue, increased energy costs associated with water treatment, and associated increase in carbon footprint due to the additional water treatment and pumping required to make up for lost water. Treatment and collection require about 0.23 megawatt-hour (MWh) per million gallons (Mgal) for surface water and 0.61 MWh per Mgal for groundwater (Stillwell et al., 2011). The associated carbon footprint required for the extra treatment and pumping to make up for lost water averages 800 pounds per MWh in Texas (Scott Institute for Energy Innovation, 2017). Taking these factors into account, using the previously mentioned 2020 estimate of 186 billion gallons of water lost per year required an estimated 81,600 MWh of energy, while producing about 29,600 metric tons of carbon dioxide. The energy and carbon footprints of water leaks are likely to be exacerbated in the future, as the cost of water main breaks and leaking pipes are increasing and many cities' water infrastructure is near the end of its design lifetime (American Society of Civil Engineers [ASCE], 2020). Infrastructure repair is projected to increase the annual cost to U.S. households from $2 billion in 2019 to $14 billion in 2039 (ASCE, 2020). This is particularly relevant to low-income households, where utility bills constitute a greater proportion of their income.

Both in Texas and elsewhere in the United States, many communities have aging, inadequate, or nonexistent water infrastructure. Underserved communities already overburdened with economic, environmental, and health challenges are more highly impacted by inadequate water infrastructure and its implications on water access (U.S. Water Alliance, 2017a). In 2018, the Houston-based nonprofit Bayou City Waterkeeper conducted an investigation of sewage overflows that may have violated the Clean Water Act and disproportionately impacted lower-wealth, Black, and brown communities in the city (Morris, 2019). The City of Houston eventually negotiated a consent decree with EPA to invest $2 billion in local sanitary sewer upgrades over 15 years (Scherer, 2021). Ensuring public participation in infrastructure planning and maintenance is important for improving water sustainability and equity when designing and upgrading water and wastewater systems.

Water Access

Many Texans still lack secure access to clean, safe, reliable, and affordable water and sewer services (Jepson et al., 2017). Approximately 44,000 households, or about 0.4% of the state population, lack access to plumbing facilities in their homes (U.S. Census Bureau, 2021). This discrepancy is not evenly distributed. Many who lack access to plumbing live in colonias, the low-income, unincorporated communities along the southern border that also often lack energy and transportation infrastructure (Ward, 1999). However, there are homes without plumbing facilities statewide (U.S. Census Bureau, 2021). Many of these communities have been effectively or directly denied adequate infrastructure through historic disenfranchisement, such as lack of representation in decision-making or service boundaries drawn specifically to exclude them. In the community of Sandbranch, Texas, outside Dallas, people lack running water, and nearly all residents of this community are low-income and people of color (Riggs et al., 2017). Outside Austin, Northridge Acres is another example of a community where people lack safe drinking water and reliable plumbing (Anderson, 2007). Elsewhere in the state, residents of colonias were excluded from water district territories in the 1970s (Jepson, 2012), and as a result, the predominantly low-income Latinx residents of these communities were denied the right to vote for their regional water governance and excluded from adequate water service. Now, many colonia residents rely on non-networked means of water supply such as water vending, tankers, retail, or small decentralized water systems (Jepson, 2014). Statewide, rural Texans experience boil-water notices at a higher rate than their urban counterparts, as small water systems struggle to maintain adequate water supplies and to recover from contamination concerns (Salhotra & Carver, 2022).

These examples demonstrate a pattern of water insecurity, or unstable access to water services, based on race, ethnicity, and citizenship. In general, wealth disparities between races contribute to unequal housing opportunities and related water insecurity (Meehan et al., 2020). Similarly, households with a mix of foreign-born and U.S.-born residents are 4.2 times more likely to be water insecure compared to other households (Jepson & Vanderwalle, 2016). Due to systemic inequalities in infrastructure provision and the resultant water insecurity, underserved communities may be forced to either pay high premiums for access to clean bottled water or seek unsafe water sources (Balazs & Ray, 2014: DeMyers et al., 2017).

Housing location and type is also linked to water insecurity. Residents in mobile homes, trailer parks, and insecure housing—lacking certainty due to issues like affordability--can experience disproportionate negative impacts to their water access. For example, residents of mobile homes and trailer parks often lack adequate access to reliable water and wastewater services and suffer more issues with water quality compared to other residents of other housing types (Pierce & Jimenez, 2015). Additionally, unhoused residents have less secure access to water than their counterparts in stable housing situations (Fazel et al., 2014). Finally, residents in rural areas may lack access to public water supply (Deitz & Meehan, 2019).

Water Affordability

Water affordability limits water access. In the United States, there is no federal regulation requiring affordable water or sanitation services (Amirhadji et al., 2013). A nationwide assessment of water affordability in 2017 determined that 11.9% of households perceived water bills to be unaffordable (Mack & Wrase, 2017). Unaffordable water rates put households at risk of water service shutoff. In low-income households, paying a water bill requires a higher proportion of household income, making these households particularly vulnerable to water shutoff (Teodoro, 2018).

Larger households may use more water and thus have higher water bills than smaller households, though they may not necessarily have greater water use per capita (Potter et al., 2022). Immigrant households, which tend to be multi-generational, may be impacted by water rates for this reason. Additionally, households where there are water leaks will face higher water bills. Renters may be unable to have water leaks repaired in a timely manner. Low-income homeowners, despite owning their own homes and making their own repairs, may also be unable to afford to repair leaks or pay their water bills.

To avoid being faced with higher water bills, households may ration water supplies or use water illegally (Montag, 2019; Vanhille et al., 2018). To avoid shutoff and other negative consequences, people in these households may skip paying other bills. Unpaid bills can result in eviction or property liens, potentially pushing these low-income residents into homelessness (Amirhadji et al., 2013; Montag, 2019). While some water suppliers have affordability programs, not all have them. Where water affordability programs exist, lack of information or access to these programs may still limit participation (U.S. Water Alliance, 2022). Households lacking water service, whether due to service disconnection or lack of household plumbing, must buy water at higher prices from vendors, tankers, or bottled water suppliers (Jepson & Brown, 2014). This further increases their water-bill-to-income ratio.

Texas lacks an inventory of water shutoff information by utility, but the state does specify permitted reasons for shutoff, such as violation of a utility's rules, operation of non-standard equipment, and failure to comply with deposit or to pay charges (PUC, 2024). While electricity customers can avoid shutoff should an ill person's physician contact the electricity provider, this provision is not available to water customers (PUC, 2024). Similarly, electricity providers are required to offer deferred payment plans for non-payment upon request or during extreme weather emergencies, but water and sewer utilities are not held to these regulations (PUC, 2024). Because many households were affected by the broad economic impacts of the 2019 COVID-19 pandemic, moratoria on residential water, sewer, and energy utility bill payments were in place until June 2021 in Texas and elsewhere in the country (PUC, 2021). One study found these moratoria significantly lowered the COVID-19 infection and death growth rates (Zhang et al., 2022).

Water Contamination

Water contamination limits household water security—the ability to rely on safe, clean, affordable water supplies—by threatening residents' safety. Water contamination can impact anyone, but disproportionately impacts underserved communities, eroding these communities' trust in utility-provided water services. Lack of trust encourages residents to seek other, more expensive water sources, as well as to purchase less water from the utility (Parag & Roberts, 2009; Pierce et al. 2019). As utilities are dependent on ratepayer funding, a utility that loses ratepayers has a reduced ability to fund water infrastructure projects that could improve water quality. A survey of Texans' drinking water perceptions found that 23.5% of respondents indicated that bottled water is their primary drinking water source (Gholson, 2017). Communities may not trust water utilities if they have experienced issues associated with aging infrastructure (Grigg, 2019; Kenney et al., 2019), known contaminants, or contaminants of emerging concern (unregulated contaminants that are less well understood but that may cause ecological or human health impacts). Less than 2% of small water systems have technologies capable of treating contaminants of emerging concern (McFarlane & Harris, 2018), and many Texas residents in both urban and rural settings are served by small water systems.

While the Safe Drinking Water Act regulates the quality of public drinking water, contamination concerns in Texas have increased in frequency and magnitude in recent years. From 2011 to 2016, there was an increase in drinking water and environmental contamination incidents, including boil-water notices, sanitary sewer overflows, and the presence of lead in water supplies (Mulki et al., 2018). In February 2021, during Winter Storm Uri, the wide-scale water outages and boil-water notices due to electric grid failure may have been the largest water service disruption in U.S. history (Glazer et al., 2021).

Moreover, the lack of electricity service prevented some residents from boiling water even if they retained water service. Due to underground water main ruptures, widespread pressure loss within the distribution network and ingress of surrounding materials such as soil, residents may have been exposed to contaminants in drinking water during this time.

Surface water and groundwater resources can be contaminated by industrial facilities or activities, agricultural runoff, or waste from agricultural practices. While surface water quality is regulated by the Clean Water Act and related laws, groundwater quality is protected by a patchwork of federal regulations of other hazards to the health of the natural environment, such as hazardous waste disposal. Furthermore, households reliant on groundwater wells may experience water shortage due to diminished water levels (Pauloo et al., 2020). This is especially true in Texas, where the rule of capture presides. This doctrine is informally referred to as the "law of the biggest pump" and is discussed more in Section IV.A.

Lead contamination in drinking water is of particular concern following failed management practices that resulted in residents of Flint, Michigan being exposed to elevated lead concentrations. Because lead is toxic to humans even at low levels, EPA's maximum contaminant level goal for lead in water is 0 parts per billion (ppb; EPA, 2022c), and the action level requiring public notification of exceedance is 15 ppb. In Texas, there are an estimated 270,000 lead service lines, and 30% of community water systems are estimated to have some lead service lines (Cornwell et al., 2016). Schools in North Texas have measured lead in water above the action level requiring public notification (Ayala, 2019). In underserved communities near the Houston Ship Channel, lead was discovered in 30.8% of homes at levels above the maximum contaminant level goal of 0 ppb but below EPA's action level of 15 ppb. This is significant as lead is a toxic metal harmful to humans even at low levels. Use of lead in pipes and solder was common prior to 1930 and finally banned under the Safe Drinking Water Act Amendments of 1986. Lead may still be found in plumbing systems of homes, apartment buildings, schools, park facilities, daycare centers, school water fountains, and other structures built prior to 1986. Historically underserved communities may face multiple sources of lead exposure, including existing water systems and in-home plumbing (U.S. Water Alliance, 2017b). Utilities control their distribution lines but do not control the privately owned portion of water lines leading to homes. Removing the utility portion of a lead service line rather than the entire line can disturb the lead and worsen water quality; the Centers for Disease Control and Prevention has linked partial lead service line replacement to increases in blood lead levels (Brown et al., 2011).

Unconventional oil and gas operations, such as hydraulic fracturing, have known waste streams that could harm nearby communities and the environment, including wastewater and air emissions. Wastewater associated with hydraulic fracturing contains a variety of chemicals, many of which are known carcinogens or otherwise toxic to human health. Disposal of this wastewater has also been linked to induced seismicity. Understanding who benefits or is burdened by environmental impacts and decisions is key to providing equitable outcomes. In addition to potential health and safety impacts, residents near oil and gas development may not benefit from the development of hydraulic fracturing operations. For example, Fry et al. (2015) found that 1% of residents of Denton, Texas owned the value extracted from mineral rights developed in the area, even though the city is a beneficiary of the hydraulic fracturing industry. The residents of Denton voted to ban fracking within city limits in 2014. The disparity in ownership may explain why residents voted to ban fracking. Though Denton's demographics are similar to the state as a whole, the poverty rate is higher at 15.7%, compared to 13.9% at the state level. Denton's ban was superseded in 2015 by state legislators (Malewitz, 2015), preventing residents most impacted by the local oil and gas activity from exerting their decision-making capability. In Denton, as elsewhere, property ownership and residents' financial stake in an industry also play a role. Income, race, ethnicity, and other socioeconomic identifiers can also impact procedural environmental justice, or who is allowed to participate in decision-making.

Flooding

Texas is highly impacted by floods, outranking all other states in deaths, injuries, and property loss due to flooding (Zahran et al., 2008). From 2010 to 2022, 233 Texans died from flood events, comprising 17% of all flood-related fatalities nationwide (National Weather Service, 2022). Many Texas counties rank among the highest in the nation for flood risk, particularly coastal counties and those along the Rio Grande (NCEI, 2022). Harris County leads both Texas and the nation in flood risk (NCEI, 2022).

Flooding can impact all people. However, many studies indicate that underserved residents experience disparate exposure to flooding and other hazards in their homes (Mohai et al., 2009). Studies of the Houston area following Hurricane Harvey found that homes in majority Hispanic or Black communities, homes in communities comprising primarily lower socioeconomic status individuals, and homes with higher proportion of disabled individuals experienced more extensive flooding than their counterparts (Chakraborty et al., 2019). Redlining and other policies and practices that have systematically influenced where minoritized residents live have placed disproportionate flood risk and impacts on these residents. Coastal communities often contain a majority of socially advantaged, wealthier White residents who may have a greater means to choose to live

Table 1. Challenges to environmental justice and sustainability in Texas water resource management.

Concern area	Characteristics/attributes	Opportunities for environmental justice and sustainability	Challenges
All categories		• Co-developing research and solutions with impacted communities • Equitable distribution of funding and infrastructure maintenance	• Historic, systemic causes • Disproportionate impacts and lack of agency for underserved residents, e.g., residents who are low-income, Black and Latinx, foreign-born, rural, un-housed or in unreliable hous-ing, or live in unincorporated rural areas • Who makes decisions and what input is incorporated • Climate change exacerbates impacts
Infrastructure degradation	• Aging infrastructure is responsible for point and nonpoint source pollution, both in terms of fresh water and wastewater • Total water system loss in Texas is 186 billion gallons or about 51 gallons lost per service connection per day as of 2020 • Texas Water Conservation Scorecard reports water leaks up in 2016–2020	• Full repair of currently identified leaks to eliminate anthropogenic input/fertilization • Strategic use of treated water leaks to recharge aquifers and riparian zones during drought • Tracking and repairing leaks near disproportionately impacted residents	• Policy makers, regulators, etc., making decisions without public input/accountability • Leaks, loss of water and wastewater supply; extent of leaks/loss unknown • Fresh water and wastewater leakage is a source of pollution into natural environment (both groundwater and surface water) • Issues lead to disproportionate impacts of contamination and compounding pollution sources for underserved residents
Water access	• Water shutoffs • Interrupted water service • 44,000 Texas households lack access to clean, safe, reliable water and sewage	• Policies for improved infrastructure upkeep to ensure clean water delivery	• Disproportionately insufficient water access for colonias and other underserved communities • Disproportionately large impacts on water supply access for residents who are rural, unhoused, or in unreliable housing • Underinvestment in infrastructure
Water affordability	• Socioeconomic status drives inequities in freshwater usage • 11.9% of households in Texas find water bills unaffordable	• Development of deferred payment plans for utilities • Future planning opportunities to address city build-out and how creating neighborhoods of higher socioeconomic status in suburbs may reduce regional water sustainability for everyone • Federal funding, including grants or programs such as those put in place during the COVID-19 pandemic, to assist with affordability	• Home-level leaks increase user water costs; system-level leaks increase costs for everyone • Precarious water supplies, e.g., risk of water supply shutoff due to nonpayment • Households might ration water or use water illegally to afford bills • Higher income, lower density houses (and those with swimming pools) used much more water than lower income and higher density homes, per a San Antonio water consumption study

near coastal amenities (Chakraborty et al., 2014). These coastal communities may face higher property risk associated with coastal flooding (Ueland & Warf, 2006; Chakraborty et al., 2014). On the other hand, the risks of inland, riverine flooding are higher for socially disadvantaged individuals, including those with lower wealth or income and people of color. Residents of unincorporated areas in Texas may lack adequate drainage infrastructure, worsening flooding issues (Anderson, 2007). While green infrastructure such as trees and wetlands can lessen impacts of smaller floods, studies have shown that these projects are sited more frequently in socially advantaged neighborhoods (Park & Guldmann, 2020).. Thus, the flood reduction benefits of green infrastructure do not accrue as frequently to underserved communities.

