ADVANCING ONE WATER IN TEXAS

Rachel Cardone and Carol Howe

February 2018

PRESENTED BY

THE CYNTHIA & GEORGE MITCHELL FOUNDATION

On the cover: Benbrook Lake
Fort Worth, Texas

ACKNOWLEDGMENTS

The authors would like to thank the many people listed below who we interviewed across Texas, whose insights and knowledge helped guide our work:

Lucia Athens, *City of Austin**
Janice Bezanson, *Texas Conservation Alliance**
Raj Bhattarai, *Austin Water Utility*
Bill Bunch, *Save our Springs Alliance**
Buster Fischera, *Fort Worth Water Department, retired*
Marc Frieburg, *Edwards Aquifer Authority**
Karen Guz, *San Antonio Water Systems**
Amy Hardberger, *St. Mary's University School of Law*
Sam Marie Hermitte, *Texas Water Development Board*
Chris Herrington, *City of Austin Watershed Department**
Paul Jack, *Estrada Hinojosa & Company, Inc.*
Mary Kelly, *Culp & Kelly, LLP**
Sharlene Leurig, *The Meadows Center for Water and the Environment, Texas State University**
Luke Metzger, *Environment Texas**
Katherine Romans, *Hill Country Alliance**
Robert Stefani, *Austin Water Utility**
Tom Taggart, *City of San Marcos*
Todd Votteler, *Guadalupe-Blanco River Authority**

Appreciation is also extended to the people who participated in the One Water workshop that the Cynthia and George Mitchell Foundation (Mitchell Foundation) hosted at Shield Ranch on March 27, 2017, which, in addition to those noted with an * above, included:

Kristen Chiles, *Google*
Glenn Clingenpeel, *Trinity River Authority*
Steve Costello, *City of Houston*
Sarah Faust, *Protect our Water*
Tom Gooch, *Freese and Nichols, Inc.*
Mary Kelleher, *Tarrant Regional Water Authority*
Doug Melnick, *City of San Antonio*
Nora Mullarky, *Lower Colorado River Authority, retired*
Stacy Allison Steinbach, *Texas Water Conservation Association*
Emily Warren, *The Meadows Center for Water and the Environment, Texas State University*

This work is part of a larger water knowledge portfolio that the Mitchell Foundation commissioned in 2016–2017. We have enjoyed exchanging ideas and information with our counterparts, including Ryan Strode and Nikki Toten from Arabella Advisors and Jacqueline Ashmore, Margaret Cherne-Hendrick, and Victor Marttin from the Institute for Sustainable Energy at Boston University.

We would like to extend a special thank you to the Mitchell Foundation for enabling us to undertake this project, particularly to Sarah Richards, program officer, and Jamie Olson, senior program associate, who each provided guidance, insight, and valuable feedback to this research, and to Sam Rosenburg, who provided administrative support.

A note from the authors on terminology:

While conducting this research, we noticed that some “water” words held meaning that was specific to Texas, which can be confusing in a One Water context. Our understanding of these words is below.

- **Alternative water** includes brackish, reclaimed/recycled water, rainwater, condensate, stormwater, and greywater.
- **Auxiliary water** is similar to alternative water and generally refers to any water source other than what is delivered through the potable water system. It is defined by Austin Water Utility as reclaimed water, well water, rainwater harvesting, and/or the collection and use of various waters (e.g., river, lake, detention pond, etc.) used on the same premises where potable water is distributed.
- **Water conservation** generally refers to water efficiency and water loss reduction, but in Texas it also includes increasing recycling or reuse of water.
- **Recycled or Reuse water** is previous wastewater that has been treated and is fit for a specific purpose, depending on the level of treatment. It is a component of all the above terms.

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Jacob's Well
Wimberley, Texas

PREFACE

If I were asked to share a photo that captured the heart and spirit of Texas, it would be the image of Jacob's Well in Wimberley, in the Hill Country near Austin. Texas summer days are filled with the gasps and laughter of children as they cannonball into cold, refreshing spring-fed swimming holes like Jacob's Well, San Solomon Springs, or Barton Springs.

The Cynthia and George Mitchell Foundation envisions a future where both Texans and the beautiful natural resources (that we depend on) thrive. The foundation's water program aims to ensure ample, healthy waters above and below ground to support the rich, diverse ecosystems throughout Texas.

The future of these Texas icons is in jeopardy as population growth and climate change stretches thin our precious water resources and complicates water management during our famous weather extremes. The current water management paradigm in Texas does not adequately promote sustainable water management or, quite frankly, place a priority on sustaining the needs of our environment.

These challenges, however, are not unique to Texas. Across the United States and throughout the world, community leaders, water planners, and policymakers are wrestling with how best to manage water to maximize economic and social welfare equitably without compromising the sustainability of vital ecosystems. Leaders in sustainable solutions are rethinking our traditional urban water management practices, working to advance a more resilient strategy called integrated water management or "One Water."

The concept of coordinated development and management of water, land, and related resources is not new although related policies and practices in Texas and across our nation are severely out of sync. Clear leadership is needed to drive a paradigm shift.

The Mitchell Foundation commissioned this report to learn how advocates can cultivate a viable model in Texas. *Advancing One Water in Texas* attempts to characterize and demystify One Water, identify drivers and challenges to its path forward, and provide clear recommendations for advancing One Water in our state.

So, what *is* One Water, and importantly, what *is not* One Water?

Simply, One Water promotes the management of all water within a specific geography—e.g., drinking water, wastewater, stormwater, greywater—as a single resource, a resource that must be managed holistically, viably, and sustainably. While this report details the many dimensions of One Water and its inherent difference from the traditional management approach, there are a few significant observations to highlight:

- **Community decisions, not utility decisions.** A One Water approach asks a *community* to consider and manage all waters running through it *holistically*. This includes rivers and aquifers, wastewater, stormwater, recycled water, and greywater. The days of feeding vast Texas lawns with water so pure a newborn baby could drink it should cease immediately. The practice of funneling stormwater into concrete culverts should stop as soon as possible. And, municipal hierarchies that afford the city water utility the right to make water supply decisions independent of the stormwater manager or even the parks department or energy utility should become a thing of the past.

  Instead, *a community*—and all the city management 'branches' that impact water—should consider all waters available in their system and all water needs (including drinking, parks, energy production and delivery, and maintaining natural assets) alongside one another. This approach avoids the false choice of working for the economy or environment or society and, rather, recognizes the critical importance of sustaining the community's water resources for all audiences and, most importantly, the public good.

- **Collaboration is the essential building block.** Under the current system of water management, within any given community, different streams of water are compartmentalized, managed in almost complete isolation from one another. Collaboration across these silos is a critical ingredient, and an absolute necessity, if decision are to be made that are truly in the best interest of the community and water resources. These practices, however, don't come easily. Collaboration, often times between disparate audiences, requires committed leadership, common sense, political capital, a diversity of participants and institutions, as well as the right supporting tools and techniques.

- **It's not going to be easy, but if anyone can do it, Texans can.** A transition to a One Water approach is inevitable but can be a painstaking and challenging journey for our communities to traverse. One Water is challenged by the inertia that comes with any systemic change, particularly a system that's been the default practice for decades. Yet it's because of the leadership and tenacity of a few innovative lone rangers that we see shining examples of One Water being heralded by state agencies and in cities across Texas.

  Texas is the national leader in water reuse and the State Water Implementation Fund of Texas (SWIFT) with its 20 percent conservation set aside puts real money on the table for conservation. The city of Austin is developing a 100-year integrated water resource plan, cities like Arlington and Mesquite are embracing green infrastructure in new and innovative ways, and Fort Worth is taking resource recovery to new heights. With resilient, opportunistic, and determined Texans working together at the local and state level, this paradigm shift to One Water will occur, helping us to sustain our treasured natural resources, from Big Bend to the East Texas Piney Woods.

This report characterizes One Water, describes the influencers of this water management shift, and outlines emerging challenges and opportunities. It also provides three "areas for action": (1) promoting good policy, (2) building across silos (or breaking them down), and (3) mainstreaming successful pilots and demonstrations.

The Cynthia and George Mitchell Foundation is committed to supporting Texas's transition to One Water and sustaining our state's water resources. With an eye on the future, we hope that this report will serve as a means of informing change-makers and fueling actionable solutions in securing and managing our waters for generations to come.

I would like to send a Texas-sized thank you to Carol Howe and Rachel Cardone for sharing their thoughtful, intelligent technical expertise as co-authors of this report. Additional thanks go to the dozens of field experts who provided valuable insight during interviews and workshops, which greatly informed our thinking. Lastly, we acknowledge the late George P. Mitchell whose unconventional thinking and vision continues to impel the foundation to act as an engine of change in Texas, supporting work at the nexus of environmental protection, social equity, and economic vibrancy.

Sarah Richards
Water Program Officer
Cynthia and George Mitchell Foundation

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Hamilton Pool Preserve
Dripping Springs, Texas

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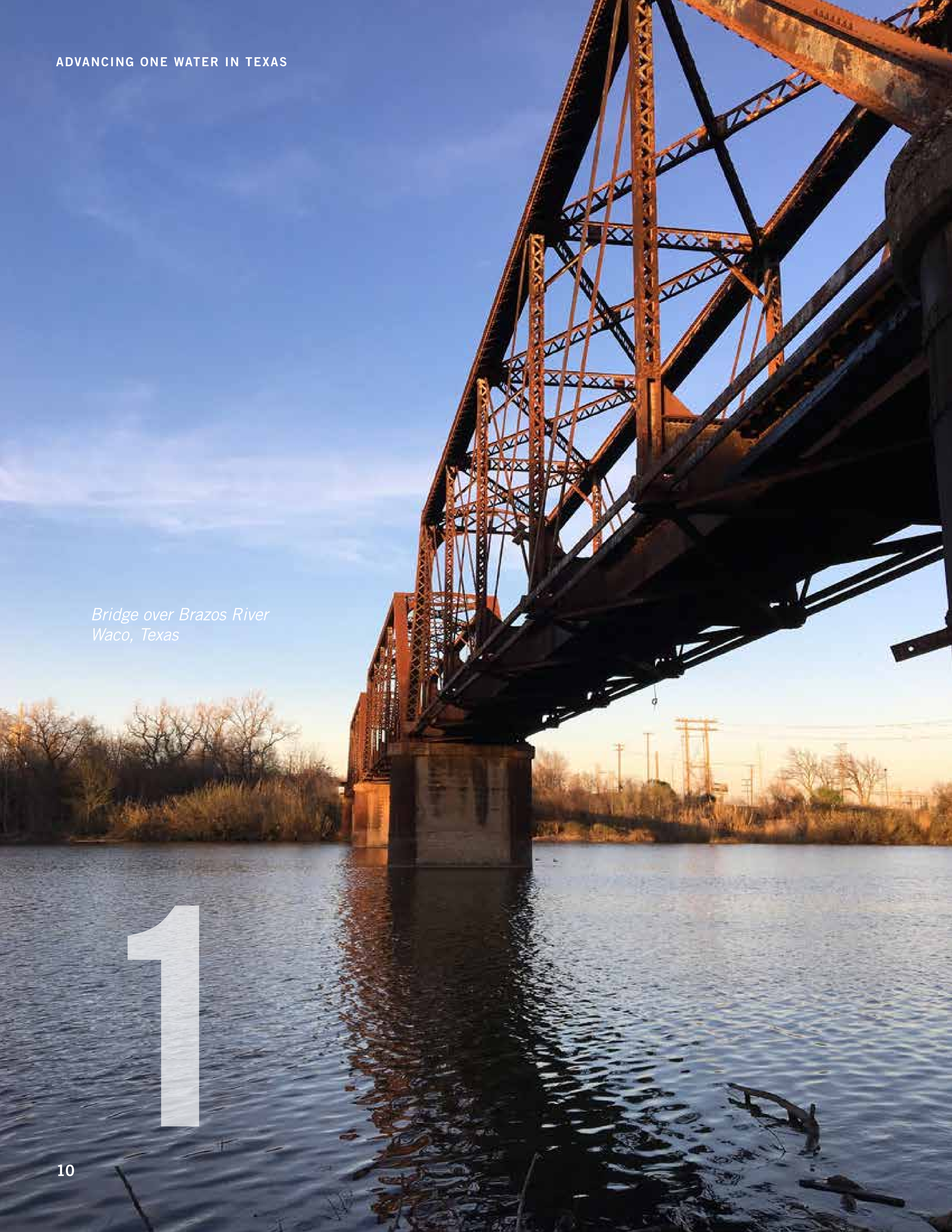


Bridge over Brazos River
Waco, Texas

INTRODUCTION

WHY ONE WATER IN TEXAS?

The goal of the Mitchell Foundation's Water Program is to ensure that the water quantity and quality needs of the Texas environment are met, now and into the future. Using a sustainability science approach, the foundation works to increase scientific understanding of water issues in Texas to inform the design of effective policy approaches. The foundation pursues interdisciplinary, place-based, and adaptive management methods in its program strategy and grantmaking portfolio. One goal is to increase knowledge about water issues in Texas and identify approaches that will meet the water requirements of growing urban areas without compromising Texas's environmental needs.

The connection between urban water use and environmental needs is multifaceted and concerns the ways water systems are managed across the water cycle; across government agencies at local, regional, and state levels; and across public, private, and civil society agencies. One Water, or integrated urban water management, is one way to facilitate this integration.

An integrated approach considers the potential for multiple uses and multiple benefits of water in a city.

While the concept of integrated urban water management is not new, it is a relatively recent practice. Traditional urban water management practices perpetuate a one-way use of water, from sourcing and treating, to polluting it through a diversity of uses before discharging it downstream. As cities and suburbs expand, water needs for domestic, industrial, and commercial uses also grow, increasing pressure on watersheds and natural habitats. By contrast, an integrated approach considers the potential for multiple uses and multiple benefits of water in a city. As a result, the integrated multi-use of water is of significant interest to cities and water managers around the world. It is seen as a practical way to address the challenges of building livable cities for an expanded urban population, while protecting the underlying environment. Around the world, active experimentation, learning, and boundary pushing is ongoing. Experience to date has demonstrated that advancing One Water requires an evolution in how water is governed and managed by service providers, governing authorities, and a range of other stakeholders.

In Texas, a variety of stakeholders from public, private, and civil society sectors have expressed interest in One Water and have begun experimenting with the concept through demonstrations of technology and pushing for an evolution in water management and regulation. This report is the result of a six-month discovery and development process. It included desk-based research; stakeholder meetings in Austin, San Antonio, and San Marcos with public, private, and civil society interests; and a one-day workshop to explore preliminary findings. The workshop also allowed participants to learn more about city and regionally specific issues and brainstorm opportunities to advance towards One Water implementation. The workshop attracted participation from public, private, and civil society agencies from Austin, San Antonio, Dallas/Fort Worth, Houston, and the Hill Country, which contributed significantly to the thinking in this report.

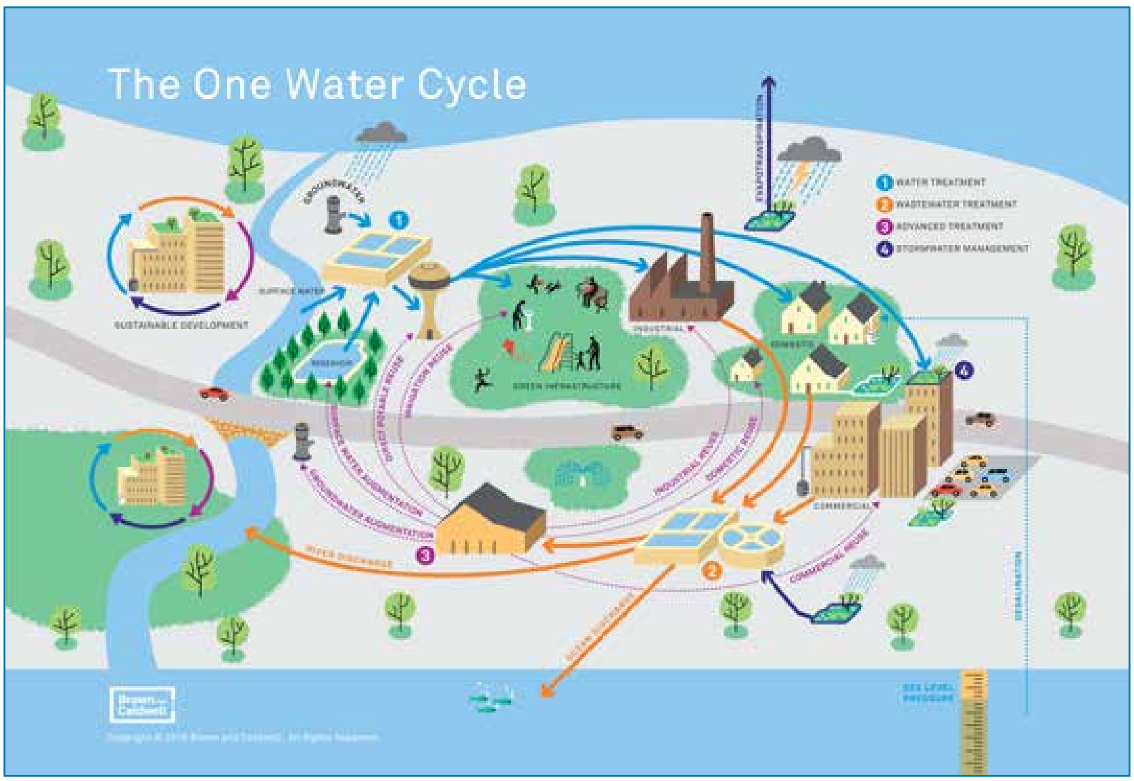
This report is divided into four sections:

01	Introduces the One Water concept—including traits and benefits—and gives examples of global and national implementation, along with emerging experience in Texas;
02	Examines drivers for more holistic management in Texas, including rapid population growth, climate variability, and inadequate infrastructure funding;
03	Explores the national and Texas-specific institutional barriers that are limiting the ability for Texas to advance One Water thinking in its urban areas; and
04	Provides areas of focus where action would help to advance One Water.

1.1 | WHAT IS ONE WATER?

One Water is defined by the Water Research Foundation (WRF) as an integrated planning and implementation approach to managing finite water resources for long-term resilience and reliability, meeting both community and ecosystem needs.[i] It is the emerging term in the United States for what is commonly known as integrated urban water management.

Figure 1 | The One Water Cycle



Source: Brown and Caldwell (2017)

Using a One Water approach requires thinking of water as a single system and recognizing that all urban water flows—including stormwater, rainwater, and wastewater—are potentially useful resources. For professionals, identifying water as a single system requires a shift in mindset to think beyond one's individual area of expertise (e.g., water conservation, drinking water quality, or groundwater management) to how this area is connected to the wider system of water management (Figure 1). It involves exploring the connections between water supply, groundwater, stormwater and rainwater, wastewater, and the overall impact of managing these water sources on flooding, water quality, wetlands, watercourses, estuaries and coastal waters.[ii]

Conducting a water balance

A system-wide water balance at local or regional levels allows stakeholders to understand all existing and future water quantity and quality demands by all end-uses (toilets, outdoor use, environmental flows, etc.) along with potential sources and locations of supply. Through analysis and discussion, innovative ideas like stormwater capture and use can be vetted, possibly as a way to increase supply, but with data on how much the approach would actually yield and at what cost. Likewise, increased demand for water recycling and the implications for select river systems can be better understood and discussed.

Table 1 identifies the differences between how water has been traditionally managed, and how water is managed using a One Water approach.

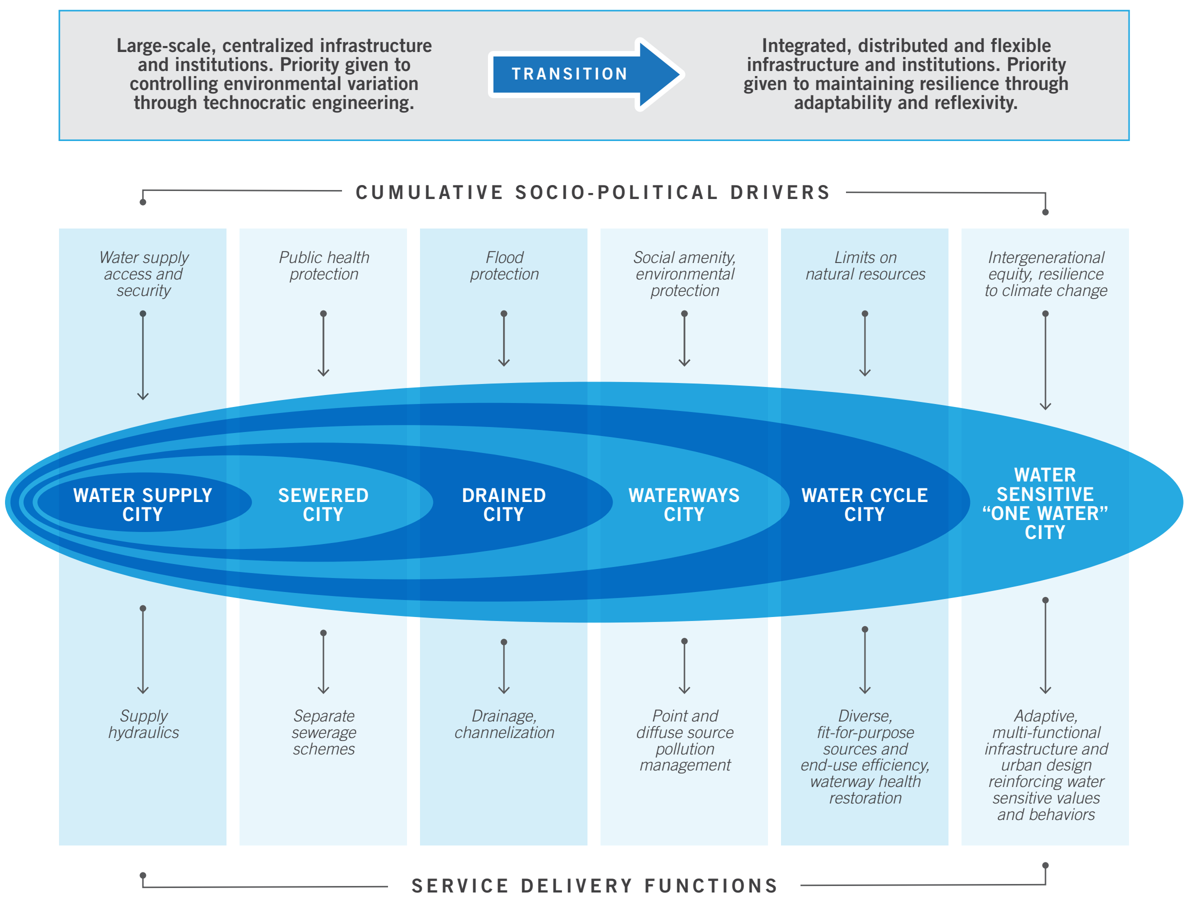
Table 1 | Key differences between traditional and integrated urban water management