(Table 1 continued)

Concern area	Characteristics/attributes	Opportunities for environmental justice and sustainability	Challenges
Water contamination	• Municipal drinking water regulated by Safe Drinking Water Act • Personal groundwater wells not regulated • Contamination caused by aging infrastructure, industry, agriculture, and oil and gas exploration • Lead in older pipes can get into drinking water • Extreme rain events pick up pollution, increase risk of human contact with contaminated water	• Enforceable policies for companies who impair water quality • Financial assistance for testing household wells • Research on emerging contaminants and treatment • Design of infrastructure for extreme weather • Better communication of alerts • Better access to potable water in emergency situations	• Large-scale rainfall events can cause turbidity, leading to prolonged boil-water notices • Lower-income neighborhoods may not receive boil-water notices as quickly as higher-income neighborhoods, and also have limited access to bottled water or other methods for preparing/reacting to alerts • Small water systems, particularly in rural areas, may be slower to address boil-water notices or not able to treat contaminants of emerging concern • Lead in pipes and their partial removal is linked to increased lead exposure; also, lead pipes can only be removed if doing so is affordable • Risk of surface- or groundwater contamination from oil and gas wastewater • Produced water disposal linked to induced seismicity
Flooding	• High impact and high risk of flooding in Texas • Types include coastal flooding, riverine flooding, and flash flooding • Many people live near flood risk areas • Flooding is exacerbated by climate change due to increased intensity of rainfall; increased drought also intensifies floods	• Green infrastructure • Local community and government initiatives to reduce flooding • State funding, applied equitably	• Disproportionate application of flood prevention infrastructure and response funding • Inadequate drainage • Coastal flood risk higher for affluent • Inland flood risk higher for non-affluent

Following flooding events, response and relief funding are often disproportionately allocated to affluent communities, and this disparate allocation of funds impacts underserved communities' ability to recover from disasters (Collins et al., 2019). Small Business Administration disaster loan applications are approved for majority White communities at twice the rate of majority Black communities (Emrich et al., 2020). Residents who had been impacted by Hurricane Harvey, who were interviewed as part of a community-based research effort in Northeast Houston, described feeling as if their neighborhood was invisible (Hirsch et al., 2021). Moreover, Texas Housers and Northeast Action Collective, two organizations involved at the state and local levels in housing, environmental, and climate justice, filed a complaint resulting in the U.S. Department of Housing and Urban Development (HUD) ruling that the Texas General Land Office discriminated against people of color in Houston and Harris County by denying them federal flood relief funds (Vasquez, 2022).

POLICY, PLANNING, AND REGULATION CONSIDERATIONS FOR SUSTAINABILITY AND ENVIRONMENTAL JUSTICE IN TEXAS

Policy, planning, and regulations can both impede and help address sustainability and environmental justice issues. For example, regulations may be under-enforced, leaving communities under-protected (Christian-Smith et al., 2012). In this section, we describe how this plays out in Texas's water management, drought planning, flood planning, and lack of climate planning. Each subsection also identifies gaps in addressing justice and sustainability in water management, including public participation in decision-making and design and adequate and equitable funding for regulatory protections and disaster response. A summary of these issues is included in Table 2 at the end of the section.

State and Regional Water Management

Texas water ownership, governance, and management varies based on location. Rainwater, overland flow, and runoff not in a state-recognized stream course are owned by the landowner and can be captured for use without use permits. Texas has permissive laws for capturing and using rainwater. For example, homeowners associations cannot implement new covenants preventing rainwater harvesting system installation, and water providers cannot disallow potable use of rainwater (Texas Water Development Board [TWDB], 2024).

While surface water is owned by the state, permits are treated as private property that can be bought and sold. Texas permits surface water through the prior appropriation doctrine, where water is allocated in order of the date or priority of the water right. However, in an echo of Spanish and Mexican law, riparian landowners using water for household or livestock demands have superior rights to all others (Porter, 2009). Landowners are allowed to install small tanks capable of storing no more than 246,696 cubic meters (200 acre-feet) without a permit (2 Texas Water Code, 1997). Except in the Lower Rio Grande, the Texas Commission on Environmental Quality (TCEQ) permits non-exempt surface water uses using the prior appropriation doctrine. In a two-decade-long adjudication, the Texas Supreme Court determined that irrigation users did not have riparian rights for the Lower Rio Grande, thus giving the river's municipal users a preferred-use status (Jarvis, 1991).[7] Environmental flows—the minimum amount of water that needs to remain in the river or stream to maintain the habitat while considering human needs—were not considered when water policy was developed, but environmental flow standards have been added to most rivers in the state.

Overuse, drought, and population growth has made groundwater a critical water source for industrial, commercial, and residential users (Collins, 2021). Texas landowners own groundwater under the rule of capture, which allows them to withdraw as much as they want from their property regardless of the impacts to neighbors. This ownership model can lead to disparate access to water because wealthier residents or businesses may be able to drill deeper into an aquifer than underserved residents, whose wells would run dry faster. As of 2022, Texas has 103 groundwater-regulating bodies, which account for 70% of the state's surface area and 90% of its groundwater production (TWDB, 2022). Most of these regulating bodies are locally controlled groundwater conservation districts, which supersede certain aspects of the rule of capture, such as spacing requirements and permit limitation. There are also three special districts that regulate groundwater withdrawal in specific cases. The Edwards Aquifer Authority regulates groundwater for the protection of endangered species reliant on springflows, while the Fort Bend and Harris-Galveston subsidence districts do so to manage land subsidence. Limiting land subsidence caused by groundwater use is important for reducing environmental damages, such as floodplain changes that increase local residents' flood risk.

Water Planning

Texas has a long history of drought planning and response, following extreme drought in the 1950s. Drought planning and response occurs in Texas in three ways: (1) regional and state water plans for meeting long-term water needs under drought-of-record conditions; (2) local drought contingency plans; and (3) state agencies' drought response, including reporting to the governor. Public input is part of multiple components of drought planning.[8]

The most recent version of Texas's state water plan was published in 2022 (TWDB, 2021). The first plan, which began in response to the drought of record in the 1950s, was published in 1961 and referenced both drought and flood as major concerns (Texas Board of Water Engineers, 1961). The 2022 plan includes information regarding drought response, existing water supplies and needs, future water demands, water management strategies and conservation efforts, financing needs, and an update on the previous state water plan's implementation (TWDB, 2021).

A new plan is published every 5 years and is a product of a planning process involving 16 State-designated regional plan-

[7] Riparian rights give the water user the right to capture and use water solely due to certain criteria, for example ownership of land along which a river flows. Riparian rights in Texas include domestic water use and livestock use.

[8] Regional water planning, drought management planning, and drought contingency planning all have their roots in Texas Senate Bill 1, passed in 1997.

ning groups with members from different stakeholder groups.[9] While members of the public are included, intentionally selecting community members historically vulnerable to drought has not been a priority, though that could assist with overcoming historic disenfranchisement and ensuring residents' ability to participate fully. Lack of coordination between all water suppliers and entities responsible for water and land-use planning may also contribute to underserved residents' water supply and demand not being included in forecasting or planning.

Water resources sustainability is a key piece of the state and regional water plans, but justice is not a focus. Also, though the most recent state water plan references Texas's "highly variable" (p.48) and "unpredictable" (p.17) climate several times, it does not mention or acknowledge ongoing climate change or its current or future impact on Texas's water resources. However, 10 of Texas's 16 regional water plans reference climate change's impact on water supplies or the need to consider this risk in water planning.[10] Moreover, the state climatologist is now providing input to both TWDB and regional planning groups on potential future conditions. Incorporating future climate forecasts into state and regional water planning would improve Texas's capacity to avoid impacts to water supplies and water systems during extreme weather events, including prolonged drought and winter storms (Nielsen-Gammon et al., 2020b).

Drought Planning

Wholesale and retail public water suppliers and irrigation districts must have drought contingency plans, the requirements of which are governed by TCEQ (Additional Requirement, 1997; Drought Contingency Plans, 1999). Essentially, a drought contingency plan is an explicit plan for how a water provider or water-right holder will plan to reduce usage as a function of a depleting water supply, generally through the phased elimination of outdoor water use. State law requires public input during plans' preparation before they are submitted to TCEQ. While these plans are intended to address drought, they are individual solutions and are not incorporated into the state water plan, which is meant to meet state water needs under conditions like the drought of record. Some municipalities, such as Austin Water Utility, City of Cedar Park, City of Dallas, and San Antonio Water System, adjust their tiered water rate structures such that larger water users pay much more for using more water, with the intent of encouraging water conservation to reduce vulnerability to drought. During drought periods, the municipalities may increase the tiers to encourage additional water conservation. However, for some families with many individuals in a residence—such as in low-income, multi-generational households—these water rate structures can create inequities where the marginal rate of water use is higher for these residents compared to others.

Drought Response

Drought response is determined largely by state agencies' response to drought conditions. Drought response and preparedness plans are developed by the Drought Preparedness Council, which is led by the chief of the Texas Division of Emergency Management (TDEM) and primarily consists of water-related state agencies (Drought Response Plan, 1977). During drought, the council facilitates communication between relevant agencies and assists TCEQ in addressing imminent water shortfalls through interconnections and alternative water supplies. Ultimately, during a drought, there is a great deal of local responsibility in ensuring that local water supplies are secure. However, if a water supply fails, then TDEM coordinates bottled water deliveries to impacted communities.

Plans on paper are only as good as the active planning that results from them, and communities' attention to detail in drought response planning has varied. The drought of 2009–2015 helped cities identify how to improve their plans in response to an actual drought. For example, the City of Austin and other communities modified their plans during and after the drought when they realized that banning all outdoor watering placed the city's tree canopy in jeopardy (Austin Water, 2012).

Flood Planning

Watershed management approaches are as diverse as watersheds themselves, but there are some water management commonalities across watersheds and states that shape Texas flood planning. Like every state, Texas relies on Federal Emergency Management Agency (FEMA) flood maps as part of the National Flood Insurance Program, though these are infrequently updated or nonexistent in disadvantaged communities or areas with low population density (Flavelle et al., 2020; Pralle, 2019). The Natural Resources Defense Council ranks

[9] In 2022, members of regional water planning groups represented agriculture, counties, electric generating utilities, environmental, economic development, groundwater conservation districts, groundwater management areas, higher education, industries, municipalities, public, recreation, river authorities, small business, travel/tourism, water districts, water utilities, and other entities as designated by Chapter 357 of the Texas Administrative Code and Chapter 16 of the Texas Water Code (TWDB, 2022).

[10] Texas's state water plan is developed from 16 regional water plans. Water planning regions A, C, E, G, H, K, L, M, N, and O mention climate change as a risk to water supplies. They do not plan with climate data. Region L includes a resident response that explains why: "While climate variability is mentioned in Chapters 6 and 7 of the IPP; the plan uses drought of record conditions and historical hydrological data to estimate water demands and supplies and does not currently incorporate climate models to predict impacts to future water resources." Region M includes a recommendation to the state: "The State should continue to consider the impacts of climate change in terms of Regional Water Planning and future water supplies."

Texas, Louisiana, and Oklahoma among the best in the nation in terms of disclosing flood risk—whether a location is within a regulatory floodplain—to home buyers (Natural Resources Defense Council, 2023). Recent Texas legislation extends the same right to renters (Rice, 2022). Additionally, like many other states, Texas has received technical assistance and funding related to federal programs such as the Watershed Protection and Flood Prevention Act of 1954 and various flood control acts passed by the U.S. Congress (Congressional Research Service, 2019). Texas also participates in coordination efforts such as the National Dam Safety Program to monitor potential impacts from and on water infrastructure (FEMA, 2022). When flood disasters do occur, Texans have access to financial assistance through FEMA, various programs offered by HUD, and other federal agencies via municipal, county, or state government entities, depending on the specific complex funding scheme response to the flood event. Despite these efforts, access to flood risk information, flood insurance, and flood mitigation and disaster recovery funds is still often highly inequitable. Preparing and meaningfully involving underserved communities, who are often most at risk, is critical to risk management, both within and outside formal planning processes.

Federal and state legislation is typically enacted after major flood events, but recent extreme events have pushed Texas to take a more proactive strategy. Non-tropical storm floods across Texas spurred the Texas Legislature in 2017 to require TWDB to conduct and prepare a state flood assessment with recommendations for taking appropriate actions to address recurring floods. In the next legislative session in 2019, the state flood assessment and Hurricane Harvey's widespread damage in 2017 prompted the creation of new statewide flood programs similar to the state's approach to water supply planning (Berg, 2020). These flood programs use a watershed-based approach to split the state into 15 regional flood planning groups. Each group consists of 12 voting members representing different stakeholder sectors who identify and prioritize projects for funding.[11] While members of the public are included, including community members vulnerable to flooding is not prioritized. There are also separate but related efforts to analyze and address flood risk along lower reaches of major river basins and along the entire Texas coast (e.g., Spring Creek (San Jacinto River Authority, 2024)). These are aimed at ensuring flood planning is available to all communities, not just those with large populations or greater financial resources.

[11] The 12 voting members represent agricultural interests, counties, electric generating utilities, environmental interests, flood districts, industries, municipalities, the public, river authorities, small businesses, water districts, and water utilities.

Climate Adaptation Planning

Texas does not have a statewide climate adaptation plan that describes the projected impacts of or responses to climate change. While Texas does not have an overall climate adaptation plan, some Texas cities have led climate-planning efforts that include sustainability and environmental justice concerns for water management and mitigation actions to reduce greenhouse gas emissions.[12]

- The City of Austin has been a leader in the development of climate adaptation planning in Texas. Austin City Council passed Resolution 20070215-023 in 2007, which established the Austin Climate Protection Program and directed city staff to develop plans and programs to reduce negative impacts from global warming. In 2012, Austin published the Imagine Austin Comprehensive Plan, which included climate components (City of Austin, 2018b). Austin is specifically planning for climate equity and climate impacts on water. The City also produced a climate equity plan (City of Austin, 2021) and a 100-year water use management plan (Austin Water, 2012) that accounts for climate impacts on supply and identifies strategies to address shortfalls using a One Water approach (*See* One Water on page 121; Austin Water, 2018).[13]
- Travis County, in which Austin resides, produced its own climate action plan in 2020 (Conserve Travis County, 2020). The plan includes goals to reduce water use and emissions, as well as water management strategies such as low-impact development (*See* Nature-based Infrastructure on page 118) and wastewater recapture.
- In the Houston area, the Houston-Galveston Area Council (H-GAC), a regional council of local governments, published a report that assessed potential local climate change effects and provided regional adaptation recommendations (H-GAC, 2008).[14] In 2020, the City of Houston published a climate impact assessment, a resiliency plan with a climate focus, and a climate action plan (City of Houston, 2020a; City of Houston, 2020b). The climate action plan focuses on reducing emissions; water and wastewater are discussed in the context of reducing emissions associated with treatment. The resiliency plan includes strategies aimed at flood management, green infrastructure (*See* Nature-based Infrastructure on page 118), and climate equity.

[12] The City of El Paso (2008) considered climate change in its sustainability plan and began developing a climate action plan in 2021 (Montes, 2021).

[13] Other documents include city department thoughts on climate resiliency (City of Austin, 2014) and a climate plan for city assets and operations (City of Austin, 2018a). The City of Austin also collaborated with the Capital Area Metropolitan Planning Organization to assess the vulnerability of transportation infrastructure to climate change (Cambridge Systematics, Inc., 2015).

[14] H-GAC includes 108 cities, 13 counties, and 11 school districts.

- Harris County, in which Houston resides, developed its Climate Action Plan for Internal Operations (2023) and will develop a Phase II Climate Justice Action Plan w through a partnership with the Coalition for Environment, Equity, and Resilience, a local nonprofit with this expertise, and additional local partners like the Jacob and Terese Hershey Foundation. The 2023 plan touches on flood, drought, water quality, and water supply impacts from climate change and makes recommendations for green infrastructure use.
- The City of Dallas (2020) published its climate action plan in 2020. The plan includes goals of protecting its water resources and its communities from drought and flood and enhancing green spaces with an eye toward flood management. Under the water goal, Dallas plans to promote awareness around water conservation, reduce water leaks, encourage planting drought-tolerant vegetation, protect water quality, educate about and protect communities from flooding, assess and plan for storm drainage, and protect key water infrastructure from extreme weather events, among other strategies. Under the green spaces goal, Dallas plans to use green infrastructure to reduce flood risk and impacts of drought. The plan does not include an equity or justice goal. However, the city's Resilient Dallas (2017) plan includes an initiative to "implement green infrastructure projects in neighborhoods disproportionately vulnerable to the impacts of … poor water quality" (City of Dallas, 2017, p. 49).
- The City of San Antonio (2016) considered climate change in its sustainability plan and published a climate action plan in 2019 (City of San Antonio, 2019). Strategies related to water management and climate equity include flood-proofing roads and critical infrastructure, retrofitting homes in floodplains, assessing the need to install public water fountains in areas of high vulnerability, creating a green infrastructure plan, developing an equity assessment of sustainability programs, and prioritizing vulnerable residents.