ASPECT OF URBAN WATER MANAGEMENT	TRADITIONAL APPROACH	ONE WATER APPROACH
Overall approach	Integration is by accident. Water supply, wastewater and stormwater may be managed by the same agency as a matter of historical coincidence, but physically the three systems are separated.	Physical and institutional integration is by design. Linkages are made between water supply, wastewater, and stormwater as well as other areas of urban development through highly coordinated management.
Collaboration with stakeholders	Collaboration = public relations. Other agencies and the public are approached when approval of a preselected solution is required.	Collaboration = engagement. Other agencies and the public collaborate to identify effective solutions.
Choice of infrastructure	Infrastructure is made of concrete, metal, or plastic.	Infrastructure can also be green including soils, vegetation, and other natural systems.
Management of stormwater	Stormwater is a constant that is conveyed away from urban areas as rapidly as possible.	Stormwater is a resource that can be harvested as a water supply source and retained to support aquifers, waterways, and biodiversity.
Management of human waste	Human waste is collected, treated, and disposed of into the environment.	Human waste is a resource and can be used productively for energy generation and nutrient recycling.
Management of water demand	Increased water demand is met through investment in new supply sources and infrastructure.	Options to reduce demand, including harvesting rainwater and reclaiming wastewater, are given priority over other sources.
Choice of technological solutions	Complexity is neglected and standard engineering solutions are employed to deal with individual components of the water cycle.	Diverse solutions, both technological and ecological, and new management strategies are explored that encourage coordinated decisions between water management, urban design, and landscape architecture.

Source: Based on Pinkham (1999) – adapted by ICLEI (2011).

Looking at water holistically is a new approach to urban water management. Historically, cities sought to first secure their water supplies, then sewer their cities to deal with sanitation issues. More recently, cities have been striving to determine methods to better cope with issues of flooding and improvement of waterways. This process has taken over 100 years and has occurred in a very sequential way. A One Water approach seeks to break this linear pattern and adopt a more sustainable water management plan that not only provides basic services but also uses water to preserve and enhance ecosystems, provide urban amenities, and connect people more closely to their water resources. The urban water continuum, shown in Figure 2, is a way to illustrate the current versus the desired scenario for urban water management.

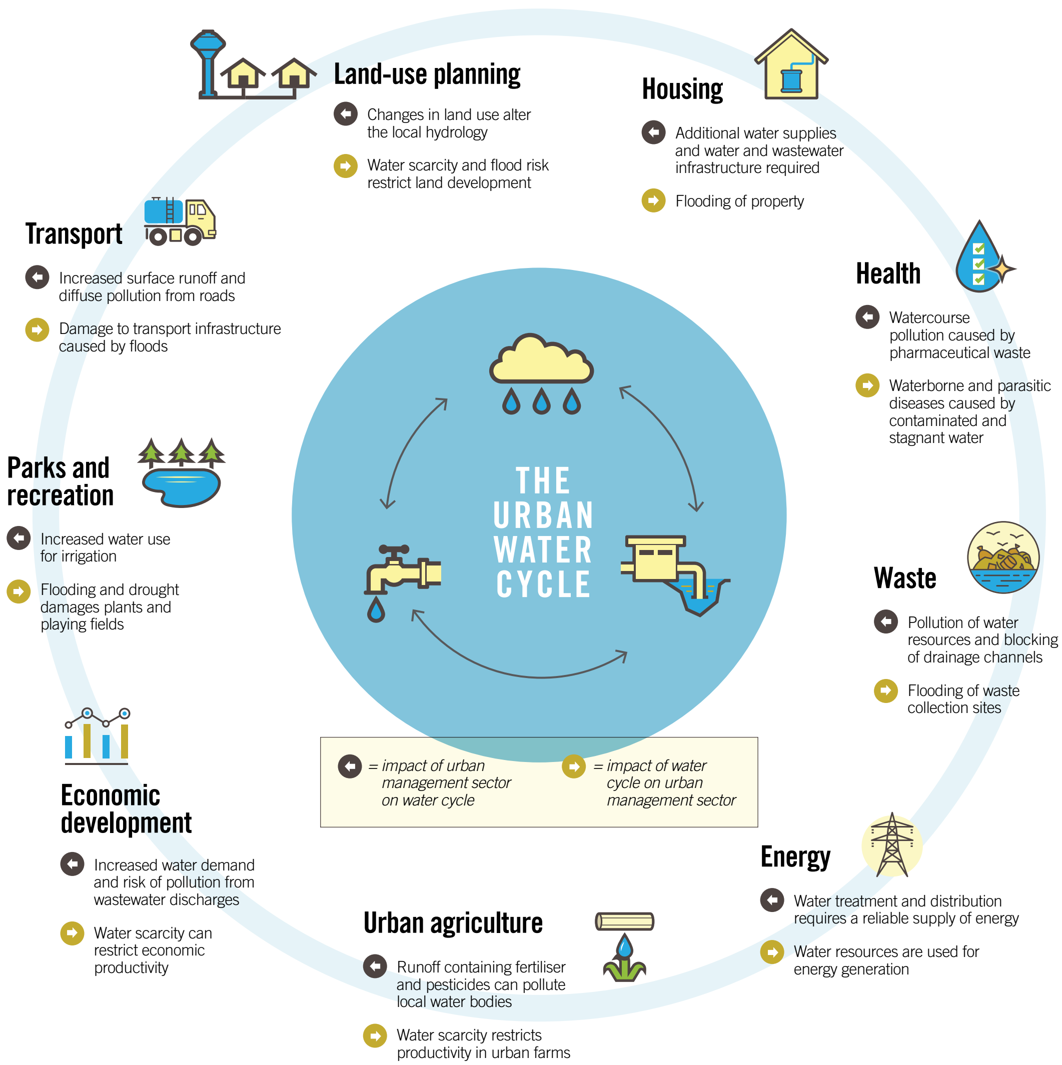
Figure 2 | The One Water continuum



Source: Brown, R. et al (adaptation), 2009.

A common theme in One Water is the support of collaboration between diverse groups. In addition to looking across the water cycle, connecting with other institutional service providers and urban organizations can optimize opportunities for efficiency and joint beneficial outcomes while minimizing negative impacts, as seen in Figure 3.

Figure 3 l Examples of urban water linkages to other urban sectors



Source: SWITCH, 2011.

Traits of One Water

Emerging experience indicates common traits to implementing One Water in cities around the United States and the world. These are outlined in Table 2.

Table 2 | Common traits of a One Water approach

COMMON TRAIT	DESCRIPTION
Collaboration	…with a wide variety of stakeholders and engagement with the community
Economics and finance	…that recognize the true cost of water, prices it accordingly, and are attractive for public and private investors
Green infrastructure	…that works with and mimics nature
Closed-loop systems	…that enhance nutrient and energy recovery and encourage water sensitive behaviors
Built environment	…with multifunctional infrastructure that supplements the natural environment
Enabling conditions	…that foster innovative institutional and management arrangements
Flexible and adaptive	…to allow for innovation and strengthen resilience to climate change and other forces

Source: Howe & Mukheibir, 2015.

1.2 | BENEFITS OF A ONE WATER APPROACH

A recent WRF survey[iii] of 800 water professionals in the United States, Australia, Mexico, and Canada found that participants identified the following advantages of implementing One Water, in order of importance:

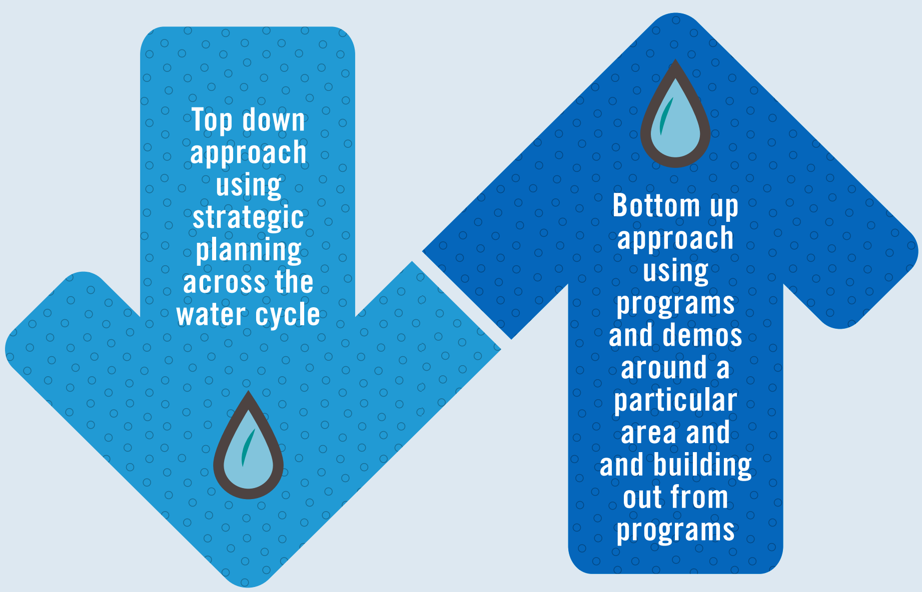
- Greater resilience and reliability;
- Opportunities to optimize regional infrastructure;
- Sustainable community development;
- New regulatory flexibility or opportunity;
- Economic growth opportunity; and
- Increased coordination among agencies/departments.

This same survey found that over 60% of respondents have some knowledge of One Water, but only 16% felt they had experience in its implementation. The WRF findings reinforce the wider societal benefits of implementing a One Water approach.[iv]

1.3 | LEARNING FROM OTHERS' EXPERIENCE WITH ONE WATER

A One Water approach can be initiated at a variety of scales, from the household scale to city or regional scale. Cities can also incorporate One Water in multiple ways, depending on their needs and local context (e.g. growth patterns, climate, and politics). Action can be as broad as looking at the entire system and strategically planning interventions or by taking a particular issue, such as water scarcity, and expanding to other aspects of the water cycle. A top-down approach is generally driven by strong executive leadership, whereas a bottom-up approach is often driven by a core group of passionate professionals.