To increase state-level visibility and awareness of climate change and adaptation needs, it will be necessary to increase the presence and voice of both climate scientists and people negatively affected by climate change impacts. Currently, little state-level work has been done because of many lawmakers' resistance to the idea of climate change. Thus, moving forward, it is likely that the most effective action will be an expansion of locally driven adaptation efforts like those described above. Unfortunately, this means that adaptation efforts may be focused in urbanized areas, which tend to have a greater number of residents who are aware and accepting of climate change impacts.

Uncertainty of Transboundary Waters

Since 1990 and approximately every 5 years after that, Texas and its southern neighbor Mexico have faced diplomatic water conflicts related to fulfilling the 1944 Water Treaty (Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, 1944). The treaty states that Mexico must deliver 350,000 acre-feet of surface water to the United States annually and on a 5-year cycle, meaning that water transfers are only verified every 5 years. The treaty also allows for the accumulation of one remaining water debt for a subsequent 5-year cycle if Mexico claims an extraordinary drought, which is not defined in the treaty. Since 1992, Mexico has been unable to reach the total amount of allocations to the United States three times: cycles 1992–1997, 1997–2002, and 2010–2015 (Robb, 2022).

The treaty was successful and dispute-free for over 50 years before these conflicts arose. However, since 1990, International Boundary and Water Commission (IBWC) officials on both sides of the border have recommended residents pray for rain as water shortages increased (Mendieta Sánchez, 2023; Sanchez, 2024a). This trend happens every 5 years before the end of the agreed-upon water cycle, as shortages and lagging required annual deliveries accumulate.

Climate variability, more frequent and intensive drought conditions, population growth, and limited transboundary water management create a perfect scenario for water conflicts. Transboundary water conflicts are a reflection of domestic and local governance disruptions. This was demonstrated in 2020, when farmers in Chihuahua challenged the Mexican federal government and took over the main reservoir of Conchos River, which supplies 70–90% of the flow to the Lower Rio Grande (Pskowski, 2023). The Mexican federal government had to look for alternative solutions because the local resistance to deliver water to the United States claimed priority rights based on equity and social justice, setting a legal and historical precedent for who gets the priority. The 1944 Water Treaty does have the legal instruments and the operation process to adapt to current conditions (Minute process), so this resistance based on equity and social concerns is not a legal or institutional challenge. In the future, two major concerns will need to be addressed: the current transboundary water framework will need to be adapted to the climatic conditions, and water priorities will need to be adjusted to ensure equity and justice without compromising sustainability. How these concerns are addressed will continue to be a cause of conflict

Nonetheless, the Mexican federal government has never denied nor refused to comply with its obligations. In 2020, at the end of the corresponding 5-year cycle, Mexico and the United States signed Minute 325, wherein Mexico agreed to give up its corresponding storage committed to downstream states (Coahuila, Nuevo Leon, and Tamaulipas) to fulfill its obligations (IBWC, 2020). U.S. Minute 325 was a historic event that was referred to as a success in the binational water relations of both countries.

However, officials believe there is no longer enough water to comply with every legal right and need within the Rio Grande/Rio Bravo basin (Sanchez, 2024b). Moreover, paying this generation's water supply debts could impact residents on both sides of the border now and in the future, creating an intra- and inter-generational environmental justice concern. Water users and stakeholders in the basin are starting to question international priorities as issues of equity and social justice become a strong pressure for the Mexican federal government. Who should have the priority, the international treaty or the farmers in Mexico that rely on water for economic survival and social stability? So far, this question does not have a straightforward answer. Climate change, unsustainable agricultural and industrial water practices, and limited efforts to adapt and manage transboundary water resources have led to a vulnerable and uncertain scenario for all users.

Disconnect Between State Policy Making and Community Needs

The disconnect between community-based experience and state-level policy making was evident in the debate in the Texas Legislature over water-related allocations from the federal government through the American Rescue Plan Act (ARPA) of 2021. ARPA set aside $350 billion in stimulus funds to states, tribes, and local governments, with nearly $16 billion allocated for Texas. ARPA explicitly authorized use of the funds for "necessary investments" in drinking water and wastewater systems (American Rescue Plan Act of 2021 Sec. 9901.a.c.1.D.). While at least 22 other states and territories allocated a total of at least $5.4 billion to water and sewer projects, Texas lawmakers declined to allocate any funds toward water infrastructure (Lazere, 2021). Senate Bill 8, passed during the third session of the 87th Texas Legislature in September 2021, allocated $13.3 billion in ARPA funds to a wide range of projects including infrastructure spending on broadband and dune restoration but no funding for water-related projects (Tex. S.B. 8, 87th Leg., 3d C.S., 2021)

Texas lawmakers declined to allocate funds despite evidence that many Texans felt otherwise. A broad coalition of equity, rural, and conservation groups carried out an extended in-person advocacy effort in favor of allocating funds toward water infrastructure (National Wildlife Federation, 2021). In the same month Senate Bill 8 passed, Texas 2036 (2021) released a poll showing that 88% of respondents favored using $3 billion of available federal funds for state water projects to improve drinking water quality and water access during drought conditions. In ASCE's 2021 Report Card for America's Infrastructure, Texas received a C– for water infrastructure and a D for wastewater (ASCE, 2021).

While there were myriad factors involved in Texas lawmakers' decision to delay funding water infrastructure via ARPA, the absence of community voice during in-person testimony may have contributed to water infrastructure's exclusion from the decision. The 10 witnesses advocating for various water infrastructure allocations during the Senate Bill 8 hearings on October 4, 2021, all occupied full-time leadership or specialist roles in conservation or water interest groups (Texas Senate Bill 8, 2021). While practitioner witnesses were well-represented, lawmakers did not hear from constituents with firsthand experience of the perceived failings and/or inequities in Texas water infrastructure. This lack of community voice in the decision to exclude water infrastructure from funding priorities stood in sharp contrast to several other ARPA advocacy efforts that included non-specialist community members testifying in-person (Texas Senate Bill 8, 2021). The Infrastructure Investment and Jobs Act (IIJA) of 2021 and other federal infrastructure funding packages may bring significant funds to Texas over the next 5 years. Direct in-person communication from non-specialist constituents affected by inadequate water infrastructure could be critical to drawing Texas lawmakers' attention to community-perceived water infrastructure inequities and needs.

SUSTAINABLE WATER MANAGEMENT PRACTICES AND THEIR CHALLENGES AND OPPORTUNITIES IN ADDRESSING ENVIRONMENTAL JUSTICE AUTHORITY

This section discusses two avenues currently employed to address sustainability in water management: nature-based infrastructure and One Water. When applied deliberately and carefully, they could be used in tandem to address environmental justice in tandem. This section outlines each technique and how to apply each technique sustainably in a way that delivers just outcomes. Table 3, at the end of this section, summarizes these issues.

Nature-based Infrastructure

Nature-based infrastructure are practices that conserve existing environmental features or are human-made features constructed to imitate natural processes. They can be used to reduce the impacts of urban heat or flooding and may help communities better bounce back from extreme events or reduce the effect of climate changes (The Nature Conservancy, 2024).

However, recent research has brought to light disparities in the distribution of nature-based infrastructure across urban social-ecological systems (Locke et al., 2021). For instance,

Table 2. Sustainability and environmental justice challenges and opportunities of Texas water policy, planning, and regulation.

Planning area	Characteristics/attributes	Opportunities for environmental justice and sustainability[a]	Challenges
All areas		• Greater consideration of input from stakeholders and scientists • Incorporation of climate change impacts in planning and funding decisions • Intentional incorporation of community experience into water planning	• Public participation challenges, including equitable information access, flexibility with finances and/or time, and transportation • Public participation challenges limit perspectives from residents most impacted by environmental justice • Equitable and sustainable infrastructure design • Better communication
State and regional water management	• Prior appropriation with some riparian rights for most rivers; Rio Grande adjudicated • Groundwater governed by rule of capture, managed by groundwater conservation districts, groundwater management areas, and special districts created to address subsidence, endangered species	• Public participation in the regional planning process • Consideration of environmental justice via prioritizing inclusion of communities with lived experience in meetings • Inclusion of sustainable water management techniques in state water plan	• Legal and physical water scarcity, i.e., who can access water and at what price • Rule of capture: unlimited groundwater use if one owns the land[b] • Subsidence: groundwater use can lower ground level for other residents, increase risk of flooding
Drought planning	• Texas's state water plan, regional plans • Drought contingency plans; state law requires public input • Drought Preparedness Council • Texas Division of Emergency Management bottled water delivery	• State law requires public input • Improved water management in agriculture • Incorporation of regional and local water planners	• Implementing and enhancing water conservation plans • Drought contingency plans not incorporated into state or regional water planning • Climate change not incorporated into drought planning • Lack of cohesive water monitoring at a state level; many localities have networks but do not communicate with one another or work together • Addressing soil moisture deficits
Flood planning	• Federal Emergency Management Agency (FEMA) mapping out of date, does not account for climate change impacts or land-use changes • Watershed Protection and Flood Prevention Act of 1954 • Flood Control Acts • National Dam Safety Program • Financial assistance via FEMA and U.S. Department of Housing and Urban Development • Texas Flood Infrastructure Fund • Texas Water Development Board flood plan	• Consideration of climate change impacts regarding flooding and extreme rain events, particularly for long-term planning and infrastructure projects	• FEMA mapping not available everywhere • Failure to consider climate change puts lives and property at risk

(Table 2 continued on next page)

(Table 2 continued)

Planning area	Characteristics / attributes	Opportunities for environmental justice and sustainability[a]	Challenges
Climate adaptation planning	• Plans discuss how to respond to impact of climate change	• Inclusion of environmental justice and sustainability in local climate planning • Incorporating needs of communities experiencing injustice • Incorporating sustainable water management techniques to address multiple climate impacts	• No state-level climate plan or accounting for climate change in state-level water planning efforts such as Texas's state water plan (though climate change is mentioned in regional plans) • Disconnect between policy makers and those most likely to be impacted by climate change • Designing infrastructure for extreme weather • Ensuring vulnerable residents receive alert communications • Access to potable water in emergency situations
Transboundary water management	• 1944 Water Treaty • Minute 325 water delivery from Mexico	• Consideration of surface-water–groundwater interactions • Definition of "extraordinary drought" • Ensuring adaptability to current uncertain climatic conditions • Stakeholder involvement at binational level	• Water conflicts every ~5 years since 1990 • Not enough water to meet Rio Grande Basin needs • Water stress from climate change, agriculture, and industrial demands • Allocation of water use priority • Water protests (e.g., in 2020 on Conchos River)

[a] These opportunities may exist in some cases but are not common across all political subdivisions or planning bodies.
[b] This assumes water ownership has not been severed from the land ownership.

Table 3. Environmental justice opportunities and challenges of sustainable water management strategies.

Sustainable water management strategy	Characteristics / attributes	Opportunities for environmental justice and sustainability	Challenges
Nature-based infrastructure	• Low impact development • Green infrastructure • Nature-based solutions	• Improved stormwater management, environmental quality, biodiversity, urban aesthetics, etc. • Inclusion of community members in design and planning • Crime reduction • Improved mental and physical wellbeing • Green job creation • Remediation/restoration of degraded sites • Flooding, erosion, and property damage reduction • Increased access to green space	• Maintaining equitable access to and benefits from nature-based infrastructure • Incorporating environmental justice data into design • Establishing shared understanding between communities and practitioners • Limiting gentrification brought on by upgraded greenspace • Need for additional scientific research • Lack of funding for installation and maintenance • Lack of understanding from practitioners or residents, lack of local knowledge from practitioners, lack of technical knowledge from residents
One Water	• Transcends traditional silos and disciplinary barriers • Aims to be integrated, inclusive, and sustainable	• Reduces redundancies, potentially reducing long-term infrastructure costs • Expands stakeholder input and incorporation of community voices • Optimizes for economic, environmental, and social benefits	• Requires long-term vision and extensive planning • Potential for higher up-front capital costs • Requires broad expertise to understand complex systems • Requires close coordination between municipal departments and across jurisdictions

some communities cannot access and benefit from the ecosystem services that nature-based infrastructure provides. Neighborhoods with high concentrations of underserved residents have a disproportionate lack of trees and other green space, which is one form of inequity (Locke et al., 2021; Schell et al., 2020). Depending on how funding is allocated, who participates in the decision and design process, and whether accurate data exists to inform planning and siting, nature-based infrastructure can privilege certain populations over others. Green gentrification is a significant concern in nature-based infrastructure planning. These improvements are intended to create positive outcomes, but they may raise property values, which can squeeze lower income residents out of their communities.

Despite these challenges, when nature-based infrastructure is thoughtfully implemented with equity and justice aims in mind, it can be highly beneficial. Nature-based infrastructure can help address inequities in disadvantaged communities that lack green space, are burdened by environmental contamination, have disproportionate health risks, or are vulnerable to climate hazards. Access to nature-based infrastructure improves residents' overall quality of life by giving them sustained connection to nature, regardless of their socioeconomic status. Biophilic interactions bolster social capital, physical health, and mental wellbeing (Dean et al., 2018). Additional benefits that people derive from nature-based infrastructure can include water and air purification, urban heat and flood mitigation, climate resilience, erosion control, reduced environmental contamination, enhanced biodiversity, improved access to green space, and/or the creation of green jobs.

To achieve long-term equitable outcomes when implementing nature-based infrastructure, as with other infrastructure, it is necessary to incorporate inclusive community-driven approaches to align planning and design. For example, nature-based infrastructure has been recommended alongside advocacy and planning to combat inequitable effects of land-use changes that disproportionately impact under-resourced communities (Zhu et al., 2021). Specifically, community science has been used to engage residents in the nature-based infrastructure project process. For instance, Hendricks et al. (2018) used participatory assessment techniques to engage researchers, planners, and residents in a neighborhood vulnerable to flooding to inform potential sustainable stormwater solutions. In another example in a flood prone community, located in proximity to industrial sites, residents evaluated their environmental conditions and determined that nature-based infrastructure could reduce pollutant loadings by 41% (Newman et al., 2020).

However, to best align nature-based infrastructure with environmental justice aims, further insight could be gained by applying socio-ecological systems thinking, technological advancements, adaptation policies, additional training, education, design standards, and inclusive community-driven planning approaches.

One Water

Given the complex and evolving challenges and demands that cities across the United States face, many of them have begun to consider a One Water approach to water management. This philosophy asserts that all water—stormwater, wastewater, drinking water, surface water, groundwater, sea water, etc.—has value and should be managed sustainably and inclusively (U.S. Water Alliance, 2016). It proposes that because waters are all interconnected, they should be managed as one system rather than multiple separate resources. It also purports that water challenges should be managed holistically. Similar to the older concept of integrated water resources management, One Water applies to both water quantity and water quality and can be applied at the watershed and larger scales. It also prioritizes inclusion and engagement that leads to clean, safe, reliable water for all users.

One Water encourages a unified planning and implementation approach that increases long-term resilience and reliability, meeting both community and ecosystem needs (Paulson et al., 2017). As a result, applying a One Water approach demands blurring the traditional boundaries between technical disciplines as well as between siloed municipal departments.

One Water initiatives also consider stressors resulting from climate change and intentionally involve all necessary partners and stakeholders in planning rather than including solely the traditional water decision-makers. One Water encourages a robust approach to engagement, which can create more opportunities for residents and community organizations to be involved in their water-planning processes. This emphasis on community engagement has increasingly aimed to incorporate voices from disadvantaged and underrepresented communities and to do so in a meaningful way (Cardone & Howe, 2018).

A growing number of Texas cities are gradually building momentum to implement One Water approaches. The idea of an approach that can achieve multiple benefits across economic, environmental, and social priorities—while also pushing for right-sized solutions for each community—is understandably appealing. It is also becoming a critically important risk management strategy. Notably, cities like Austin and New Braunfels have adopted the philosophy in their water-planning process, and Dallas and Houston are in the process of incorporating it as well (Texas Living Water Project, 2023).

Additional challenges to equitable One Water implementation include true representation among involved stakeholders, meaningful incorporation of diverse voices, and lasting engagement both during and after planning cycles. Developing and adequately maintaining stakeholder relationships is hard work. It is also vital, particularly when navigating questions of affordability and accessibility. Without this involvement, it is incredibly easy for technical expertise to drive decision-making or for familiar solutions to perpetuate the status quo.

Overall, One Water can be a helpful framework for integrating numerous goals and solutions across disciplines in complex communities. If done well, it can also be a key driver to achieving both sustainability and equity in Texas water issues.

However, there are important considerations to effectively implementing a One Water approach. While integrated water resources management can be adopted at any scale, many One Water efforts to date have been applied at the scale of individual cities, even if the waters flowing into and out of any single city are shared with surrounding communities. As a result, while departmental silos within a city government can be integrated in pursuit of One Water, it may still be difficult to avoid siloing between jurisdictions. Involving stakeholders from other jurisdictions in a One Water effort is extremely important, despite the inherent challenges.