Figure 4 | Starting points to advance One Water



Source: Authors' analysis

Experiences with One Water around the world

Many cities around the world have begun to strategically plan and implement programs using a One Water approach. Some have taken a purposeful One Water leadership role, encouraged by clear drivers and need.

ROTTERDAM

Living with water

Rotterdam is at the confluence of the Meuse-Scheldt river delta and the North Sea. It is faced with having too much water that often inundates the city after massive downpours. The government of Rotterdam has decided to view climate change as an opportunity to revitalize their city. Infrastructure, like public squares and parking garages, is being designed to help reduce flooding by slowing down and storing water while also providing other multi-functional public uses. This 'Living with Water' approach is improving the vitality and attractiveness of their city.

The drawings illustrate an example of a public square whose use changes with dry conditions (top), after a rain approximately 30 times per year (middle) and during cloud bursts about once a year (bottom).

Source: www.urbanisten.nl

SINGAPORE

Connecting people with water

Public Utility Board (PUB), Singapore's national water agency, has worked to diversify its water sources through the 'Four National Taps' program of desalination, potable reuse (NEWater), local rainwater collection, and imported water. The primary driver for this diversification is water security and reduced reliance on water supplies that are outside of its control. The PUB also has a vision to transform Singapore into a City of Gardens and Water. The 'Active, Beautiful, Clean (ABC) Waters' program is designing infrastructure to be functional but also enjoyable for people. Examples include the "super trees" at the Gardens by the Bay which visually engage the public as they collect rainwater and solar energy, and the Marina Barrage water pumping station which functions as a water education center and provides well-utilized public green space.

Source: www.pub.gov.sg

One Water in the United States

Likewise, several cities in the United States are moving to implement One Water approaches, based on their own unique set of drivers, with momentum increasing as initiatives are shared and benefits understood. Drivers can include regulatory requirements around sewer overflows or impaired streams, water scarcity, persistent flooding, economic constraints or other factors.

PHILADELPHIA

Green City, Clean Waters

Philadelphia's efforts to advance One Water are being driven by an EPA mandate to reduce combined sewer overflows. The Philadelphia Water Department (PWD) is re-thinking the way they manage stormwater by creating living landscapes to slow and filter water before it enters waterways through its Green City, Clean Waters' program. Their goal is to reduce stormwater runoff by 85%. They believe that it is better for the community to manage water in this way because it minimizes rate increases while providing benefits of increased property values and natural habitats along with fueling a green jobs economy. It also will help in reducing the impact of extreme summer heat as well as beautify neighborhoods. PWD collaborates with other city departments as well as residents, private developers, elected officials and environmental advocates. The program is moving from the demonstration phase to a full scale program across the city.

Source: http://phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan

SAN FRANCISCO

Reducing its water footprint

In 2012, San Francisco adopted the Non-potable Water Program, which created a streamlined, inter-agency permitting process allowing the collection, treatment, and use of alternate water sources for non-potable uses in buildings. Spearheaded by the San Francisco Public Utilities Commission (SFPUC), the Non-potable Water Program supports San Francisco's One Water approach of matching the right water source for the right use and looking holistically at the utility's services to develop programs and policies that provide multiple benefits to conserve resources and promote ecosystem health. Leading by example, the SFPUC installed a Living Machine treatment system in their headquarters building that treats all of the building's blackwater for toilet and urinal flushing. The wetland treatment system reduces the building's potable water consumption by 60%, lowering per person water use from 12 gallons to 5 gallons. The SFPUC building also has a 25,000 gallon rainwater harvesting system that provides water for irrigation around the building.

Source: San Francisco PUC

LOS ANGELES

Collaborative One Water planning

Los Angeles has embraced the concept of One Water as the foundation of its collaborative planning across government agencies. The One Water LA 2040 plan provides a framework, vision and implementation strategy to meet the region's near- and long-term water supply. It also provides a strategy to meet the mayor's directive to reduce imported water by 50% by 2024. The city's guiding principles are linked to seven One Water objectives:

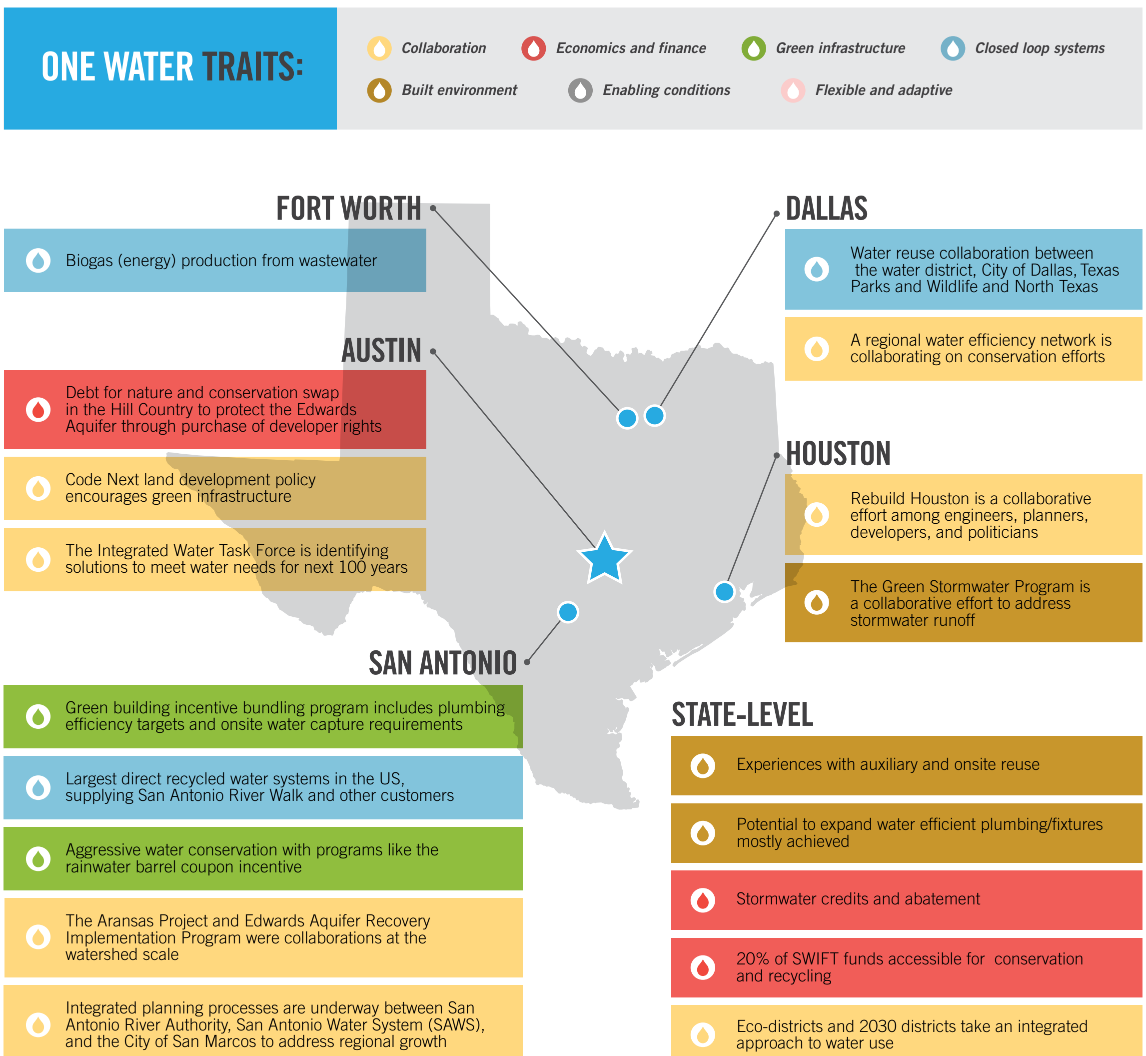
1. Integrate water resource management and policies by increasing coordination between all city departments, partners, and stakeholders.
2. Balance environmental, economic, and societal goals by implementing affordable and equitable projects that provide multiple benefits to communities.
3. Improve health of local watersheds by reducing impervious cover, restoring ecosystems, decreasing pollutants in waterways and mitigating local flood impacts.
4. Improve local water supply reliability by increasing stormwater capture, conserving potable water and expanding water recycling.
5. Implement, monitor, and maintain a reliable wastewater system that safely conveys, treats and reuses wastewater while also reducing sewer overflows and odors.
6. Increase climate resilience by planning for climate change mitigation and adaptation strategies in city actions.
7. Increase community awareness and advocacy for sustainable water by active engagement, outreach and education.

Source: One Water LA 2040 Plan, 2015

1.4 | EMERGING ONE WATER EXPERIENCE IN TEXAS

This research mapped a variety of activities in Texas that align with One Water principles and traits, as seen in Figure 5. Several examples of collaboration were identified, as were new technologies such as closed-loop systems, expansion of green infrastructure, and innovation in the built environment. Some aspects of innovative finance are being explored, such as the creation of stormwater utility districts and allocation of state funding for conservation and recycling.

Figure 5 | Examples of Texas One Water aligned activities



Source: Authors' analysis

Margaret Hunt Hill Bridge spanning the Trinity River at twilight, Dallas, Texas

2 WHAT'S DRIVING THE SHIFT TO ONE WATER IN TEXAS?

Texas's 2012 State Water Plan notes that under certain conditions, Texas does not, and will not, have sufficient water to meet the requirements of its people, businesses, and agricultural enterprises.[1] This section outlines key trends which are contributing to the state's water supply challenges, which can be seen as drivers for One Water approaches in Texas's cities.

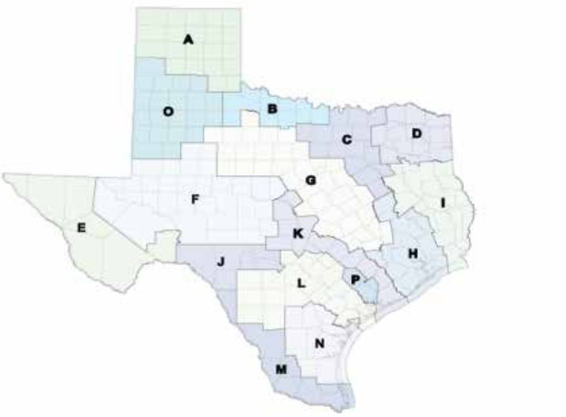
1 For example, the 2017 State Water Plan has a useful analysis of key drivers of water scarcity in Texas. See: https://2017.texasstatewaterplan.org/statewide.