While application of One Water and nature-based infrastructure can improve sustainability and equitable outcomes in water planning and infrastructure, environmental justice principles must be intentionally and actively incorporated to ensure these outcomes. The recommendations below apply to the application of One Water and nature-based infrastructure as well as to other planning and infrastructure changes.

RECOMMENDATIONS FOR ADDRESSING ENVIRONMENTAL JUSTICE AND SUSTAINABILITY

This section focuses on three actions necessary to address environmental justice issues:

1. prioritizing equity in government spending;
2. elevating community voice and participation; and
3. identifying and dismantling the cause of inequities.

All of these apply to Texas water infrastructure and policy. This section describes ways to address these three environmental justice actions in Texas and includes recommendations for improving water management to address environmental justice and sustainability in infrastructure and policy. A summary is provided in Table 4 at the end of the section.

Equity in Spending Government Funds

Environmental justice advocates prioritize equity in government spending on all fronts, including water infrastructure. Scholars such as Laura Pulido (2016) and Malini Ranganathan (2016) have highlighted how the Flint, Michigan, water crisis demonstrated the material impacts of systemic and intentional racism in water infrastructure spending. They outline how deliberate decisions to underfund and fail to maintain Flint's water system yielded contaminated water that created the Flint crisis. Furthermore, Hendricks and Van Zandt (2021) emphasize that people of color, low-income residents, and other underserved communities who experience the greatest impacts of climate change—particularly increased flooding—are not inherently vulnerable due to their identities. Rather, these communities exist within critical physical infrastructure systems that have been neglected and under-resourced. As the "father of environmental justice," Dr. Robert Bullard, stated, "An equity lens needs to be applied to how government funds are being spent, because inequities were built into the process of overcoming environmental injustice and this climate crisis … The equity lens has to be upfront. It is not something hidden, it is not a footnote. It is the framing by which monies are to be allocated and plans are to be made" (Bullard, 2020, p. 241).

An Example of Equitable Local Funding to Address Flooding in Texas

Harris County Thrives is a local Texas initiative which aims to promote equitable flood recovery to address the longstanding inequitable impacts of flooding. In 2018, the Harris County Flood Control District announced a $2.5 billion bond for flood resilience (Smith & Collier, 2018). Local organizations including the Coalition for Environment, Equity, and Resilience pushed for passage of a resolution to mandate that these funds be administered equitably, guided by a community flood resilience task force that included people with technical expertise and community knowledge (Harris County, 2022). At the time of the committee's establishment, the racial and ethnic diversity of its members proportionally represented the diversity of the community, and 60% of them lived or worked closely with flood-prone, low-income residents. Committee expertise included equity, social justice, flood risk, engineering, and environment and sustainability. Harris County Thrives now boasts over 200 local projects to reduce the impact of future flood events.

Major Federal Investment in Infrastructure and Environmental Justice

The federal government has made significant investment in infrastructure and environmental justice, particularly through the IIJA of 2021 and the IRA of 2022 and through policy actions such as Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," which announced the Justice40 initiative. Each bill established major funding sources or added to existing ones to increase spending on infrastructure, including on water and climate priorities. All funding must meet Justice40 requirements that at least 40% of the benefits of these investments must flow to "disadvantaged communities," a term used by the federal government to describe areas that experience inequities or have faced historic injustices (The White House, 2023).

The IIJA, better known as the Bipartisan Infrastructure Law, is a historic investment in drinking water and clean water infrastructure. It provides more than $50 billion to upgrade and maintain U.S. drinking water infrastructure, including $23.4 billion for the Drinking Water State Revolving Fund and the Clean Water State Revolving Fund, $15 billion to replace lead service lines, and $10 billion to address per- and polyfluoroalkyl substances (PFAS) and other emerging contaminants. EPA has developed national implementation guidance and tools to ensure that states receive the funds necessary to help communities with the greatest need.

In EPA Administrator Michael Regan's December 2021 letter to state governors, he urged states to "maximize the potential to remove barriers and prioritize the distribution of grant funds to disadvantaged communities" (Regan, 2021, p. 2). EPA has also publicly announced its commitment to providing technical assistance through its Thriving Communities Technical Assistance Centers to help remove frequent obstacles that often prevent small, rural, and low-income communities from accessing state revolving funds programs. The emphasis on helping disadvantaged communities access infrastructure funding aligns with President Biden's Justice40 initiative (The White House, 2021a). Additionally, the first of eight priority strategies in EPA's 2023 update to its Equity Action Plan is to "improve access to federal funding and assistance programs for communities with environmental justice concerns" (EPA, 2024, "Overview of the Equity Action Plan").

Texas is projected to receive $2.9 billion for water infrastructure from the IIJA through 2026 (The White House, 2021b). These funds will pass through the Clean Water State Revolving Fund (2010) and the Drinking Water State Revolving Fund (2010), administered by TWDB as authorized by state law. Texas's initial allotment in year 1 is $507,672,000, and at least 49% must be utilized as grants and fully forgivable loans. This represents an increase of more than $100 million in available funds from 2021 to 2022. In fiscal year 2021, TWDB advertised that between the Clean Water State Revolving Fund and the Drinking Water State Revolving Fund programs, it had at least $400 million available, including $58.6 million in principal loan forgiveness (TWDB, 2021). To encourage robust engagement in the state revolving fund programs, the IIJA scales the first 2 years of the state cost share/match from the standard 20% down to 10% and then resumes the 20% threshold in years 3–5.

The IRA is a historic investment in climate change mitigation and adaptation. It builds on the IIJA and the overall objectives of improving both the country's infrastructure and the lives of the most vulnerable among us. Like the IIJA, one of the IRA's many goals are to bring environmental justice to communities across the country that have often borne the brunt of pollution and degrading infrastructure (The White House, 2023). The IRA is also intended to help promote the Justice40 Initiative. IRA funds are earmarked for a variety of programs that help address water and equity, including:

- $1 billion for HUD's Green and Resilient Retrofit Program to provide owners of HUD-assisted multifamily properties with a variety of upgrades including projects to improve water efficiency and conduct water benchmarking.
- $550 million for Bureau of Reclamation projects "to provide domestic water supplies to disadvantaged communities or households that do not have reliable access to domestic water supplies" (Inflation Reduction Act of 2021, Sec. 50231).
- $12.5 million to "fund near-term drought relief actions to mitigate drought impacts for Indian Tribes affected by the operation of a Bureau of Reclamation water project, including water shortages, and to mitigate the loss of Tribal trust resources" (Inflation Reduction Act of 2021, (80004(a)).

It is important for historically underserved communities to have a voice in how these funds are spent and to be able to use funds to address previously identified equity disparities in sustainable water management.

Incorporating Community Voice

Elevating community voice and participation in the various levels of environmental governance is the second recommended method for improving environmental justice outcomes (Harris, 2017). Equal participation in environmental decisions has long been a pillar of environmental justice (Cole & Foster, 2001; Schlosberg, 2013; Walker, 2012). The seventh of the 17 environmental justice principles established at the First National People of Color Environmental Leadership Summit of 1991 states that "environmental justice demands the right to participate as equal partners at every level of decision-making, including needs assessment, planning, implementation, enforcement and evaluation" (First National People of Color Environmental Leadership Summit, 1991, 7th principle).

Scholars and activists focused on water infrastructure research have suggested that greater participation is needed in infrastructure planning and monitoring (Gharaibeh et al., 2021; Hendricks et al., 2018; Hughes et al., 2021). However, some scholars, such as Hughes et al. (2021) and Lynn (2017), have also argued that the conception of participation itself needs to be reevaluated and redefined. In their discussion of centering racial justice in urban flood policy and planning, Hughes et al. (2021) argue for the coproduction of knowledge and the co-ownership of planning between the community and practitioners. Some also suggest that government officials and other practitioners need to practice more community immersion—to learn about a group by spending time among them

(Lynn, 2017) and institutionalize representation—formalizing the inclusion of impacted communities in planning and decision-making roles (Hughes et al., 2021) to build trust and enhance equity between the community and practitioners.

Methods for Increasing Engagement in Water Infrastructure Planning

An approach that considers input from a variety of stakeholders is valuable, but representing all relevant groups within a community is a difficult task for community members. Participating in meetings on workdays requires the financial flexibility to sacrifice work hours, dependable transportation to meeting sites, and the ability to access and digest technical information presented. This can be a challenge for individuals with work or family constraints, particularly low-income residents. Thus, stakeholder participation may not adequately reflect the diverse composition and perspectives of an entire population. Some jurisdictions, such as Harris County, have attempted to address this gap and the historical lack of diversity in planning efforts. For example, the county has worked with the Coalition for Environment, Equity, and Resilience to develop a climate justice action plan with initial outreach focused on precincts that have historically experienced disparate impacts and are considered to be most vulnerable to climate disasters (Harris County, 2022). Further efforts are needed to enable equitable participation in public meetings.

Representation of impacted communities is important to ensure equitable decision-making, planning, and governance. Lack of community representation can lead to water insecurity issues (Berke et al., 1993), meanwhile communities represented in larger planning groups are more likely to be able to ability to recover and access post-disaster recovery funds (Berke et al., 1993). Mismatched boundaries between utility providers, a municipality, and decisions about water services can yield fragmentation in water governance. This fragmentation can result in exclusion of residents who do not have time to participate in multiple decision-making groups (Meehan et al., 2020; Pierce et al., 2019). More affluent or otherwise privileged residents who are able to participate benefit more from these processes (Meehan et al., 2020). For example, in South Texas, this type of network exclusion has led to decades of water insecurity (Vandewalle & Jepson, 2015). To avoid these negative impacts and ensure equitable and sustainable water management, it is imperative that impacted communities are invited to and engaged in decision-making processes, and that public participation is accessible for all who may want to participate, not just those who have previously been involved.

The National Association of Regulatory Utility Commissioners (McAdams, 2021) and the International Association for Public Participation have developed guides (e.g., the Spectrum of Public Participation) to help engage the public, providing similar suggestions for effective stakeholder engagement and involvement in projects. Some of their suggestions are included below.

First, the staff of the water planning entity (e.g., utility or agency) must determine how much engagement is needed and who needs to be engaged. The greater the amount of public engagement, the number of stakeholder groups, and the complexity of the project, the larger-scale a stakeholder process becomes. More engaged stakeholders require more of staff's time to listen to and incorporate their concerns. The benefit of increased engagement across multiple stakeholder groups is a higher likelihood of public support in communities who have not typically had their voice heard in the decision-making process. Because incorporating community voice into design is a key tenet of environmental justice, it is imperative to allocate enough staff to support sufficient community involvement.

It is challenging, yet vital, to ensure that the correct stakeholders are involved. To achieve this aim, it can be helpful to develop a list of local leaders who can help organizers reach all subgroups in the community, building trust with them and sharing the expectation that their voices will be heard and used to inform planning efforts. It can help build trust with the community to set up individual meetings with these leaders to discuss the project and explain the constraints, problems, and goals. It can also help to ask these leaders to talk about the project with their networks and explore whether they know other potential stakeholders can help build trust with the community. Providing educational information about projects at existing community meetings, block parties, or places where residents already gather can also help reach community members prior to project planning meetings.

It is important to determine the level of input needed from stakeholders, and the resources available to support them, especially when setting the project timeline and establishing job duties. As staff determine which type of engagement is best for the project, they should consider the following questions:

- Will there be one large public meeting to discuss project goals, possible solutions, proposed design(s), and gauge support? Or are multiple smaller meetings the best way to promote discussion?
- Will stakeholders be able to discuss concerns or support at these meetings?
- Will stakeholders have access to decision-makers, or will input be compiled and submitted to them for later review?
- Will stakeholders be asked to help define the problems to be solved, then help come up with solutions?

An initiative co-developed with community members, i.e., where they define the problem and collaborate with planners to co-develop solutions, requires more resources but ensures that the target community is involved and prioritized in the plan. This type of engagement is recommended to address historic or current injustices (Hughes et al., 2021). To get the best outcomes from stakeholder engagement, it is important not to develop the solutions before discussion has started. Many stakeholders are not exposed to the functions of daily water infrastructure tasks and are not aware of what measures have or have not worked. It will improve discussions throughout the process to take time at the outset to explain the issues that have led to the current problem and the type of input you want to receive from the stakeholder group(s).

In populations that have not historically participated in planning, various incentives can help alleviate barriers to participation. One method of increasing engagement is to hold city council, town hall, or community-led forums held in affected underserved neighborhoods, so participants do not have to travel during the workday. Providing childcare, transportation, and/or interpreters can reduce barriers for those with limited childcare or transportation options and those who are deaf or do not speak the language of the facilitators or planners. Additionally, providing food or compensation can incentivize low-income individuals to attend and signal a desire to include them. Providing a digital or hybrid participation option may also encourage additional attendance among those with mobility or other limitations to in-person participation.

Using an experienced facilitator that stakeholders perceive as neutral can help garner their trust and ensure that their opinions, needs, and desires are heard. It is common to choose an outside individual or organization to lead the engagement portion of the project; once this facilitator is determined, they will need to clearly define their role, establish ground rules, and develop goals for the engagement effort (McAdams, 2021).

While this section focuses on addressing the challenges of equitable in-person engagement, there are other methods of listening to and amplifying community voice. Survey research in particular allows for a variety of participants to weigh in on issues while eliminating the need for them to take off work, secure transportation, or overcome a reticence to speak publicly.

There are a number of recommendations that apply to any form of stakeholder engagement. Staff should provide instructions to community members on how to participate and how their input will be used. It is also important to set expectations with community members. Community input has historically often been a "rubber stamp" effort, so community members might not be used to the time required to develop a project from start to finish. It is imperative to listen to and incorporate respondents' concerns, including, at minimum, by repeating back what they say or writing it down on a group document or whiteboard. When staff is ready to offer ideas or solutions, they should explain how the solution incorporates stakeholders' input.

These recommendations focus on engaging stakeholders prior to and during water-related projects. However, it is important to continue to engage the community throughout the process, as well as after a project or effort is complete, to check whether solutions are meeting community needs or whether new issues arise. This kind of extended engagement can help community members build trust in their water and connection to their water supply. It can also change how they use water; for example, San Antonio Water System's continuous engagement with the public on water supply has contributed to its success in water conservation (Brown, 2017). Public education and awareness campaigns can also be used to develop interest that leads to more participation in the planning process. Increasing public participation and concern about water issues requires improved engagement at local, regional, and statewide levels of planning and development, particularly with underserved communities.

The Importance of Values and Messaging

Effective communication is as important as public participation in policy development. Planners, decision-makers, and policy makers must effectively communicate with impacted communities, both to inform and to encourage continued participation. In doing so, they must consider their messaging and understand community members' personal[15] and relational[16] values toward water as well as equity and sustainability considerations. Otherwise, despite any incentives to encourage participation, practitioners' underlying values and behaviors can create barriers to effectively communicating with a community (Lamm et al., 2015). Additionally, strategic communication of policies can more effectively minimize unintended adverse impacts when a range of community voice are heard and included in the process of environmental governance.

Communication is best received when the knowledge or information shared aligns with the values of the recipient. An understanding of these values becomes the foundation of how a strategic communicator may reach their audience. Understanding community members' attitudes is especially important for designing strategic communication efforts to increase public participation as part of policy assessment, planning, implementation, enforcement, and evaluation (Dozier et al., 2013). Successful campaigns to understand attitudes are advised to begin with focus groups, interviews, or surveys to determine the personal traits and characteristics that lie behind community members' attitudes, as well as their willingness to participate in governance and act in accordance with recommendations (Atkin & Freimuth, 2001; Floress et al., 2015; Rowe & Frewer, 2000).

[15] Beliefs held by an individual regarding water.

[16] Beliefs related to people's connection with water.

An understanding of relational values is critical to effective strategic communication. Relational values toward the environment are those values commonly held by social or cultural groups and connect resources to place. There are several types of relational values a community or individual can hold towards water. The instrumental value of water refers to when one regards water as a means to an end. The intrinsic value of water refers to how one positively appraises water regardless of any action they may take. The value of water equity is one person's evaluation of what is fair compared to their neighbor, especially when there is conflict over competing interests. The value of water resilience can involve valuing both past and future states, e.g., how to return to a previous water supply level, or how to adapt to water supply changes and address climatic conditions in the future (Elshall et al., 2020). If these values are shared across a specific population, they give a community a certain environmental consciousness that adds to unique individual, demographic, or socioeconomic factors (Bijani et al., 2019; Varua et al., 2017).