Ann and Roy Butler Hike-and-Bike Trail and boardwalk at Lady Bird Lake Austin, Texas

2.1 | A TEXAS-SIZED POPULATION GROWTH RATE

According to the 2017 State Water Plan,[v] overall population is expected to increase by 70% between 2020 and 2070, i.e., from 29.5 million to 51 million. However, population growth will not be evenly distributed. Considering the sixteen regions represented in the State Water Plan (Figure 6), over half of the total population increases are expected to happen in Region C – Regional Water Planning Area, which includes the Dallas-Fort Worth metropolitan area and surrounding counties, and Region H, which includes Houston and surrounding counties. Other fast-growing regions include Region L – the South Central Texas Regional Water Planning Area (major cities include San Antonio, Victoria, San Marcos, and New Braunfels); Region M – Rio Grande Regional Water Planning Area (major cities include Brownsville, McAllen, and Laredo), and Region G, the Brazos Regional Water Planning area (major cities of Abilene, Waco, and College Station).

Figure 6 | Texas's regional planning areas



Source: Texas 2017 State Water Plan

2.2 | POPULATION GROWTH IS ACCOMPANIED BY URBANIZATION AND SPRAWL

A complementary force to population growth is urbanization. A few decades ago, Texas was a predominantly rural state. Now, 85% of the population lives in urban areas.[2] This includes substantial suburban population increases as well as expansion in smaller towns that are within commuting distance to the larger metropolises. The state's landscape has few natural boundaries to promote density and prevent sprawl, which is compounded by minimal land use planning and zoning requirements that favor private property rights' holders. Texas's business-friendly environment[3] is also a force for population growth, as major companies including Toyota, Frito Lay, Google, and Oracle, have in recent years shifted their headquarters or expanded into Texas. Put in perspective, five cities in Texas are in the top eleven cities in terms of national urban population growth.[4]

Water shortages are projected to begin as early as 2020, with a statewide shortage of close to 9 million acre feet by 2070.

Texas's urbanization has resulted in the substantial loss[5] of open, permeable surfaces to impermeable ones, like roofs and roads. This adversely affects watersheds by decreasing natural drainage, and increasing the impact of polluted runoff from rainwater events. Communities are likewise impacted economically and socially to devastating effect during flood events.

Water demand in Texas exceeds supply, even using different assumptions around use

State-level, 50-year projections of water demand and supply in Texas are based on self-reported data generated through the regional planning process. In 2012, The Texas Center for Policy Studies (TCPS) wrote a study critical of the 2012 State Water Plan, suggesting that it over-estimates future water demand and under-estimates supply. The State Water Plan's demand projections were compared with other data sources projecting irrigation and electricity water use, and revised estimates for per-capital municipal water use that are more in line with national standards, to 140 gallons per capita per day. The study also "found" 1.5 million gallons per day by analyzing drought management plans included in the State Water Plan against alternative approaches. By changing a few underlying assumptions, the variance in the water demand/supply gap between TCPS's study and the State Water Plan exceeded 5 million gallons a day.[6] The study illustrates the role of assumptions in making projections in any model, and how changing assumptions about water management can lead to very different policy recommendations. Whereas the sizable gap of over 8 million gallons per day could be used as the basis for policy promoting new pipelines and reservoirs, a gap of under 3 million gallons per day could become a rallying cry for policies that promote greater water efficiency.

Source: http://www.texascenter.org/water/Learning%20From%20Drought%20Final.pdf

2 See: http://www.oocities.org/tex_sfa/urbanareas.htm.

3 For example, see: http://www.areadevelopment.com/stateResources/texas/diverse-companies-seek-texas-pro-business-environment-909077.shtml.

4 http://www.census.gov/newsroom/press-releases/2016/cb16-81.html. The combined metropolitan area Houston–The Woodlands–Sugar Land added about 159,000 people, more than any other metro area in the country. See: http://www.census.gov/newsroom/press-releases/2016/cb16-43.html.

5 A 2003 study from the University of Connecticut found that levels of impervious land in a watershed affected all water characteristics the team studied. Some studies suggest that paving over anything above 10 to 20% of the landscape is bad for the water; others put the concentration much lower for fish populations, for example. Estimates of the percentage of impervious surface in urban areas range from 50% of moderately dense suburban dwellings to over 94% in Mid-Manhattan West. Source: http://blogs.ei.columbia.edu/2010/07/13/no-more-pavement-the-problem-of-impervious-surfaces/.

6 For example, pools and lawns are demanded but not necessarily needed.

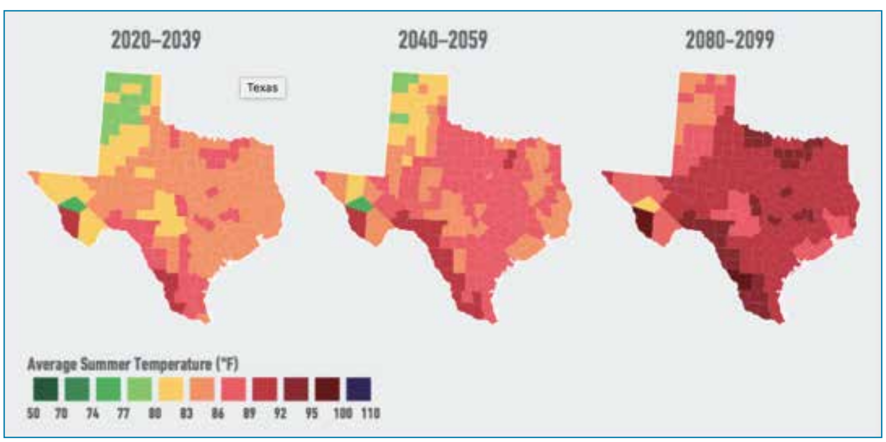
2.3 | PROJECTED WATER DEMAND EXCEEDS WATER SUPPLY

A growing population often implies higher water use, and in Texas's most recent 50-year projection, demand outstrips current supply. Water shortages are projected to begin as early as 2020, with a statewide shortage of close to 9 million acre feet by 2070. According to the 2017 State Water Plan, municipalities face the greatest potential shortages when compared to irrigation, electric power, livestock, manufacturing, and mining. Also, water supplies are expected to decline by 11% between 2020 and 2070,[vi] reducing overall supply and the ability to respond to drought.[7] In 2012, the State Comptroller's Office stated that not meeting projected demand could result in the loss of over a million jobs and reduce state revenue by $116 billion by 2060, illustrating the importance of a secure water supply for economic development as well as basic human needs.

2.4 | TEXAS'S CLIMATE IS HIGHLY VARIABLE AND CHANGING

Texas has a long history of variable and extreme weather. Its drought and flood events[vii] have shaped water use and management throughout the state, from the arid west to the more humid/wet east. This high level of inter-annual variability is challenging to model and predict. Climate change presents additional complexity,[8] with expected higher—and more extreme—average temperatures. This variability presents challenges for water managers and service providers for whom reliability and stability are paramount. For example, Figure 7 shows projections from the American Climate Prospectus, of average summer temperatures between 2020 and 2099.

Figure 7 | Projected average summer temperatures, 2020–2099



Source: American Climate Prospectus, cited in:
http://riskybusiness.org/report/come-heat-and-high-water-climate-risk-in-the-southeastern-u-s-and-texas/

7 There has been a 40% reduction in per capita water storage since the 1980s. See: http://www.beg.utexas.edu/research/programs/the-water-energy-nexus/water-and-power-generation.

8 The following website offers useful visuals about the impacts of climate change in Texas. See: https://www.texasobserver.org/climate-change-means-texas-11-charts/.

Temperature increases can contribute to economic losses, as seen in figure 7. These increases present a clear challenge for water planners and policy makers but also those who provide energy and other public services in Texas. For example, as temperatures rise, demand for air conditioning increases, which in turn increases energy demand, even as the increased temperature makes generating and transmitting energy less efficient. Electricity generation relies on large quantities of surface water. In fact, the energy sector is the largest user of surface water in the State,[9] representing 45% of all use in 2000.[10]

Effects of climate change and the energy/water nexus

According to Risky Business, a philanthropy-backed project to assess the economic impacts of climate change in the United States, increased temperatures in Texas will result in increased electricity use and health impacts. Economic losses associated with climate change are estimated to reach up to $12.5 billion per year. The analysis suggests that by 2020–2039, electricity demand from residential and commercial energy customers will increase by 7% in the 2020–2039 period and by 12% in the 2040–2059 period. Translated into monetary terms, these projections suggest expenditures on energy to be $3.7 billion per year by 2050, with a 5% chance of expenditures reaching as high as $5.3 billion.

Source: https://riskybusiness.org/report/come-heat-and-high-water-climate-risk-in-the-southeastern-u-s-and-texas/#

2.5 | LIMITS TO WATER SECTOR FUNDING

The 2017 State Water Plan estimates that up to $73 billion will be needed to meet Texas's water needs in 2020, and reach $151 billion by 2070. Appreciating the constraints of a bottom-up planning approach, where proposed projects are listed by region, though not prioritized, the estimates still exceed the potential scope of SWIFT and the State Water Implementation Revenue Fund of Texas (SWIRFT). SWIFT and SWIRFT were established in 2013 through a constitutional amendment, which transferred $2 billion from Texas's Rainy Day fund to support water projects around the state, and that hopes to leverage $27 billion for water projects over the next 50 years. State funding could contribute just 17% of the projected Texas water funding needed over the next 50 years.

Prior to the 1980s, federal grants were the predominant funding source for large-scale water storage and conveyance systems. Expenditure was justified by the multiple public benefits for agriculture, industry, and municipalities. Since 1980, federal investment in water has drastically decreased,[viii] and current funding is primarily through loans, not grants, making large-scale infrastructure more expensive.[11] Municipal finance for water projects is also constrained. Between 2009 and 2014, public spending on water infrastructure declined,

9 Notably, thermo-electric plants that are common in Texas recycle much of the water they consume. See: http://www.beg.utexas.edu/files/content/beg/research/water-energy-nexus/ThermoelectricWaterProjection.pdf.

10 Irrigation is also a large-scale user, representing 21% of total water withdrawals in 2000; however, it uses groundwater. See: http://www.beg.utexas.edu/files/content/beg/research/water-energy-nexus/ThermoelectricWaterProjection.pdf.

11 The above analysis was contributed at the workshop and has not been validated in the literature.

12 See: https://www.texastribune.org/2015/03/05/rising-local-debt-draws-attention-legislature/.

and by 2015, Texas held the second-highest level of local debt per resident, of the ten most populous states.[12] Despite recent efforts to bring water rates in line with costs, the ability of water managers to maintain existing assets is limited, given rising costs and political pressure to keep water prices low.

The above suggests that while traditional, centralized infrastructure may be politically preferred to meet growing demand (e.g. in Texas, large pipelines and reservoirs are still touted as a primary solution to meet long-term supply needs), in practice, these may not be feasible, particularly when more flexible, cost-effective alternatives are available. This limits the possibility of raising public debt for water infrastructure. Further, despite recent efforts to bring water rates in line with costs, such tariff increases are politically challenging, even if they are needed to maintain existing assets.

State funding could contribute just 17% of the projected Texas water funding needed over the next 50 years.

3

Santa Elena Canyon
Big Bend National Park, Texas

WHAT HINDERS ADOPTION OF ONE WATER?