The ways that individuals and communities value water resources are as important as water equity and sustainability in effectively communicating about these issues. If a community's water-related values deteriorate over time, they may feel less connected to their water resources. If communicators seek to develop strategic messages about water scarcity, water pollution, or other water issues and positively impact public attitudes and behaviors, they should explore and understand how message factors (i.e., argument strategies) and audience characteristics (i.e., social and cultural identities and values among others) affect a community's perceptions about water (Callison & Holland, 2017; Graymore & Wallis, 2010). Failure to consider how these underlying factors are tethered to behaviors will be a barrier to effectively communicating with individuals in a community, regardless of any incentives to participation in the governance process (Lamm et al., 2015).

Attitudes and values related to water issues are slowly becoming an area of productive inquiry. Several studies explore the traits and values that researchers should consider when communicating with a community to encourage pro-environment attitudes and behavior change (Fielding et al., 2012; Quinn & Burbach, 2010; Semenza et al., 2008). Researchers recommend considering how community members' political ideology and past personal experience with water scarcity and pollution affect their attitudes and values (Callison & Holland, 2017). A recent meta-analysis of multiple surveys of Texas water user groups revealed a persistent set of attitudes and opinions among non-White communities around water affordability, the future of water availability, flooding, and water quality (Lopez et al., 2022). For example, a majority of non-White respondents to both online and in-person surveys expressed a distrust in water quality due to repeated experiences with boil-water notices and infrastructure failures (Lopez et al., 2022). This distrust translates into relatively higher valuation and usage of bottled water for consumption and household use. Further study of water attitudes and values among underserved communities in Texas will be critical for shaping strategic messaging and equitable outcomes.

Incorporating Lived Experience and Professional Experience in Water Management

Water management draws on available scientific and technical expertise, information from practitioners, and participation from water users. Sometimes there is a breakdown between the information communicated and water users' behavior, referred to as a communication gap (Nzau et al., 2018), or in the bidirectional communication between water users and practitioners.

To understand these communication gaps, it is important to investigate why they exist. Residents' generational or experiential knowledge may conflict with or be disconnected from information that practitioners convey. Residents' experience, or the information they have been told or understand as part of their culture or social network, may differ from the information practitioners share such that it limits the two groups' ability to understand each other and find common ground. Social and cognitive factors influence community perceptions of risk regarding the sustainability of a familiar resource. Individuals' and communities' experiences may have demonstrated that they and the resources are resilient to threats, which may contradict practitioner information and give them a false sense of control over potential adverse outcomes (McDowell et al., 2021).

Another reason for the communication gap is the lack of bidirectional information sharing. Practitioners may develop a water resources project before gaining empirical knowledge from water users and those impacted by a water policy (Olago, 2019). This can lead to the development of policies and approaches to management divorced from relevant communities' knowledge and input. Because impacted communities' actions can drive policy outcomes, this communication disconnect can lead to solutions that do not address the problem or rely on a technique that has previously failed. Effective communication of technical information should take into account a target community's social, economic, and cultural contexts, risk preferences, and lived experience, which is its own form of expertise. Closing (or at least narrowing) the communication gap requires soliciting, surveying, and including community experiences to provide guidance and direction for water policies and their implementation (Baldwin et al., 2012; Elshall et al., 2020). In addition, researchers should actively include community members in decision-making, co-design research objectives with community members experiencing inequities, and incorporate community members' expertise.

Identifying and Dismantling Causes of Inequities

In addition to equitable government spending and incorporating community voice, effective co-development of environmentally just and sustainable solutions requires identifying and dismantling the root causes of inequities (Hendricks & Van Zandt, 2021; Hughes et al., 2021). There are many examples of environmental inequities and injustices, several of which are outlined below.

Funding may be lacking to enforce environmental protection regulations and this may expose communities of color and other underrepresented communities to environmental injustices (Christian-Smith et al., 2012). Industrial and commercial developers may seek to buy the relatively more affordable property where people in these communities live. Underserved communities are less likely to have legal power, voice, or other means of engaging in political or rule-making processes, and often live in neighborhoods that have been systematically neglected, isolated, and under-resourced (Checker, 2011; Cole & Foster, 2001; Hendricks & Van Zandt, 2021). In Texas, this has been shown in the aforementioned examples of the colonias, Sandbranch, and Northridge Acres areas.

To help address these issues, environmental justice activists and advocates cite a need for community-based research that investigates links between causes and symptoms of water inequity. Potentially relevant research topics include wealth gaps, public health, water contamination, water and sewage leaks, exclusion of impacted communities from decision-making, and equity and justice in water governance and management (Geller et al., 2016). For example, in a community research initiative in Northeast Houston in 2021, community members served as primary sources and participated in evaluation of research results. The study drew on the knowledge and experiences of underserved communities on flood impacts, including fatalities, unlivable conditions, and mental anguish (Barrios et al., 2021). The research is being used to inform a neighborhood strategy for disaster preparedness.

Identifying and Dismantling Causes of Inequities: a Proposed Research Agenda

We present here a focused and inclusive research agenda to identify and dismantle causes of inequities associated with water and environmental justice.[17] For each investigation, we recommend application of the outlined actions through creation of a community of practice, including adopting community-based participatory research principles. This framework will help ensure that impacted communities and their representative leaders can be involved at every stage, including initiation and co-creation of research objectives, data collection, data analysis and co-generation of knowledge, communication of lessons learned to inform next steps, implementation, and measurement and verification (Minkler et al., 2012, Commodore et al., 2017). The framework will also give agency to communities that have been impacted by distributional and procedural environmental injustices.

Infrastructure degradation:

- How are cities being managed for key water metrics (e.g., systemic water leaks) for underserved communities?
- In what ways are these metrics reported to those communities?
- What technical and political challenges are keeping us from standardizing to best practices?

Water access:

- What are the fundamental economic and political drivers responsible for Texas's separate planning, policy and permitting related to surface water and groundwater?
- Instead of considering surface water and groundwater separately, what changes would be necessary to move toward a One Water management approach that would guarantee access for all residents?
- What opportunities exist for implementation of new water technologies that can deliver safe and affordable water to rural, unincorporated, and infrastructure-challenged communities?
- What economic conditions need to exist in order to deliver reliable water infrastructure to these communities?

Water affordability:

- What policy changes could help incentivize municipal water companies to institute policies or practices that provide affordable water rates and/or avoid water shutoff?
- What are the barriers for introduction of a statewide water conservation plan that includes prepayment for replacement of leaking or aged pipes and fixtures for low-income households?
- How can city planners mitigate elevated water use at the neighborhood level (such as for swimming pools, irrigation, etc.) by creating built-in conservation policies that reduce total water use and improve city-wide water affordability?

Water contamination:

- What policy and technology implementations are required to ensure that one user's decisions and behaviors do not impact water quality for other users, especially in the case of aquifer contamination in rural areas?
- What are the challenges to remediating existing and/or abandoned industrial pipelines near oil and gas exploration sites that are leaking and contaminating water, often near neighborhoods of color?

[17] This work assumes an institution is already actively dismantling inequities internally.

- What is needed to ensure that municipal and small-scale water systems can maintain quality and avoid prolonged boil-water requirements under future climate conditions and extreme weather events?
- What can be done to improve communication with underserved communities when a boil notice is issued?
- What proportion of underserved residences retain lead pipes, and what are the economic levers and opportunities to remediate the lead issue in those households?

Flooding and flood planning:

- What are the barriers and procedural inequities currently preventing impacted communities from the highest level of integration into the state flood planning program?

Drought planning:

- What do we need to know to maintain balance between individual water rights and industrial/agricultural concerns under future drought scenarios, especially in west Texas where soil moisture and aquifer recharge is projected to decrease drastically?

Water planning:

- What are barriers to incorporating historical, instrumental, and modeled climate data (as well as atmospheric and soil water budget projections) into state and city water planning, such that water security is guaranteed for all citizens under future climate conditions?
- To what extent can infrastructure solutions for underserved communities in one region be applied to others?
- What are the underlying geographic, geologic, socio-political, and institutional challenges associated with transferring knowledge of infrastructure solutions from one underserved area to another?
- In what ways will changing climate, expansive urbanization, and rapid population growth affect underserved communities who already suffer from other environmental justice issues related to water, such as urban heat island effects, reduced access to green spaces, reduced water affordability, increased flooding, and lack of communication during emergencies? How will these effects be manifested in West versus East Texas?

Nature-based infrastructure:

- What have we learned from applying nature-based infrastructure initiatives to extreme weather events to date? How can these lessons be strategically leveraged to maximize benefit to both the environment and at-risk communities across the state?
- What opportunities exist to design future green infrastructure that benefits the environment, human health, and socioeconomic wellbeing? Under what future climate conditions can all three be satisfied, and to what extent?

Equitable spending of government funds:

- What are the current barriers to equitable investment in communities?
- How can researchers help governments and other funders more equitably distribute funding or invest in sustainable and equitable infrastructure to address injustices?

Incorporating community voice and public awareness:

- What are the existing sustainability and environmental justice issues in Texas by city, region, biome, and demographic?
- Who are the key populations that need this information to make informed decisions about water concerns?
- What are the most effective ways to enhance community members' understanding of their water sources, access rights, and safety, as well as how their water is managed and how regulatory decisions are made, to enable them to contribute to solutions to current and future problems?
- What are the primary hurdles for educating underserved communities about environmental injustice so that they feel empowered to engage policy makers? What are the primary hurdles for underserved communities to engage and inform their policy makers about environmental injustice?
- What resources are needed to inform underserved communities about the health risks associated with increasingly extreme weather and give them agency to address their specific challenges, especially in low-lying communities where population influx and gentrification increase susceptibility to flooding?
- What are the current barriers to incorporating best practices that encourage equitable public participation and improve representation in decision-making? How can researchers help governments better engage, inform, and empower their communities?

For each of the categories above, researchers should consider optimal ways to collect information, how to ensure that information is updated, and how frequently to update information. Collectively, these lines of inquiry will foster learning and growth opportunities among practitioners and community members, and help establish an authoritative knowledge base on environmental justice and water security in Texas from which to engage decision-makers.

Table 4. Areas of need to enhance environmental justice.

Key environmental justice area of need	Examples	Recommendations for ensuring justice and sustainability in Texas water resource infrastructure and policy
Equity in spending of government funds	• Major infrastructure funding included in the Infrastructure Investment and Jobs Act and Inflation Reduction Act, including climate and environmental justice provisions • Prioritization of community voice in funding allocation, e.g., as in the example of Harris County Thrives	• Prioritize allocation of funds to communities currently vulnerable to environmental injustices and communities that will become vulnerable to climate risks • Ensure transparency in funding allocations
Incorporating community voice and participation in decision-making process	• Forums held in underserved neighborhoods • Community engagement efforts provide childcare, food, interpreters, and/or other services that reduce barriers to attendance for underserved communities	• Policy makers, regulators, practitioners, and other specialists listen to and incorporate community members' lived experiences in research and planning • Community engagement prioritizes accessibility for all, especially groups that experience injustice or have been disenfranchised
Identifying and dismantling causes of inequities	• Neighborhoods lack access to clean drinking water or adequate drainage • Neighborhoods have a disproportionate number of waste disposal sites or wastewater discharges	• Partnering with disproportionately impacted communities to co-create water research projects and implement sustainable and just solutions

CONCLUSION

Despite state and federal environmental justice initiatives in the last half century, there is much to be done to improve water equity in underserved communities in Texas. In addition to widespread water access, affordability, and contamination issues affecting communities of color, the impacts of climate change and rapid population growth will compound the existing burdens on the state's water infrastructure. Without significant intervention, vulnerable communities will experience worsening environmental injustice and water insecurity in the future.

Texas leads the nation in number and economic cost of natural disasters. Affluent, White communities have disproportionally benefited from disaster relief funding and the resulting climate adaptation and mitigation policies. To meaningfully achieve equitable water outcomes in Texas, we recommend that water practitioners commit to the following:

- Thoroughly understanding Texas water equity issues, including, for each city: who is most affected; what remedies have been attempted; and what outcomes resulted. To help achieve this goal, in the section Identifying and Dismantling Causes of Inequities: a Proposed Research Agenda on page 127, we propose a 7–10-year research prospectus to further identify and begin to dismantle causes of water inequities in Texas. Research topics focus on climate change, flooding, and drought, as well as water access, affordability, and infrastructure.
- Consider incorporating historic and modeled climate change data in the 50-year water plan rather than using the drought of record as the primary benchmark for water scarcity. While planning groups may consider regional drought periods that are drier than the statewide historic drought of record (TWDB, 2021), there remains a dearth of planning climate model projections or pre-20th century historical climate reconstructions incorporated into water planning. Only when we account for the full range of potential water availability conditions and their projected impacts on vulnerable communities can water equity issues be appropriately mitigated before they occur.
- Engaging community leaders at the beginning of any research or water planning efforts, as well as before creating or amending water policies and regulations. Community experience and knowledge must become part of the fabric of state and regional water management, structuring drought and flood planning, climate adaptation planning, and transboundary water management. Only when community perspectives are incorporated from project inception onwards can we evolve beyond historical exclusion and implement sustainable and just solutions. We acknowledge that this represents a paradigm shift and will require enormous effort at all levels. To facilitate this shift, in the section Incorporating Community Voice on page 123, we have provided a detailed outline of best practices for equitable engagement and incorporation of community voices into decision making. We strongly recommend that decision makers, planners, and researchers prioritize

adopting these best practices in all future management, policy, and planning decisions.

- Identifying and mitigating the full range of water equity challenges in state and city-level infrastructure planning and management. This will involve acknowledging disparities in water access, affordability, contamination; communicating appropriately about all three; addressing implications of infrastructure deterioration; and incorporating nature-based infrastructure and One Water principles whenever possible. Applying these recommendations will help make water infrastructure more sustainable and improve water equity among underserved residents.
- Developing and adopting state-level climate action, adaptation, and sustainable development plans in collaboration with underserved communities. Plans should build on existing city-level plans, and address lessons learned during their development, to streamline workflow and ensure systematic integration of community knowledge.

ACKNOWLEDGMENTS

This paper resulted from the collective efforts of Texas Water Research Network members. Support for the Texas Water Research Network was provided by the Cynthia and George Mitchell Foundation. This work was a collaboration among independent researchers; any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of their employers. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Finally, the authors would like to thank Maya Velis and Sequoia Riley for their review of this manuscript.

REFERENCES

Additional requirement: Drought contingency plans for certain applicants and water right holders, 2 Texas Water Code, § 11.1272 (1997). https://statutes.capitol.texas.gov/Docs/WA/htm/WA.11.htm#11.1272

Amirhadji, J., Burcat, L., Halpert, S., Lam, N., McAleer, D., Schur, C., Smith, D., & Sperling, E. (2013). *Tapped out: Threats to the human right to water in the urban United States. Georgetown Law Human Rights Institute.* https://scholarship.law.georgetown.edu/hri_papers/7

Anderson, M. W. (2007). Cities inside out: Race, poverty, and exclusion at the urban fringe. *UCLA Law Review, 55,* 1095.

American Rescue Plan Act of 2021, Pub. L. No. 117-2. (2021). https://www.govinfo.gov/app/details/PLAW-117publ2

American Society of Civil Engineers. (2020, August 8). *Chronic underinvestment in America's water infrastructure puts the economy at risk.* https://www.asce.org/publications-and-news/civil-engineering-source/society-news/article/2020/08/26/chronic-underinvestment-in-americas-water-infrastructure-puts-the-economy-at-risk

American Society of Civil Engineers. (2021). *2021 report card for America's infrastructure.* https://infrastructurereportcard.org/

Atkin, C. K., & V. S. Freimuth. (2001). Formative evaluation research in campaign design. In R. E. Rice & C. K. Atkin (Eds.), *Public Communication Campaigns* (3rd ed.). SAGE Publications.

Austin Water. (2012, October). Water use management strategy: The Austin water block leader program. https://www.austintexas.gov/sites/default/files/files/Water/Conservation/Block%20Leader%20OCT.pdf

Austin Water. (2018). *A water plan for the next 100 years.* https://www.austintexas.gov/department/water-forward

Ayala, E. (2019, March 21). Texas schools have dangerous levels of lead in drinking water, advocates say. *Dallas Morning News.* https://www.dallasnews.com/news/education/2019/03/21/texas-schools-have-dangerous-levels-of-lead-in-drinking-water-advocates-say/

Balazs, C. L., & Ray, I. (2014). The drinking water disparities framework: On the origins and persis-tence of inequities in exposure. *American Journal of Public Health, 104*(4), 603–611. https://doi.org/10.2105/AJPH.2013.301664

Baldwin, C., Tan, P.-L., White, I., Hoverman, S., & Burry, K. (2012). How scientific knowledge informs community understanding of groundwater. *Journal of Hydrology, 474,* 74–83. https://doi.org/10.1016/j.jhydrol.2012.06.006

Banner, J. L., Black, B. A., & Tremaine, D. M. (2024). Positive unintended consequences of urbanization for climate-resilience of stream ecosystems. *npj Urban Sustainability, 4*(1), 16.