3.1 | INSTITUTIONAL BARRIERS TO ADVANCING ONE WATER

Experience suggests that in most situations where One Water is making progress, it is not a lack of technology that hampers advancement. Rather, inertia among institutions slows progress. This section provides an overview of global experience of institutional barriers before offering a more focused and nuanced analysis of what is happening in Texas.

Dominant institutional models for urban water management in the United States and around the world were designed and have evolved to support and perpetuate large-scale, centralized infrastructure. As a result, water management is siloed into separately managed drinking water, wastewater, and stormwater systems. In the United States, these are reinforced at every level of government, from the Clean Water Act and Safe Drinking Water Act at the federal level, to water rights, regulation, and finances that are managed at the state level, and the fragmented nature of how local utilities and city agencies are organized. Water resource allocation and management is also influenced by agriculture, industry, and ecosystem management, often in ways that are separate from the decisions made by water utilities and community advocates sharing the same watershed.[ix]

Because institutional structures were not designed to support integration and collaboration, barriers to mainstream a One Water approach exist at the strategic, tactical, and operational levels within a city and across public and private sectors at local, regional, state, and federal levels. At a local level, these barriers often limit an organization's ability to collaborate vertically and horizontally to achieve common objectives, or even to integrate activities internally to achieve common goals. The potential to advance the adoption of new technologies and approaches to alleviate pressure on existing and exhausted water infrastructure is then also

While traditional, centralized water infrastructure may be politically preferred to meet growing demand, in practice, traditional approaches may not be feasible.

limited (e.g. optimizing green-grey infrastructure and resource recovery). At a city scale, the lack of a unifying vision for water, and shared values for its various uses, stifles opportunities for collaboration and integration, even where there are natural synergies, as with stormwater and transportation, or treatment and wetlands/parks. This is also reflected in state and federal institutional structures that work to support municipalities, and in particular, how water infrastructure is financed.

The institutional structures in place that define and govern water use are biased towards large-scale, centralized infrastructure systems and delivery models.

In many places, adoption of One Water traits occurs in reaction to regulatory drivers. For example, health and economic impacts from flooding are accelerating interest in new approaches to stormwater management. Likewise, growing concerns about wastewater pollution is influencing policies and programming to consider wastewater as a resource, not a byproduct. There are myriad examples of innovation in reaction to an immediate challenge, illustrated in the many bottom-up approaches mentioned throughout this document. Far less common is a proactive, holistic systems approach to management that is more in line with top-down strategic planning across the water cycle.

In Texas, aspects of One Water are actively being pursued, with innovation taking place across the water cycle, across urban departments, and across public and private sectors. Texas has exhibited an ability to adopt large-scale demand management as well as reuse, even adopting direct potable water recycling in Wichita Falls and Big Spring. Technology to make better use of existing resources and to capture new sources of supply is being developed and deployed in various contexts across the state. Investors are looking to fund new technologies and products to better meet urban demand, at both household and commercial scales. These efforts are largely small-scale, and the dominant institutional structures that define and govern the management and use of water still bias large-scale, centralized infrastructure systems and delivery models.

Using One Water traits (Table 2, page 17), we considered limiting factors to advancing One Water in Texas through the following institutional lenses:

- **Professional culture and societal values.** Professional culture requires diversification of disciplines and methods to encourage collaboration and innovation across nontraditional aspects of the water cycle as it relates to urban management. It also refers to how public, private, and civil society interacts and collaborates. Societal values relate to advancing consumer/citizen attitudes and behaviors around water, particularly towards valuing efficiency and supporting reuse.

- **Policy and planning.** State and city level policy establishes boundaries for water management and often inhibits collaboration and integration. Planning sets a course for long-term investment and action by utilities and city managers as well as private investment. A policy and planning environment that is informed and supportive of risk taking to plan for future water scarcity requires several characteristics that are indicative of a One Water approach.
- **Laws and regulations.** Water law is the foundation of how water is sourced and used by cities. This influences how it is managed and delivered, while a regulatory framework puts in place protections for various interests, such as human health, economic development, and social equity. One Water approaches may raise questions about water law, including the legal basis for stormwater and/or auxiliary water. It may also spur innovation around the use of water. Supportive regulatory frameworks are also critical. They often bias traditional water management and limit opportunities for replication and mainstreaming of successful experimentation and innovation at a pilot or a demonstration scale.
- **Economics and finance.** Economics often connects conceptual planning with a financed project. Economic analysis offers an opportunity to test assumptions about costs and benefits over time, often using historical data. Cities around the world, and in Texas, are grappling with how to plan for long-term water investment based on precipitation models that are increasingly inaccurate. Acceptance of new models that reflect more current water availability is slow in a sector that is naturally conservative about risk. Considering finance, traditional investment models for urban water bias public debt and grants for capital expenditures from state and, historically, national sources. A One Water approach, with its bias towards flexible, decentralized, and distributed delivery models, creates possibilities for private debt and equity, whether for infrastructure or for products and services.

The following section offers a review of the institutional environment in Texas as it relates to adopting One Water, through these four lenses.

3.2 | PROFESSIONAL CULTURE AND SOCIETAL VALUES

Professional culture refers to the knowledge, attitudes, and practices of professionals engaged in all aspects of securing, delivering, and managing water across the water cycle and within the urban environment. For example, the technical training and education backgrounds reflected in the water sector workforce can strongly influence whether collaboration is practiced and incentivized within a utility's many departments and across a city's agencies. By contrast, the extent to which ratepayers are aware

In many respects, the mindset of professionals working in water is where One Water approaches begin.

of the full cost to deliver a quality water service and their willingness to pay for it reflects a societal value. Societal values are also reflected in the extent to which citizens support and vote for politicians and policies to meet current and future water needs.

Both professional culture and societal values influence other institutional factors in diverse ways. Whether nontraditional mindsets are supported and championed within their professional cultures, as well as by the wider citizenry, is key to whether One Water will gain traction as a new paradigm for water management.

While the professional culture is experiencing a shift in mindset, societal values lag behind.

The professional culture of the water sector in Texas is vibrant and networked, with a range of organizations and individuals representing public, private, and civil society interests who seem to know, or know of, each other. However, engineering and legal professions dominate the mostly siloed institutions that support traditional water infrastructure. Still, awareness of One Water and a willingness to learn and experiment is growing, supported by a wider political and professional culture. Austin's mayor and city council commissioned an Integrated Water Task Force to design an Integrated Water Resources Plan to meet supply and demand challenges for the next 100 years, suggesting high-level awareness and leadership. In Houston, a mayor-appointed "Flood Czar" was appointed to meet that city's pressing stormwater management challenges using integrated approaches. In San Antonio and Dallas, utilities are collaborating with other urban departments across the water cycle, connecting water supply with treatment and reuse (e.g., use of biosolids). Utility departments are communicating to identify ways to achieve common objectives. For example, in Austin this collaboration is taking place between the utility and the watershed protection department around use and benefits of stormwater for ecosystems and water supply. In addition, there is some evidence of private sector engagement and interest through the private sector-led Architecture 2030 district initiative,[13] which includes three Texas cities within its 17 US city portfolio (Austin, Dallas, and San Antonio).

If the professional culture is experiencing a shift in mindset, societal values lag behind, perhaps owing to the following challenges:

- Texas's primacy of private property rights and low levels of regulation around development are ultimately reflections of societal value and pose a risk and barrier to One Water approaches. This is particularly true in situations where higher levels of regulation on water quality are needed, or where restrictions on development are being considered to protect watersheds.

13 For more information about the 2030 district initiative, see: http://www.2030districts.org.

- Consumer behavior is not drought tolerant, and there is a low societal value placed on water in its different uses, despite decades of educational and awareness-raising campaigns. While behavior does change during times of drought, the "stickiness"[14] of conservation messages across precipitation cycles is low. In drought-prone areas such as Dallas/Fort Worth, ratepayers prioritize irrigated lawns, while advocating for lower tariffs.[x]

Texas's primacy of private property rights and low levels of regulation...pose a risk and barrier to One Water.

One Water approaches can be advanced within cities without involving ratepayers directly. However, efforts that make water more visible to ratepayers—as seen in the examples for Singapore and Rotterdam (see page 17), for example—can stimulate a virtual cycle of demand for integrated water practices.

Water conservation such as increasing efficiency is increasingly accepted as a way to meet growing demand, but ratepayers prioritize irrigated lawns in drought prone areas.

3.3 | POLICY AND PLANNING

Policy and planning processes emerge to establish rules for development that are in line with a long-term vision as well as the law.[15] Because water allocation and governance affects all facets of economic, social, and environmental needs, One Water approaches have seen the most success when conducted in an open and collaborative way. Several cities in Texas have experience with this approach in the creation of sustainable development vision statements and plans (e.g., Austin's Imagine Austin Comprehensive Plan;[16] San Antonio's SA2020 Plan[17]). While planning processes can be visionary and inspiring, delivering on the plan depends on a supportive institutional environment. Key policy and planning challenges to advancing One Water include:

- **The bottom-up and regional nature of statewide planning processes for surface water and groundwater.** Since 1961, the Texas Water Development Board (TWDB) has conducted ten cycles of planning to ensure the state's supplies and demands are understood. More recent planning processes have added tools and data to support the regions as they develop their plans. While the process maximizes local ownership, it is also fragmented, as the state has little control over what regions and local councils agree to do, or the science and data used to inform their decisions.

14 As per the World Resources Institute's Aqueduct Water Risk Atlas.

15 There are three key senate bills for water: Senate Bill 1, Senate Bill 2, and Senate Bill 3. Senate Bill 1704 is also a landmark piece of legislation around the grandfathering of groundwater rights. The Water Code and various city ordinances are also relevant for local-level water policy.

16 See: http://www.austintexas.gov/department/imagine-austin.

17 See: http://www.sanantonio.gov/sustainability/SA2020.

- **Groundwater and surface water planning processes are independent from each other, even in the same watershed.** This is a challenge for "whole-water-cycle" planning and investment, given the diversity of interests and institutions involved.

- **Surface and groundwater planning processes use self-reported demand, not need, with less consideration (if any) for environmental flows.** While water conservation efforts like increasing efficiency are accepted as a way to meet growing water demand, planning processes are only just beginning to incorporate environmental flows. It is unclear whether planning processes account for changes in demand as a result of drought, flood cycles, or cost increases. In particular, demand projections are built on estimates that reflect all wet-year uses during the drought of record. According to the Texas Living Waters Project, this results in over-estimated demand projections and cost estimates.[xi]

- **Limited funds for long-term measurement and monitoring.** State and regional planning processes are not supported with funds for monitoring and measurement so as to strengthen water management over time.

- **Political boundaries often result in overlapping and confused accountability.** In practice, groundwater districts are established around political boundaries, not aquifers.[18] Likewise, urban utilities are asked—or compelled—to provide services beyond city boundaries to outer counties and unincorporated districts, where mayor and/or city council-backed policy processes may not be applicable.

- **Statewide planning processes are directly connected to state funding allocations.** SWIFT[19] is a $2 billion fund created in 2013. It was designed to offer finance for water infrastructure projects that are included in the bottom-up regional planning process. While connecting local planning with state-level funding is useful, it is also limiting to cross-regional projects, projects promoting regional efficiency, or those in need of funding between the five-year cycles.

Water conservation such as increasing efficiency is increasingly accepted as a way to meet growing water demand, yet planning processes are only just beginning to incorporate environmental flows.

Policy and planning processes also present a few specific professional culture and societal challenges to advancing One Water in Texas cities:

18 Groundwater management areas, another layer of governance, are more aligned with aquifer boundaries, and their relationship with groundwater districts is evolving.

19 In 2013, SWIFT was created by the legislature through a one-time, $2 billion allocation from the state's Rainy Day Fund, and first projects were funded in 2015. SWIFT is expected to leverage revenue bonds over the next 50 years to finance approximately $27 billion through 2065. SWIFT funds are intended to primarily support infrastructure, with 20% allocated for conservation projects.

- Concerns have been raised over the roles that engineering firms play in local and regional planning processes to identify projects and then execute those projects. Specifically, there do not appear to be any conflict of interest/disqualification guidelines for firms offering planning and implementation services.

- With respect to policy, although many cities have adopted tiered pricing schemes and drought management policies, water service providers do not use caps on water use to address absolute water scarcity.[xii] This policy choice, coupled with relatively low tariffs and the lack of awareness about a city's water balance,[20] perpetuates a sociocultural mindset about water use that is based on willingness to pay. When coupled with traditional economic thinking that is embedded into utility models, and a legal framework that actively discourages conservation, there is a risk that One Water approaches are seen as emergency measures only and not "normal" operating practice.

- There is also a professional-political disconnect in how state level policies and regulations and regional planning processes are experienced by urban and rural constituencies. Often discussions about regulation get distilled into questions of private ownership and individual rights. This plays out in the legislature and the political ambitions of elected officials and their challengers in multiple ways. For example, some elected officials and developers call for building additional reservoirs and pipelines to meet urban demand, despite pushback from rural communities and citizens that oppose pipelines crossing private property, as well as perceive these efforts as a water grab.[21,xiii] This could present an opportunity for urban One Water advocates to forge alliances with rural areas.

3.4 | LAWS AND REGULATIONS

In Texas, water law and related regulation is messy and adaptive, based on and informed by, among other factors, cycles of drought and electoral politics. The basis for Texas water law was established last century, when Texas was predominantly a rural state. Further, 98% of the state's land is privately owned. As a result, the judiciary appears to be concerned primarily with issues of water ownership and tort cases relating to water use.

Texas's water laws—particularly groundwater law—are not science based, which creates out-sized sustainability risk.

20 A water balance is an analytical approach used to describe flow of water into, changes in water storage, and flow out of a system and can be conducted across multiple scales. At a city scale, a City Water Balance (CWB) can be developed to model a city's total water balance, including natural and man-made systems, as a basis for scenario planning to inform development. For example, see: http://www.switchurbanwater.eu/outputs/pdfs/W2-3_GEN_PHD_CWB_MSc_Thesis_-_Spencer.pdf.

21 Two examples of this: Dallas is considering huge stormwater pipes, but climate change could mean that flooding isn't happening where it "normally" happens. See: http://tinyurl.com/j5balj2.

Groundwater law dates back to 1904, when the Texas Supreme Court ruled[22] in favor of common law rule of capture and not rule of reasonable use, which means that a landowner can pump groundwater from their land without limit, irrespective of whether such pumping damages their neighbor, except in cases of malice, waste, subsidence, or limited cases of trespass. At the time, groundwater was not well understood. Now, much more is known about aquifer flows, volumes, and the interface between surface and groundwater. However, this "science knowledge" is not readily translated into practice in water planning and policy. Meanwhile, surface water is owned by the state and can be used with permission, via water rights, under a prior appropriation doctrine. While surface water law is widely perceived as more established than groundwater law, the number of water rights allocated by the state exceeds the volume of streamflows in many watersheds, and in most cases, monitoring of the activities of water rights holders is limited. While there is ample literature on groundwater and surface water law in Texas,[23,24] a few areas where One Water approaches could face legal and regulatory hurdles include:

- The legal framework for capture and use of stormwater before it discharges into a surface watercourse is limited and novel.[25] Questions of who owns stormwater and legal distinctions between rainwater and stormwater are not well established through legislation or regulation, and may result in lawsuits and judiciary involvement.
- The use of wastewater effluent could raise legal issues among upstream and dependent downstream users. For example, concerns have been raised about the Dallas Metropolitan area expanding water recycling capacity to the detriment of the Trinity River, a supply of growing importance to Houston.

Questions of who owns stormwater and legal distinctions between rainwater and stormwater are not well established through legislation or regulation.

- Use of Aquifer Storage and Recovery (ASR) to increase water storage during times of drought or to capture "overflow" in terms of treated stormwater. San Antonio's ASR is often heralded as a drought insurance policy. However, the ability to store a "firm" yield of water from an ASR project depends on having a closed aquifer with limited (or no other) users. As municipalities seek alternatives to large-scale reservoirs for water storage, the legal basis for storing and using underground water may require clarification and testing.[26]

22 Houston & Texas Central Railroad Co vs. East, as cited in http://tinyurl.com/hmvrye7.

23 See: http://texaswater.tamu.edu/water-law.

24 A summary of all the landmark cases relating to groundwater law in Texas can be found at: http://tinyurl.com/hmvrye7.

25 Notably, the Texas Environmental Flows Working Group is exploring these questions as relates to policy.

26 For additional information, see: http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/0904830940_AquiferStorage.pdf.

In addition to these hurdles, there are professional culture and societal values at play, namely:

- Texas's water laws—particularly groundwater law—are not science based, which creates out-sized sustainability risk when private interests are not aligned with conservation. Despite technological advances for monitoring and metering water use, there is little support in the legislature to fund monitoring. Many groundwater districts are unaware of how much water is pumped each year, nor how much water is left. Rights are allocated based on historical use, and in practice, are granted in perpetuity. Where private interests are in conflict with conservation goals, for example, in the emerging market for water transfers from rural to urban areas, the legal framing may present a barrier to integrated approaches. While conservation easements and land trusts are useful, they are also limited in their ability to protect underlying aquifers.

There appears to be a preference for settling water disputes through the court system.

- Legal backgrounds are prevalent among Texas's water sector professionals, in policy and planning as well as advocacy and financing. There appears to be a preference for settling water disputes through the court system. Texas courts are heavily involved in water law, particularly as it relates to property and torts. Water lawyers are also prominent in policy, planning, and advocacy roles throughout the sector. This is because water is both a public and private element in the hydrological cycle, in a state where private property is considered paramount. While legislative advances that aim to accelerate One Water approaches may pose a risk of being challenged in court, the abundance of trained lawyers working on behalf of conservation goals also offers an opportunity to change the law to meet twenty-first century water management needs.

- Lawsuits may catalyze consensus-based collaboration around conservation. In a few cases, surprising institutional collaborations around water use emerged when organizations were forced to do so by law. Two clear examples of this are the Edwards Aquifer Recovery Implementation Plan[xiv] and the Guadalupe-Blanco River Authority (GBRA) and The Aransas Project's (TAP's) agreement to work together to protect the Guadalupe River watershed, San Antonio Bay, and the last remaining flock of whooping cranes that winter on the Texas coast.[xv] Today, both are heralded as conservation successes, for a number of endangered species in the former, and the whooping crane in the latter. Each began with long-fought legal battles. This is also the case in the "truce" between Save Our Springs Alliance and the Real Estate Council of Austin,[xvi] suggesting that when an integrative, collaborative approach is achieved, One Water implementation is possible. On the other hand, whether such collaboration is possible without lengthy prior conflict remains questionable.

Reflections on the Edwards Aquifer Recovery Implementation Program (EARIP)

The creation of EARIP ensures water flows to protect endangered species in the San Marcos and Comal Springs, which in turn, protect downstream users in the Guadalupe River. Creating EARIP took a consensus-based approach that involved a spectrum of stakeholder interests in its design. How EARIP came about offers useful lessons for stakeholders who are interested to advance One Water principles in urban water management.

- First, the consensus-based recovery implementation plan was fifty years in the making as a last ditch effort to avoid federal takeover of aquifer management. It followed several failed attempts to find a "solution," with particular conflict between the Guadalupe River Authority and San Antonio Water System (SAWS), with the river authority championing stronger aquifer management to conserve its [downstream of the springs] supplies, and SAWS, which sought to preserve the status quo.
- Next, by the time the consensus process started in 2007, the Edwards Aquifer Authority (EAA) was well-established, with rule of capture suspended in the EAA groundwater district for over ten years. In other words, even though there were significant differences of opinion around how to move forward, all stakeholders were already familiar and operating under a new regulatory approach.
- At the outset of the process, stakeholders paid considerable attention to what data they should use, and what science (and scientists) could be trusted as honest brokers. Ultimately, the group agreed to use best available science and a peer review process, which was intended to remove politics from any given scientist or team of scientists' data / analysis.
- Once core concepts for EARIP were successfully negotiated, continued negotiations nearly broke down over who would fund the program. Expectations for federal funding were not met, and debates over fairness and equity were deadlocked by an earlier legislative action, which established rate caps for irrigators and not for other users, who now pay orders of magnitude more for the same water.

In reflecting on the success of the EARIP process, Robert Gulley, the facilitator and author of a history/memoir on the subject, notes that the plan ultimately arose because of the commitment of individuals and agencies to the process. He somberly notes in his conclusion that "[I]t is not likely that the working relationships we have forged and the momentum we have achieved will ever happen again." This raises two questions worth examining in the context of pursuing collaborative approaches to achieve One Water. First, to what extent do those working relationships transcend the individuals and become firmly ingrained in an institutional culture? And second, how firmly established are the results of EARIP in the face of potential changes to underlying legislation, in this case, the Endangered Species Act?

Source: Gulley, Robert L. Heads Above Water: The inside story of the Edwards Aquifer Recovery Implementation Program. Texas A&M University Press, 2015.

When an integrative, collaborative approach is achieved, One Water implementation is possible.

3.5 | ECONOMICS AND FINANCE

Economics and financing for One Water approaches present multiple hurdles across the spectrum of planning and development processes, from discussions on whether an individual project or program is economically viable to whether it is financially feasible—and of interest—to potential public or private investors. Areas where One Water approaches in Texas could face challenges include:

- **Economic models for evaluating water investments bias large-scale investments** and do not factor the many other benefits associated with One Water approaches. Assumptions are based on historical data and asset performance and are conservative in nature. Further, water prices do not reflect scarcity risk or opportunity cost, which could dramatically alter the business case for One Water investments. Notably, in 2014 the legislature transferred responsibility of economic regulation and determination of rates for water and sewer utilities from the Texas Commission on Environmental Quality (TCEQ) to the Public Utility Commission (PUC), which also regulates the electric and telecommunications sectors. The legislation also created more flexibility in rate making, which could also be an opportunity to account for the needs of diverse service providers.[xvii]

- **Current economic valuation models also inadequately account for the energy costs and benefits associated with alternative water projects**,[27] nor do energy projects account for costs associated with water scarcity, despite the high water intensity of Texas's current power generation and transmission systems. Understanding the intersection of water and energy needs in economic models—and implications of meeting those water and energy needs—is of increasing importance for state planning processes as well as for financing either water or energy projects. This understanding could increase opportunities for One Water approaches and acceptance.