Barrios, A., Brown, D., & Hirsch, B. (2021). *Learning from disaster survivors to improve resilience.* National Academy of Sciences Gulf Coast Resiliency Program. https://docs.google.com/document/d/e/2PACX-1vSZp0EXCIW0hcHX2AqGrrOlSmvpn2RAtNf6fXlxOKEI_cY1_yjdCtM5Rodsfv5lYyHuH3sl2E0B2Fw9/pub

Barron, M. (2017). Remediating a sense of place: Memory and environmental justice in Anniston, Alabama. *Southeastern Geographer, 57*(1), 62–79. https://doi.org/10.1353/sgo.2017.0006

Beal, L., Senison, J., Banner, J. L., Musgrove, M., Yazbek, L., Bendik, N., Herrington, C., & Reyes, D. (2020). Stream and spring water evolution in a rapidly urbanizing watershed, Austin, TX. *Water Resources Research, 56*(4), e2019WR025623. https://doi.org/10.1029/2019WR025623

Berg, M. (2020). State legislature, voters moves to eighty-six Texas's flooding challenges. *Texas Water Journal, 11*(1), 1–14. https://doi.org/10.21423/twj.v11i1.7101

Berke, P. R., Kartez, J., & Wenger, D. (1993). Recovery after disaster: achieving sustainable development, mitigation and equity. *Disasters, 17*(2), 93–109. https://doi.org/10.1111/j.1467-7717.1993.tb01137.x

Bijani, M., Ghazani, E., Valizadeh, N., & Fallah Haghighi, N. (2019). Predicting and understanding farmers' soil conservation behavior in Mazandaran Province, Iran. *Journal of Agricultural Science and Technology, 21*(7), 1705–1719. http://jast.modares.ac.ir/article-23-20838-en.html

Bixler, R. P., Yang, E., Richter, S. M., & Coudert, M. (2021). Boundary crossing for urban community resilience: A social vulnerability and multi-hazard approach in Austin, Texas, USA. *International Journal of Disaster Risk Reduction, 66,* 102613. https://doi.org/10.1016/j.ijdrr.2021.102613

Brannen, J. (2023). After census redefines urban and rural, Texas remains steadfastly both. Kinder Institute for Urban Research. https://kinder.rice.edu/urbanedge/census-redefines-urban-rural

Brown, M. J., Raymond, J., Homa, D., Kennedy, C., & Sinks, T. (2011). Association between children's blood lead levels, lead service lines, and water disinfection, Washington, DC, 1998–2006. *Environmental Research, 111*(1), 67–74. https://doi.org/10.1016/j.envres.2010.10.003

Brown, F. L., & Ingram, H. (1987). The community value of water: Implications for the rural poor in the Southwest. *Journal of the Southwest, 29*(2), 179–202. https://www.jstor.org/stable/40169561

Brown, K. P. (2017). Water, water everywhere (or, seeing is believing): The visibility of water supply and the public will for conservation. *Nature and Culture, 12*(3), 219-245. https://www.jstor.org/stable/pdf/26430644.pdf?casa_token=PLig_6V6bs0AAAAA:pvatP4aRVfFxapz2Vq8MSvFS3HzwzySNulPe_fj06ISE3gUeuI--ZMOfnH1dz59iEjRzbpN3t4zqnVmzla5aFtqXEYHErtMIdABjRHjcKq5JSRE8tg

Bullard, R. (1983). Solid waste sites and the Black Houston community. *Sociological Inquiry, 53*(2-3), 273–288. https://doi.org/10.1111/j.1475-682X.1983.tb00037.x

Bullard, R. (2020). Addressing environmental racism. *Columbia Journal of International Affairs.* https://jia.sipa.columbia.edu/news/addressing-environmental-racism

Callison, C., & Holland, D. (2017). Impact of political identity and past crisis experience on water attitudes. *Journal of Contemporary Water Research & Education, 161,* 19–32. https://doi.org/10.1111/j.1936-704X.2017.3249.x

Cambridge Systematics, Inc. (2015). *Central Texas extreme weather and climate change vulnerability assessment of regional transportation infrastructure.* Capital Area Metropolitan Planning Organization & City of Austin Office of Sustainability. https://www.austintexas.gov/sites/default/files/files/CAMPO_Extreme_Weather_Vulnerability_Assessment_FINAL.pdf

Cardone, R., & Howe, C. (2018). *Advancing One Water in Texas.* The Cynthia & George Mitchell Foundation. https://cgmf.org/graphics/cgmf_one_water_report_02_14_18_final.pdf

Chakraborty, J., Collins, T. W., Montgomery, M. C., & Grineski, S. E. (2014). Social and spatial inequities in exposure to flood risk in Miami, Florida. *Natural Hazards Review, 15*(3), 04014006. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000140

Chakraborty, J., Collins, T. W., & Grineski, S. E. (2019). Exploring the environmental justice implications of Hurricane Harvey flooding in Greater Houston, Texas. *American Journal of Public Health, 109*(2), 244–250. https://doi.org/10.2105/AJPH.2018.304846

Checker, M. (2011). Wiped out by the "greenwave": Environmental gentrification and the paradoxical politics of urban sustainability. *City & society, 23*(2), 210-229.Christian, L. N., Banner, J. L., & Mack, L. E. (2011). Sr isotopes as tracers of anthropogenic influences on stream water in the Austin, Texas, area. Chemical Geology, 282(3–4), 84–97.

Christian, L. N., Banner, J. L., & Mack, L. E. (2011). Sr isotopes as tracers of anthropogenic influences on stream water in the Austin, Texas, area. *Chemical Geology, 282*(3–4), 84–97.

Christian-Smith, J., Gleick, P. H., Cooley, H., Allen, L., Vanderwarker, A., & Berry, K. A. (2012). *A twenty-first century US water policy.* Oxford University Press.

Christian-Smith, J., Balazs, C., Heberger, M., & Longley, K. (2013). *Assessing water affordability: A pilot study in two regions of California. Oakland, CA.* Pacific Institute. https://pacinst.org/wp-content/uploads/2013/08/assessing-water-affordability-1.pdf

City of Austin. (2014, May 1). *Toward a climate-resilient Austin—A report in response to City Council Resolution 20131121-060.* https://austintexas.gov/sites/default/files/files/Sustainability/Climate/Toward_a_Climate_Resilient_Austin.pdf

City of Austin. (2018a, April). *Climate resilience action plan for city assets and operations.* https://www.austintexas.gov/sites/default/files/files/Sustainability/Climate_Resilience_Action_Plan.compressed.pdf

City of Austin. (2018b). *Imagine Austin comprehensive plan.* https://www.austintexas.gov/sites/default/files/files/Imagine_Austin/IACP_2018.pdf

City of Austin. (2021). *Austin climate equity plan summary.* https://www.austintexas.gov/sites/default/files/files/Sustainability/Climate%20Equity%20Plan/Climate%20Plan%20Full%20Document__FINAL.pdf

City of Dallas. (2020, April). *Dallas comprehensive environmental and climate action plan.* https://27aabd9a-6024-4b39-ba78-f6074e2fc631.filesusr.com/ugd/349b65_38f32c6b85ae4b20b67b79ecb5b0b106.pdf

City of Dallas. (2017). *Resilient Dallas.* https://dallascityhall.com/_layouts/download.aspx?SourceUrl=/departments/pnv/resilient_dallas/DCH%20Documents/Resilient-Dallas-Strategy-Reduced-PDF.pdf

City of El Paso. (2008). *Livable city sustainability plan.* https://uccrnna.org/wp-content/uploads/2017/06/45_El-Paso_2008_Liveable-City-Sustainability-Plan.pdf

City of Houston. (2020a). *Houston climate action plan.* http://greenhoustontx.gov/climateactionplan/CAP-April2020.pdf

City of Houston. (2020b). *Resilient Houston.* https://www.houstontx.gov/mayor/Resilient-Houston-20200402-single-page.pdf

City of San Antonio. (2016, August 11). *Sustainability plan.* https://www.sanantonio.gov/Portals/0/Files/Sustainability/SATomorrowSustainabilityPlan.pdf

City of San Antonio. (2019, October 17). *SA climate ready—a pathway for climate action & adaptation.* https://www.sanantonio.gov/Portals/0/Files/Sustainability/SAClimateReady/SACRReportOctober2019.pdf

Clean water state revolving fund, 31 Tex. Admin. Code § 375 (2010). https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=31&pt=10&ch=375

Cole, L. W., & Foster, S. R. (2001). *From the ground up: Environmental racism and the rise of the environmental justice movement.* NYU Press.

Collins, G. (2021). *Overruling the rule of capture: What can Texas learn from 10 other states' groundwater law updates?* Rice University's Baker Institute for Public Policy. https://doi.org/10.25613/knsb-6g39

Collins, T. W., Grineski, S. E., Chakraborty, J., & Flores, A. B. (2019). Environmental injustice and Hurricane Harvey: A household-level study of socially disparate flood exposures in Greater Houston, Texas, USA. *Environmental Research, 179*(A), 108772. https://doi.org/10.1016/j.envres.2019.108772

Commodore, A., Wilson, S., Muhammad, O., Svendsen, E., & Pearce, J. (2017). Community-based participatory research for the study of air pollution: a review of motivations, approaches, and outcomes. *Environmental Monitoring and Assessment, 189,* 378. https://doi.org/10.1007/s10661-017-6063-7

Congressional Research Service (2019). Flood Resilience and Risk Reduction: Federal Assistance and Programs. https://crsreports.congress.gov/product/pdf/R/R45017

Conserve Travis County. (2020). Travis County climate action plan. Travis County. https://www.traviscountytx.gov/images/tnr/Docs/conserve/climate-action-plan.pdf

Cook, B. I., Ault, T. R., & Smerdon, J. E. (2015). Unprecedented 21st century drought risk in the American Southwest and Central Plains. *Science Advances, 1*(1), e1400082. https://doi.org/10.1126/sciadv.1400082

Cornwell, D. A., Brown, R. A., & Via, S. H. (2016). National survey of lead service line occurrence. *Journal AWWA, 108*(4), E182–E191. https://doi.org/10.5942/jawwa.2016.108.0086

Council on Environmental Quality. (2023). *Climate and economic justice screening tool.* https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5

Dean, J. H., Shanahan, D. F., Bush, R., Gaston, K. J., Lin, B. B., Barber, E., ... & Fuller, R. A. (2018). Is nature relatedness associated with better mental and physical health?. *International journal of environmental research and public health, 15*(7), 1371.

Deitz, S., & Meehan, K. (2019). Plumbing poverty: Mapping hot spots of racial and geographic inequality in U.S. household water insecurity. *Annals of the American Association of Geographers, 109*(4), 1092–1109. https://doi.org/10.1080/24694452.2018.1530587

DeMyers, C., Warpinski, C., & Wutich, A. (2017). Urban water insecurity: A case study of homelessness in Phoenix. *Arizona. Environmental Justice, 10*(3), 72–80. https://doi.org/10.1089/env.2016.0043

Dozier, D. M., Grunig, L. A., & Grunig, J. E. (2013). *Manager's guide to excellence in public relations and communication management.* Routledge.

Drinking water state revolving fund, 31 Tex. Admin. Code § 371 (2010). https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=31&pt=10&ch=371

Drought contingency plans for municipal uses by public water suppliers, 30 Tex. Admin. Code § 288.20 (1999). https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=288&rl=20

Drought response plan, 2 Tex. Water Code § 16.055 (1977). https://statutes.capitol.texas.gov/Docs/WA/htm/WA.16.htm#16.055

Eagly, A. H, & Chaiken, S. (1993). *The psychology of attitudes.* Harcourt Brace Jovanovich College Publishers.

Elshall, A. S., Arik, A. D., El-Kadi, A. I., Pierce, S., Ye, M., Burnett, K. M., Wade, C., Bremer, L., & Chun, G. (2020). Groundwater sustainability: A review of the interactions between science and policy. *Environmental Research Letters, 15*(9), 093004. https://doi.org/10.1088/1748-9326/ab8e8c

Emrich, C. T., Tate, E., Larson, S. E., & Zhou, Y. (2020). Measuring social equity in flood recovery funding. *Environmental Hazards, 19*(3), 228–250. https://doi.org/10.1080/17477891.2019.1675578

Exec. Order No. 12898, 3 C.F.R. 276 (1994). https://www.govinfo.gov/content/pkg/WCPD-1994-02-14/pdf/WCPD-1994-02-14-Pg276.pdf

Essoka, J. D. (2010). The gentrifying effects of brownfields redevelopment. *Western Journal of Black Studies, 34*(3), 299–315. https://www.proquest.com/openview/aa859cb6e0ab93d88c28b8be65abab4e/1?pq-origsite=gscholar&cbl=47709

Fazel, S., Geddes, J. R., & Kushel, M. (2014). The health of homeless people in high-income countries: Descriptive epidemiology, health consequences, and clinical and policy recommendations. *The Lancet, 384*(9953), 1529–1540. https://doi.org/10.1016/S0140-6736(14)61132-6

Federal Emergency Management Agency. (2022). *Dam safety.* https://www.fema.gov/emergency-managers/risk-management/dam-safety

Fielding, K. S., Russell, S, Spinks, A., & Mankad, A. (2012). Determinants of household water conservation: The role of demographic, infrastructure, behavior, and psychosocial variables. *Water Resources Research, 48*(10), W10510. https://doi.org/10.1029/2012WR012398

First National People of Color Environmental Leadership Summit. (1991). *The principles of environmental justice.*

Flavelle, C., Lu, D., Penney, V., Popovich, N., & Schwartz, J. (2020, June 29). New data reveals hidden flood risk across America. *The New York Times.* https://www.nytimes.com/interactive/2020/06/29/climate/hidden-flood-risk-maps.html

Floress, K., Akamini, K., Halvosen, K. E., Kozich, A.T., & Davenport, M. (2015). The role of social science in successfully implementing watershed management strategies. *Journal of Contemporary Water Research and Education, 154*(1), 85–105. https://doi.org/10.1111/j.1936-704X.2015.03189.x

Fry, M., Briggle, A., & Kincaid, J. (2015). Fracking and environmental (in)justice in a Texas city. *Ecological Economics, 117,* 97–107. https://doi.org/10.1016/j.ecolecon.2015.06.012

Garcia-Fresca, B., & Sharp, J. M. (2005). Hydrogeologic considerations of urban development: Urban-induced recharge. In Ehlen, J., Haneberg, W. C., & Larson, R. A. (Eds.), *Reviews in engineering geology: Humans as geologic agents* (Vol. 16., 123–136). The Geological Society of America. https://doi.org/10.1130/2005.4016(11)

Geller, A. M., Breville, M., Eisenhauer, E., Sikes, K., Fulk, F., Quackenboss, J., Zartarian, V., Hauchman, F., Washburn, E., Jarabek, A., Lee, C., Manibusan, M., Oxendine, S., Snyder, E., & Williams, K. (2016). *Environmental justice research roadmap.* U.S. Environmental Protection Agency. https://www.epa.gov/sites/default/files/2017-01/documents/researchroadmap_environmentaljustice_508_compliant.pdf

Georgescu, M., Broadbent, A. M., Wang, M., Krayenhoff, E. S., & Moustaoui, M. (2021). Precipitation response to climate change and urban development over the continental United States. *Environmental Research Letters, 16*(4), 044001. https://doi.org/10.1088/1748-9326/abd8ac

Gharaibeh, N., Oti, I., Meyer, M., Hendricks, M., & Van Zandt, S. (2021). Potential of citizen science for enhancing infrastructure monitoring data and decision-support models for local communi-ties. *Risk Analysis, 41*(7), 1104–1110. https://doi.org/10.1111/risa.13256

Gholson, D. M. (2017). *A survey of public perception and attitudes about water resources in Texas* [Doctoral dissertation, Texas A&M University]. OAKTrust. https://hdl.handle.net/1969.1/161464

Glazer, Y. R., Tremaine, D. M., Banner, J. L., Cook, M., Mace, R. E., Nielsen-Gammon, J., Grubert, E., Kramer, K., Stoner, A.M., Wyatt, B.M., Mayer, A..& Webber, M. E. (2021). Winter storm Uri: a test of Texas' water infrastructure and water resource resilience to extreme winter weather events. *Journal of Extreme Events, 8*(04), 2150022.

Graymore, M. L., & Wallis, A. M. (2010). Water savings or water efficiency? Water-use attitudes and behaviour in rural and regional areas. *International Journal of Sustainable Development & World Ecology, 17*(1), 84–93. https://doi.org/10.1080/13504500903497249

Grigg, N. (2019). Aging water infrastructure in the United States. In P. Juuti, H. Mattila, R. Rajala, K. Schwartz, & C. Staddon (Eds.), *Resilient water services and systems: The foundation of well-being* (pp. 31–46). London: IWA Publishing. https://doi.org/10.2166/9781780409771

Harris, U. S. (2017). Engaging communities in environmental communication. *Pacific Journalism Review, 23*(1), 65-79. https://search.informit.org/doi/abs/10.3316/INFORMIT.959987755953658

Harris County. (2022). *Community flood resilience task force.* https://cfrtf.harriscountytx.gov/

Harris County (2023). Harris County's Climate Action Plan for Internal Operations: An Interdepartmental Emissions Reduction Strategy. https://oca.harriscountytx.gov/Portals/oca/Documents/Harris_County_Climate_Action_Plan_for_Internal_Operations_2023_Final_For_Web_Email.pdf?ver=Ovggl92pnikMJY27Ywk0CA%3d%3d

Hendricks, M. D., Meyer, M. A., Gharaibeh, N. G., Zandt, S. Van, Masterson, J., Horney, J. A., & Berke, P. (2018). The development of a participatory assessment technique for infrastructure: Neighborhood-level monitoring towards sustainable infrastructure systems. *Sustainable Cities and Society, 38,* 265–274. https://doi.org/10.1016/j.scs.2017.12.039

Hendricks, M. D., & Van Zandt, S. (2021). Unequal protection revisited: Planning for environmental justice, hazard vulnerability, and critical infrastructure in communities of color. *Environmental Justice, 14*(2), 87–97. https://doi.org/10.1089/env.2020.0054

Hirsch, B., Selle, B., Brown, D., Liu, A., Moses, M., Awais, M., Tristan, M., Weston, A., Hurtado, H., Mundra, V., & Villarreal, M. (2021, December). *Survivors as experts: A community evaluation of disaster recovery in Northeast Houston* (Working Paper #110). Natural Hazards Center, University of Colorado Boulder. https://www.weststreetrecovery.org/wp-content/uploads/2021/12/WSR_SurvivorsAsExperts_MainReport.pdf

Holifield, R. (2004). Neoliberalism and environmental justice in the United States environmental protection agency: Translating policy into managerial practice in hazardous waste remediation. *Geoforum, 35*(3), 285–297. https://doi.org/10.1016/j.geoforum.2003.11.003

Houston Advanced Research Center. (2022). *Spatially averaged timeseries climate indicators.* https://harcresearch.sharefile.com/d-s9b0eec89a4cc4796bb3ab8b6a3dedfbd

Houston-Galveston Area Council. (2008). *Foresight panel on environmental effects.* https://www.h-gac.com/getmedia/cae37b16-f1a2-4113-849f-96f3fb4708de/foresight_panel_on_environmental_effects_report.pdf

Hughes, S., Dobie, S., Schwarz, K., LaMarr LeMee, G., Lane, M., & Gonzalez, A. (2021). Centering racial justice in urban flood resilience policy and planning: Tools for practitioners. *Environmental Justice, 15*(2), 83–89. https://doi.org/10.1089/env.2021.0045

Inflation Reduction Act of 2022, Pub. L. No. 117-169 (2022). https://www.govinfo.gov/app/details/BILLS-118hr812ih

International Boundary and Water Commission. (2020, October 21). *Minute 325. Measures to end the current Rio Grande water delivery cycle without a shortfall, to provide humanitarian support for the municipal water supply for Mexican communities, and to establish mechanisms for future cooperation to improve the predictability and reliability of Rio Grande water deliveries to users in the United States and Mexico.* https://www.ibwc.gov/wp-content/uploads/2023/05/RG_Update_Newsletter_051923.pdf

Jarvis, G. (1991, April). *The Rio Grande from Ft. Quitman to the Gulf—Water rights and needs in the Lower Rio Grande* [Seminar]. Laws of the Rio Grande del Norte—An Interstate Seminar, Albuquerque, NM, United States.

Jepson, W. (2012). Claiming space, claiming water: Contested legal geographies of water in South Texas. *Annals of the Association of American Geographers, 102*(3), 614–631. https://doi.org/10.1080/00045608.2011.641897

Jepson, W. (2014). Measuring 'no-win' waterscapes: Experience-based scales and classification approaches to assess household water security in colonias on the US–Mexico border. *Geoforum, 51,* 107–120. https://doi.org/10.1016/j.geoforum.2013.10.002

Jepson, W., & Brown, H. L. (2014). 'If no gasoline, no water': Privatizing drinking water quality in South Texas Colonias. *Environment and Planning A: Economy and Space, 46*(5), 1032–1048. https://doi.org/10.1068/a46170

Jepson, W., & Vandewalle, E. (2016). Household water insecurity in the global north: A study of rural and periurban settlements on the Texas–Mexico border. *The Professional Geographer, 68*(1), 66–81. https://doi.org/10.1080/00330124.2015.1028324

Jepson, W. E., Wutich, A., Colllins, S. M., Boateng, G. O., & Young, S. L. (2017). Progress in household water insecurity metrics: a cross-disciplinary approach. *Wiley Interdisciplinary Reviews: Water, 4*(3), e1214. https://doi.org/10.1002/wat2.1214.

Kenney, E. L., Daly, J. G., Lee, R. M., Mozaffarian, R. S., Walsh, K., Carter, J., & Gortmaker, S. L. (2019). Providing students with adequate school drinking water access in an era of aging infra-structure: A mixed methods investigation. *International Journal of Environmental Research and Public Health, 17*(1), 62. https://doi.org/10.3390/ijerph17010062

Kloesel, K., Bartush, B., Banner, J., Brown, D. P., Lemery, J., Lin, L., Loeffler, C., McManus, G., Mullens, E., Nielsen-Gammon, J., Shafer, M., and Ziolkowska, J. (2018). Southern Great Plains. *USDA Publication, 1343*(2), 978-1026.

Lamm, K. W., Lamm, A. J., & Carter, H. S. (2015). Bridging water issue knowledge gaps between the general public and opinion leaders. *Journal of Agricultural Education, 56*(3), 146–161. https://doi.org/10.5032/jae.2015.03146

Lazere, E. (2021, November 29). *How states can best use federal fiscal recovery funds: Lessons From state choices so far.* Center on Budget and Policy Priorities.

Lerner, D. N. (1986). Leaking pipes recharge ground water. *Groundwater, 24*(5), 654–662. https://doi.org/10.1111/j.1745-6584.1986.tb03714.x

Locke, D. H., Hall, B., Grove, J. M., Pickett, S. T. A., Ogden, L. A., Aoki, C., Boone, C. G., & O'Neil-Dunne, J. P. (2021). Residential housing segregation and urban tree canopy in 37 US Cities. *Urban Sustainability, 1*(15). https://doi.org/10.1038/s42949-021-00022-0

Lopez, A., Lopez, R., Alonzo, A., Crawford, M., Smith, A., Barrientos, D., Wegner, B., Baker, D., Bruno, M., Leurig, S., Mace, R., Romans, K., Rooney, J., Walker, J., & Puig-Williams, V. (2022). *Water and equity in the Texas Hill Country. Texas A&M University Natural Resources Institute.* https://nri.tamu.edu/publications/research-reports/2022/water-and-equity-in-the-texas-hill-country

Lynn, K. (2017). Rising recreancy: flood control and community relocation in Houston, TX, from an environmental justice perspective. *Local Environment, 22*(3), 321–334. https://doi.org/10.1080/13549839.2016.1195802.

Mack, E. A., & Wrase, S. (2017). A burgeoning crisis? A nationwide assessment of the geography of water affordability in the United States. *PloS ONE, 12*(4), e0169488. https://doi.org/10.1371/journal.pone.0176645

Makar, J. M., & Rajani, B. (2000). Gray cast-iron water pipe metallurgy. *Journal of Materials in Civil Engineering, 12*(3), 245–253. https://doi.org/10.1061/(ASCE)0899-1561(2000)12:3(245)

Malewitz, J. (2015, May 18). Curbing local control, Abbott signs "Denton Fracking Bill". *The Texas Tribune.* https://www.texastribune.org/2015/05/18/abbott-signs-denton-fracking-bill/

Marino, E. (2018). Adaptation privilege and voluntary buyouts: Perspectives on ethnocentrism in sea level rise relocation and retreat policies in the US. *Global Environmental Change, 49,* 10–13. https://doi.org/10.1016/j.gloenvcha.2018.01.002

Martinich, J., Neumann, J., Ludwig, L., & Jantarasami, L. (2013). Risks of sea level rise to disadvan-taged communities in the United States. *Mitigation and Adaptation Strategies for Global Change, 18*(2), 169–185. https://doi.org/10.1007/s11027-011-9356-0

McAdams, J. (2021, January). *Public utility commission stakeholder engagement: A decision-making framework.* National Association of Regulatory Utility Commissioners. https://pubs.naruc.org/pub/7A519871-155D-0A36-3117-96A8D0ECB5DA

McDowell, C. P., Andrade, L., Re, V., O'Dwyer, J., Hynds, P. D., & O'Neill, E. (2021). Exploring risk perception and behaviours at the intersection of flood events and private groundwater supplies: A qualitative focus group study. *Water, 13*(23), 3467. https://doi.org/10.3390/w13233467

McFarlane, K., & Harris, L. M. (2018). Small systems, big challenges: Review of small drinking water system governance. *Environmental Reviews, 26*(4), 378–395. https://doi.org/10.1139/er-2018-0033

Mendieta Sánchez, E. (2023). "Pide arzobispo por lluvia oportuna y paz para Nuevo León." Milenio. https://www.milenio.com/politica/comunidad/arzobispo-de-monterrey-pide-por-lluvia-oportuna-y-paz.

Meehan, K., Jepson, W., Harris, L. M., Wutich, A., Beresford, M., Fencl, A., London, J., Pierce, G., Radonic, L., Wells, C., Wilson, N. J., Adams, E. A., Arsenault, R., Brewis, A., Harrington, V., Lambrinidou, Y., McGregor, D., Patrick, R., Pauli, B., … Young, S. (2020). Exposing the myths of household water insecurity in the global North: A critical review. *WIREs Water, 7*(6), e1486. https://doi.org/10.1002/wat2.1486

Minkler, M., Garcia, A. P., Rubin, V., & Wallerstein, N. (2012). *Community-based participatory research: A strategy for building healthy communities and promoting health through policy change.* PolicyLink. https://www.policylink.org/sites/default/files/CBPR.pdf

Mohai, P., Pellow, D., & Roberts, J. T. (2009). Environmental justice. *Annual Review of Environment and Resources, 34,* 405–430. https://doi.org/10.1146/annurev-environ-082508-094348

Montag, C. (2019). *Water/color: A study of race and the water affordability crisis in America's cities.* The Thurgood Marshall Institute at the NAACP Legal Defense and Educational Fund. https://www.naacpldf.org/our-thinking/issue-report/economic-justice/water-color-a-study-of-race-and-the-water-affordability-crisis-in-americas-cities/

Montes, A. (2021, June 8). *El Paso City Council initiates climate action plan.* KTSM. https://www.ktsm.com/local/el-paso-news/el-paso-city-council-to-initiate-climate-action-plan/.

Morris, M. (2019, March 11). Houston water bills could rise under $2B deal to cut sewer spills. *Houston Chronicle.* https://www.houstonchronicle.com/news/houston-texas/houston/article/Houston-water-bills-could-rise-under-2B-deal-to-13677431.php

Mulki, S., Rubinstein, C., & Saletta, J. (2018). Texas' water quality challenge and the need for better communication in an era of increasing water quality contamination events. *Texas Water Journal, 9*(1), 108–119. https://doi.org/10.21423/twj.v9i1.7059

National Centers for Environmental Information. (2022). *U.S. billion-dollar weather and climate disasters.* National Oceanic and Atmospheric Administration. https://www.ncei.noaa.gov/access/billions/

National Drought Mitigation Center. (2022). *U.S. Drought Monitor.* https://droughtmonitor.unl.edu/

National Weather Service. (2022). *NWS preliminary US flood fatality statistics.* National Oceanic and Atmospheric Administration. https://www.weather.gov/arx/usflood

National Wildlife Federation. (2021). *Water rescue: Using American Rescue Plan Act funds to improve our fragile water infrastructure.* Texas Living Waters. https://texaslivingwaters.org/deeper-dive/arpa/

Natural Resources Defense Council. (2023, August 31). *How states stack up on flood disclosure.* https://www.nrdc.org/flood-disclosure-map

The Nature Conservancy. (2024). See What Nature's Developing. https://www.nature.org/en-us/about-us/where-we-work/united-states/texas/nature-based-solutions-in-texas/

Newman, G., Shi, T., Yao, Z., Li, D., Sansom, G., Kirsch, K., Casillas, G., & Horney, J. (2020). Citizen science-informed community master planning: land use and built environment changes to increase flood resilience and decrease contaminant exposure. *International Journal of Environmen-tal Research and Public Health, 17*(2), 486. https://doi.org/10.3390/ijerph17020486

Earth's Future, 8(8). https://doi.org/10.1029/2020EF001552

Nielsen-Gammon, J., Escobedo, J., Ott, C., Dedrick, J., & Van Fleet, A. (2020a). *Assessment of historic and future trends of extreme weather in Texas, 1900–2036.* Office of the Texas State Climatologist, Texas A&M University. https://hdl.handle.net/1969.1/188618

Nielsen-Gammon, J., Banner, J., Cook, B., Tremaine, D., Wong, C., Mace, R., Gao, H., Yang, Z. Gonzalez, M., Hoffpauir, R., Gooch, T., & Kloesel, K. (2020b). Unprecedented drought challenges for Texas water resources in a changing climate: what do researchers and stakeholders need to know?. *Earth's Future, 8*(8), e2020EF001552. https://doi.org/10.1029/2020EF001552

Nzau, J. M., Rogers, R., Shauri, H. S., Rieckmann, M., & Habel, J. C. (2018). Smallholder perceptions and communication gaps shape East African riparian ecosystems. *Biodiversity and Conservation, 27*(14), 3745–3757. https://doi.org/10.1007/s10531-018-1624-9

Olago, D. O. (2019). Constraints and solutions for groundwater development, supply and governance in urban areas in Kenya. *Hydrogeology Journal, 27*(3), 1031–1050. http://erepository.uonbi.ac.ke/handle/11295/107084

Parag, Y., & Roberts, J. T. (2009). A Battle against the bottles: Building, claiming, and regaining tap-water trustworthiness. *Society & Natural Resources,* 22(7), 625–636. https://doi.org/10.1080/08941920802017248.

Park, Y., & Guldmann, J. M. (2020). Measuring continuous landscape patterns with Gray-Level Co-Occurrence Matrix (GLCM) indices: An alternative to patch metrics?. *Ecological Indicators, 109,* 105802. https://doi.org/10.1016/j.ecolind.2019.105802.

Pauloo, R. A., Escriva-Bou, A., Dahlke, H., Fencl, A., Guillon, H., & Fogg, G. E. (2020). Domestic well vulnerability to drought duration and unsustainable groundwater management in California's Central Valley. *Environmental Research Letters, 15*(4), 044010. https://doi.org/10.1088/1748-9326/ab6f10

Paulson, C., Broley, W., & Stephens, L. (2017). *Blueprint for one water (Project #4660).* The Water Re-search Foundation. www.waterrf.org/PublicReportLibrary/4660.pdf

Permit exemptions, 2 Tex. Water Code. § 11.142 (1977). https://statutes.capitol.texas.gov/Docs/WA/htm/WA.11.htm#11.142

Pierce, G., & Jimenez, S. (2015). Unreliable water access in U.S. mobile homes: Evidence from the American housing survey. *Housing Policy Debate, 25*(4), 739–753. https://doi.org/10.1080/10511482.2014.999815

Pierce, G., Gonzalez, S. R., Roquemore, P., & Ferdman, R. (2019). Sources of and solutions to mistrust of tap water originating between treatment and the tap: Lessons from Los Angeles County. *Science of the Total Environment, 694,* 133646. https://doi.org/10.1016/j.scitotenv.2019.133646

Porter, C. R. (2009). *Spanish water, Anglo water: Early development in San Antonio.* Texas A&M Uni-versity Press.

Potter, L. B., Tremaine, D. M., & Banner, J. L. (2022). Predictors of variations in residential water consumption in Central Texas. *Water, 14*(11), 1804. https://doi.org/10.3390/w14111804

Pralle, S. (2019). Drawing lines: FEMA and the politics of mapping flood zones. *152*(2), 227–237. https://doi.org/10.1007/s10584-018-2287-y

Pskowski, M. (2023). "Tensions rise in the Rio Grande Basin as Mexico lags in water deliveries to the U.S." *Marfa Public Radio.* https://www.tpr.org/environment/2023-10-11/tensions-rise-in-the-rio-grande-basin-as-mexico-lags-in-water-deliveries-to-the-u-s

Public Utility Commission of Texas. (2021). "News Release: PUC Lifts Moratorium on Utility Disconnections for Non-Payment." https://ftp.puc.texas.gov/public/puct-info/agency/resources/pubs/news/2021/PUCTX-REL-DNPsResume.pdf

Public Utility Commission of Texas. (2024). "Know Your Rights." https://www.puc.texas.gov/consumer/complaint/rights.aspx

Pulido, L. (2016). Flint, environmental racism, and racial capitalism. *Capitalism Nature Socialism, 27*(3), 1–16. https://doi.org/10.1080/10455752.2016.1213013

Pulido, L. (2017). Historicizing the personal and the political: Evolving racial formations and the environmental justice movement. In R. Holifield, J. Chakraborty, & G. Walker (Eds.), *The Routledge Handbook of Environmental Justice* (pp. 15–24). Routledge.

Pulido, L., Kohl, E., & Cotton, N. M. (2016). State regulation and environmental justice: The need for strategy reassessment. *Capitalism Nature Socialism, 27*(2), 12–31. https://doi.org/10.1080/10455752.2016.1146782

Quinn, C. E., & Burbach, M. E. (2010). A test of personal characteristics that influence farmers' pro-environmental behaviors. *Great Plains Research 20*(2), 193–204. https://www.jstor.org/stable/23780294

Ranganathan, M. (2016). Thinking with Flint: Racial liberalism and the roots of an American water tragedy. *Capitalism Nature Socialism, 27*(3), 17–33. https://doi.org/10.1080/10455752.2016.1206583

Redistricting and Voting Rights Data Office. (2023). Decennial census P.L. 94-171 redistricting data. U.S. Census Bureau. https://www.census.gov/programs-surveys/decennial-census/about/rdo/summary-files.html

Regan, M. S. (2021, December 2). *Sample letter.* U.S. Environmental Protection Agency. https://www.epa.gov/system/files/documents/2021-12/governors-bil-letter-final-508.pdf

Rice, J. (2022). "Texas landlords must now disclose flood risk information to renters. Housing experts say it doesn't go far enough." *Houston Public Media.* https://www.houstonpublicmedia.org/articles/news/politics/2022/01/10/416776/texas-landlords-have-to-disclose-flood-risk-information-now-but-will-it-help-renters/

Riggs, E., Hughes, J., Irvin, D., & Leopard, K. (2017). *An overview of clean water access challenges in the United States.* Global Water Challenge and the Environmental Finance Center, School of Government, University of North Carolina. https://urbanwaterslearningnetwork.org/wp-content/uploads/2019/05/UNC-Clean-Water-Access-Challenges2017.pdf

Robb, K. (2022). *The Rio Grande/Rio Bravo water deliveries under the 1944 treaty: A compendium of ideas.* International Boundary and Water Commission. https://www.ibwc.gov/wp-content/uploads/2023/04/Rio_Grande_White_Paper_FINAL.pdf

Rowe, G., & Frewer, L. J. (2000). Public participation methods: A framework for evaluation. *Science, Technology, and Human Values 25*(1), 13–29. https://doi.org/10.1177/016224390002500101

Runkle, J., Kunkel, K. E., Nielson-Gammon, J., Frankson, R., Champion, S. M., Stewart, B. C., Romolo, L., & Sweet, W. (2022). *State climate summaries 2022. National Centers for Environmental Information, National Oceanic and Atmospheric Administration.* https://statesummaries.ncics.org/chapter/tx/

Salhotra, P., & Carver, J. L. (2022, December 7). A boil-water notice in Houston made national news. In rural Texas, it's a way of life. *The Texas Tribune.* https://www.texastribune.org/2022/12/07/boil-water-notices-rural-texas/

San Jacinto River Authority. (2024). "Spring Creek Study." https://springcreekstudy.com/

Sanchez, S. (2024a). "'A dire situation': Mexico's refusal to pay water debt grips South Texas border." *News Nation Now.* https://www.newsnationnow.com/us-news/southwest/a-dire-situation-mexicos-refusal-to-pay-water-debt-grips-south-texas-border/

Sanchez, S. (2024b). "US also responsible for dwindling of water in Rio Grande, IBWC commissioner says." *Border Report.* https://www.borderreport.com/news/environment/us-also-responsible-for-dwindling-of-water-in-rio-grande-ibwc-commissioner-says/

Schell, C. J., Dyson, K., Fuentes, T. L., Roches, S. D., Harris, N. C., Miller, D. S., Woelfle-Erskine, C. A., & Lambert, M. R. (2020). The ecological and evolutionary consequences of systemic racism in urban environments. *Science, 369*(6510). https://doi.org/10.1126/science.aay4497

Scherer, J. (2021, March 24). Judge OKs federal consent decree requiring Houston to make $2 billion in sewer upgrades. *Houston Chronicle.* https://www.houstonchronicle.com/news/houston-texas/houston/article/Judge-OKs-federal-consent-decree-requiring-16050883.php

Schlosberg, D. (2013). Theorizing environmental justice: the expanding sphere of a discourse. *Environmental Politics, 22*(1), 37–55. https://doi.org/10.1080/09644016.2013.755387

Scott Institute for Energy Innovation. (2017). *Power sector carbon index.* Carnegie Mellon University. https://www.emissionsindex.org

Seager, R., Lis, N., Feldman, J., Ting, M., Williams, A. P., Nakamura, J., Liu, H., & Henderson, N. (2018). Whither the 100th meridian? The once and future physical and human geography of America's arid–humid divide. Part I: The story so far. *Earth Interactions, 22*(5), 1–22. https://doi.org/10.1175/EI-D-17-0011.1

Semenza, J. C., Hall, D. E., Wilson D. J., Bontempo, B. D, Sailor, D. J., & George L. A. (2008). Public perception of climate change: Voluntary mitigation and barriers to behavior change. *American Journal of Preventive Medicine, 35,* 479–487. https://doi.org/10.1016/j.amepre.2008.08.020

Sharp Jr, J. M., Krothe, J. N., Mather, J. D., Gracia-Fresca, B., & Stewart, C. A. (2003). Effects of ur-banization on groundwater systems. In G. Heiken, R. Fakundiny, & J. Sutter (Eds.), *Earth Science in the City: A Reader* (pp. 257–278). American Geophysical Union. https://doi.org/10.1029/SP056

Shinstine, D. S., Ahmed, I., & Lansey, K. E. (2002). Reliability/availability analysis of municipal water distribution networks: Case studies. *Journal of Water Resources Planning and Management, 128*(2), 140–151. https://doi.org/10.1061/(ASCE)0733-9496(2002)128:2(140)

Sixth Assessment Report Working Group I. *Climate change 2021: The physical science basis. Intergovernmental Panel on Climate Change.* https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SummaryVolume.pdf

Smiley, K., & Hakkenberg, C. (2020, October 5). *The rapid urbanization of Houston: How it happened and why it matters.* Kinder Institute for Urban Research, Rice University. https://kinder.rice.edu/urbanedge/2020/10/05/rapid-urbanization-houston-how-it-happened-flooding-climate-change

Smith, M., & Collier, K. (2018, August 25). Harris County voters pass historic $2.5 billion for flood control. *The Texas Tribune.* https://www.texastribune.org/2018/08/25/Harris-County-flood-control-vote/

Stillwell, A. S., King, C. W., Webber, M. E., Duncan, I. J., & Hardberger, A. (2011). The energy-water nexus in Texas. *Ecology and Society, 16*(1). https://www.jstor.org/stable/26268863

Teodoro, M. P. (2018). Measuring household affordability for water and sewer utilities: Measuring household affordability for water and sewer utilities. *Journal AWWA, 110*(1), 13–24. https://doi.org/10.5942/jawwa.2018.110.0002

Tex. S.B. 8, 87th Leg., 3d C.S. (2021). https://capitol.texas.gov/BillLookup/Text.aspx?LegSess=873&Bill=SB8#.

Texas 2036. (2021). *Texas voter poll.* https://texas2036.org/poll/

Texas Board of Water Engineers. (1961). *A plan for meeting the 1980 water requirements of Texas.*

Texas Living Waters Project. (2020, June). *Texas water conservation scorecard.* http://www.texaswaterconservationscorecard.org/usrfiles/files/FinalReport_6_22_20.pdf

Texas Living Waters Project. (2023). One Water in Texas. https://texaslivingwaters.org/projects/one-water-in-texas/

Texas Water Development Board. (2021, July 7). *2022 state water plan: Water for Texas.* https://www.twdb.texas.gov/waterplanning/swp/2022/index.asp

Texas Water Development Board. (2022). Regional water planning group member report. https://www.twdb.texas.gov/waterplanning/rwp/regions/doc/rwpg_member_report.pdf

Texas Water Development Board (2024). Rainwater Harvesting Frequently Asked Questions. https://www.twdb.texas.gov/innovativewater/rainwater/faq.asp

Ueland, J., & Warf, B. (2006). Racialized topographies: Altitude and race in southern cities. *Geographical Review, 96*(1), 50–78. https://doi.org/10.1111/j.1931-0846.2006.tb00387.x

U.S. Census Bureau. (2019, December 30). *2019 U.S. population estimates continue to show the nation's growth is slowing* [Press release]. https://www.census.gov/newsroom/press-releases/2019/popest-nation.html

U.S. Census Bureau. (2021). *DP04 Selected Housing Characteristics* [Data set]. https://data.census.gov/table?g=040XX00US48&d=ACS+5-Year+Estimates+Selected+Population+Data+Profiles&tid=ACSDP5YSPT2021.DP04

U.S. Census Bureau. (2022a). *DP03 selected economic characteristics* [Data set]. https://data.census.gov/table/ACSDP5Y2022.DP03?g=010XX00US&d=ACS%205-Year%20Estimates%20Data%20Profiles

U.S. Census Bureau. (2022b). *DP05 demographic and housing estimates* [Data set]. https://data.census.gov/table/ACSDP5Y2022.DP05?g=010XX00US&d=ACS%205-Year%20Estimates%20Data%20Profiles

U.S. Department of Agriculture. (2020). *Water resources in Texas.* Natural Resources Conservation Service, Texas. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/tx/programs/planning/wpfp/?cid=nrcs144p2_003053

U.S. Environmental Protection Agency. (2011). *Obama administration advances efforts to protect health of U.S. communities overburdened by pollution / Federal agencies sign environmental justice memorandum of understanding* [Press release]. https://www.epa.gov/archive/epapages/newsroom_archive/newsreleases/28420a5ae8467cf5852578e200635712.html

U.S. Environmental Protection Agency. (2022b). *Basic information about lead in drinking water.* https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-wa-ter#:~:text=EPA%20has%20set%20the%20maximum,even%20at%20low%20exposure%20level

U.S. Environmental Protection Agency. (2022a). *Environmental justice timeline.* https://www.epa.gov/environmentaljustice/environmental-justice-timeline

U.S. Environmental Protection Agency. (2022c). *EJScreen* (Version 2.0) [Mapping tool]. https://ejscreen.epa.gov/mapper/

U.S. Environmental Protection Agency. (2024). *Equity action plan.* https://www.epa.gov/environmentaljustice/equity-action-plan#overview

U.S. Environmental Protection Agency Office of Environmental Justice and Office of Sustainable Communities. (2010). *Environmental justice and sustainability reference deskbook.* https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EOXC.txt

U.S. Water Alliance. (2016). *One water roadmap: The sustainable management of life's most essential resource.* https://uswateralliance.org/resources/one-water-roadmap-the-sustainable-management-of-lifes-most-essential-resource/

U.S. Water Alliance. (2017a). *An equitable water future: A national briefing paper.* http://uswateralliance.org/sites/uswateralliance.org/files/publications/uswa_waterequity_FINAL.pdf

U.S. Water Alliance (2017b). *One water for America: Policy framework.* https://www.uswateralliance.org/initiatives/listening-sessions

U.S. Water Alliance. (2022). *Making Customer Assistance Programs Accessible: Guidance for the Water Sector.* https://uswateralliance.org/wp-content/uploads/2023/10/Making-Customer-Assistance-Programs-Accessible-Guidance-for-the-Water-Sector.pdf.

Utilization of waters of the Colorado and Tijuana rivers and of the Rio Grande, Feb. 3, 1944, 59 Stat. 1219 (1946), T.S. No. 994 (effective Nov. 8, 1945). https://www.ibwc.gov/Files/1944Treaty.pdf

Vandewalle, E., & Jepson, W. (2015). Mediating water governance: Point-of-use water filtration devices for low-income communities along the US-Mexico border. *Geo: Geography and Environment, 2*(2), 107–121. https://doi.org/10.1002/geo2.9

Vanhille, J., Goedemé, T., Penne, T., Van Thielen, L., & Storms, B. (2018). Measuring water affordability in developed economies. The added value of a needs-based approach. *Journal of Environmental Management, 217,* 611–620. https://doi.org/10.1016/j.jenvman.2018.03.106

Varua, M. E., Maheshwari, B., Ward, J., & Dave, S. (2017). Groundwater conservation attitudes, behaviour and water management: The case of farmers in rural India. *WIT Transactions on Ecology and the Environment, 220,* 141–150. https://doi.org/10.2495/WRM170141

Vasquez, L. (2022). The GLO discriminated against minorities in Houston and Harris County when denying federal flood relief, HUD says. *Houston Public Media.* https://www.houstonpublicmedia.org/articles/news/politics/2022/03/08/420669/the-glo-discriminated-against-minorities-in-houston-and-harris-county-when-denying-federal-flood-relief-hud-says/.

Walker, G. (2012). *Environmental justice: concepts, evidence and politics.* Routledge.

Walker, J., Wyatt, A., Seefeldt, J., Goshen, D., Bock, M., Johnston, I., & Black, M. (2022, August 24). *Hidden reservoirs: Addressing water loss in Texas.* Texas Living Waters Project and Texas Coast and Water Program, National Wildlife Federation. https://texaslivingwaters.org/deeper-dive/water-loss/

Walsh, C. J., Roy, A. H., Feminella, J. W., Cottingham, P. D., Groffman, P. M., & Morgan II, R. P. (2005). The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society, 24*(3), 706–723. https://doi.org/10.1899/04-028.1

Ward, P. M. (1999). *Colonias and public policy in Texas and Mexico: Urbanization by stealth.* University of Texas Press.

The White House. (2021a, January 27). *President Biden takes executive actions to tackle the climate crisis at home and abroad, create jobs, and restore scientific integrity across federal government* [Fact Sheet]. https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/

The White House. (2021b, August). *The Infrastructure Investment and Jobs Act will deliver for Texas* [Press Release]. https://www.whitehouse.gov/wp-content/uploads/2021/08/TEXAS_Infrastructure-Investment-and-Jobs-Act-State-Fact-Sheet.pdf

The White House. (2022, August 17). *Inflation Reduction Act advances environmental justice* [Fact Sheet]. https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/17/fact-sheet-inflation-reduction-act-advances-environmental-justice/

The White House (2023, January). *Building a clean energy economy: A guidebook to the Inflation Reduction Act's investments in clean energy and climate action.* www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf

Zahran, S., Brody, S. D., Peacock, W. G., Vedlitz, A., & Grover, H. (2008). Social vulnerability and the natural and built environment: a model of flood casualties in Texas. *Disasters, 32*(4), 537–560. https://doi.org/10.1111/j.1467-7717.2008.01054.x

Zhang, W., Villarini, G., Vecchi, G.A., & Smith, J.A. (2018). Urbanization exacerbated the rainfall and flooding caused by hurricane Harvey in Houston. *Nature, 563,* 384–388. https://doi.org/10.1038/s41586-018-0676-z

Zhang, X., Warner, M. E., & Grant, M. (2022). Water shutoff moratoria lowered COVID-19 infection and death across US states. *American Journal of Preventive Medicine, 62*(2), 149–156. https://doi.org/10.1016/j.amepre.2021.07.006

Zhu, R., Newman, G., & Atoba, K. (2021). Simulating the impact of land use change on contaminant transferal during flood events in Houston, Texas. *Landscape Journal, 40*(2), 79–99. https://doi.org/10.3368/lj.40.2.79