Water prices do not reflect scarcity risk or opportunity cost, which could dramatically alter the business case for One Water investments.

- **State-level funds through SWIFT are only available to projects that are included in the five-year planning process.** SWIFT exists to support water infrastructure investment, and at a state level, its support for municipal water management strategies is impressive. In fact, the 2017 State Water Plan includes $8.1 billion more than the 2012 plan, with 20% targeted for conservation activities. The availability of financial resources reflects an acknowledgment that the state's long-term water future is not secure and creates an opportunity for One Water models and conservation-minded infrastructure to receive

27 For example, while pumping and treating water and wastewater has high-energy intensity, it has also contributed to the growth of energy and resource recovery of wastewater through bio-solids and methane capture.

Understanding the intersection of water and energy needs in economic models is of increased importance for state planning processes, as well as for financing either water or energy projects.

funding. Still, SWIFT's reliance on project lists that are included every five years in the State Water Plan creates a time lag on innovation that could be a barrier for One Water acceptance.

- **A single agency/siloed approach to financing infrastructure is generally easier to structure.** Integrated approaches that provide multiple functions for different purpose can strengthen resilience during times of flood and drought. It can also present a very different risk profile to investors as well as elected officials, who are interested in low risk, replicable models that have been proven to work. In Texas the impetus to break the silo approach may be driven as a result of lawsuits, or, in the case of Dallas/Fort Worth, the water utility expanded to include energy and biosolids recovery for economic reasons. There is an opportunity for One Water in Texas that draws from the existence of large-scale river basin authorities and regional utilities that have the power to raise financing for infrastructure, which, with political support for One Water, could benefit from this dynamic. On the other hand, the larger scale of water management agencies could present a barrier to more innovative experimental approaches.

- **Replication and scaling up of successful approaches is often limited by constraints to accessing public (debt) finance, where the legal structure favors centralized systems.** In addition to the organizational and political challenges with financing alternative approaches, decentralized and distributed forms of water management present a financing challenge. Consideration must be given to the cost and lifespan of infrastructure, contractual obligations associated with the infrastructure (e.g. take or pay revenue models) and the risk (or perceived risk) of failure. Financing that connects piloting of ideas that have been proven to work at a small scale, with wider adoption by developers and authorities that package financing is, by and large, missing. Awareness of this gap has already inspired efforts like the Seaholm Eco-district[28] in Austin, and coordinated efforts by nonprofit organizations and foundations[29] to fund projects at a scale that is

The 2017 State Water Plan includes $8.1 billion more than the 2012 plan, with 20% targeted for conservation activities.

28 For more information, see: http://www.seaholm.info.

29 For example, see: https://star.txstate.edu/2016/04/04/texas-environmental-flows-initiative-innovates-sustainable-water-usage-honored-by-white-house-water-summit/.

amenable to financiers. The SWIFT program also presents a clear opportunity to fund new approaches; the state expressed willingness to fund potable water recycling in three towns[30] as a result of the 2011 drought.

As with other institutional lenses, sociocultural issues are also present in making an economic case for One Water and financing One Water approaches:

- Legislators often value economic development at the expense of underlying ecosystem and watershed health, which influences the economic viability of water investments targeted to meet social needs. For example, Texas's pro-business environment attracts companies from around the United States and world. While this is economically beneficial, it intensifies demand for water and energy, and increases pressure on water supplies as well as polluting watersheds.
- Developers' economic models favor installation of irrigation systems for single-family homes. Developers install these systems based on experience that homebuyers will pay for more a lawn, and often they install low-cost (and inefficient) sprinkler systems. Meanwhile, Texas utilities estimate that between 30-40% of total water use goes to outdoor irrigation.

Texas utilities estimate that between 30-40% of total water use goes to outdoor irrigation.

30 Two urban areas went ahead with DPR investments; a third, Brownwood, declined to pursue the option based on public perceptions. See: http://tinyurl.com/zgx7tuj.

3.6 | SUMMARY

There is a full range of institutional challenges and potential opportunities to advance One Water in Texas. It is important to note that even as the institutional environment favors traditional approaches to urban water management, it also changes and evolves in response to a complex array of factors, including drought cycles, politics and elections, financial markets, and cultural trends. For this reason, an analysis of barriers should not be seen as static; what may be a barrier in one area is an opportunity in other areas. However, many of the barriers identified in Texas are consistent with global experience. Table 3 provides a comparison of common institutional barriers to implementing One Water, drawing on earlier work by WERF and WRF.[xviii] A recent survey by WERF on barriers to cooperation between water professionals and urban planners supported the findings.[xix]

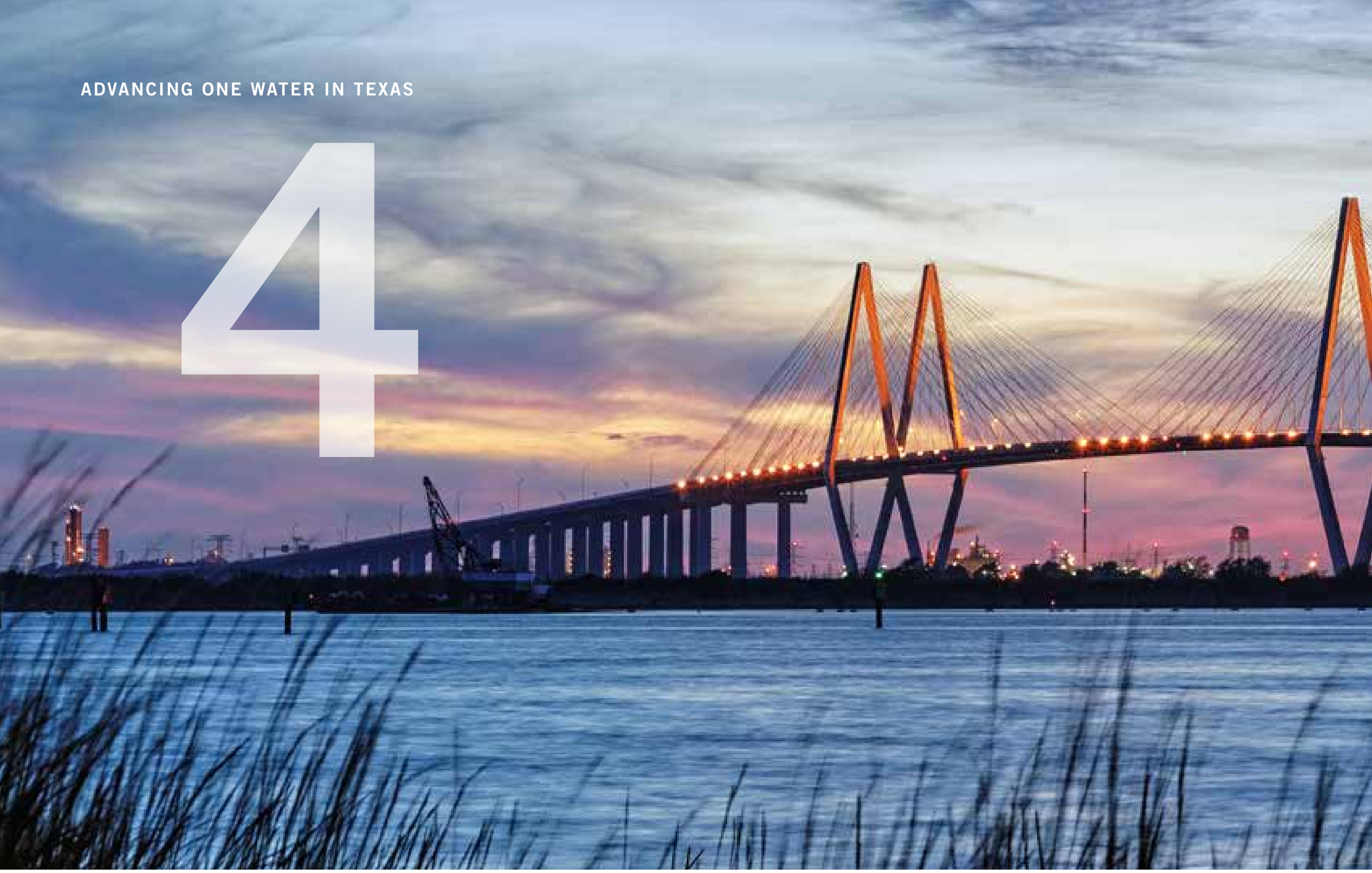
Texas's institutional environment favors traditional approaches to urban water management; it also changes and evolves in response to a complex array of factors like drought cycles, politics and elections, financial markets, and cultural trends.

Table 3 | Common and Texas specific barriers influencing One Water approaches

INSTITUTIONAL FACTOR	KEY ISSUE	COMMON BARRIERS	ADDITIONAL TEXAS SPECIFIC BARRIERS
Professional culture and societal value	Siloed and inflexible Uncoordinated, too technical, and uninspiring	Technical jargon versus layperson language Lack of knowledge or use of social media Engagement at wrong scale and wrong time Mixed messages across institutions Lack of incentives for integration/ collaboration Conflicting professional cultures or priorities Insufficient cross-organizational knowledge (e.g., water and planning, water and energy) Imbalance in disciplinary representation, lack of knowledge/respect about other disciplinary roles	Conservation messages can be difficult in eastern and coastal cities, where inter-annual rainfall variability is high Incentives for developers and homeowners to adopt water-efficient/LID practices are limited Reliance on large-scale utilities and bulk water suppliers can create a sense of complacency High proportion of engineers and lawyers in planning processes with litigious processes and few guidelines to address conflicts of interest/disqualification Lack of turnover in the water industry

INSTITUTIONAL FACTOR	KEY ISSUE	COMMON BARRIERS	ADDITIONAL TEXAS SPECIFIC BARRIERS
Policy and planning	Unpredictable Uncoordinated and not collaborative	Short political cycles Turf protection and fiefdoms Fragmentation or siloed planning Short-term solutions based on yearly funding cycles Lack of flexibility, time, and mechanisms to collaborate Unclear roles and responsibilities Lack of funding for integrated planning and facilitators Concerns over losing organizational power, resources, status or control Lack of holistic planning tools including data management Lack of systems knowledge	Groundwater districts are politically, not watershed based Politicians do not recognize absolute scarcity as a possible future Bottom-up planning presents challenges for water allocation Water rights allocations based on historic claims result in excessive demand projections Conservation and environmental flows not clear in planning documents Lack of systems data Lack of water balance analysis Power and water companies are separately regulated, making cross-benefits hard to quantify or realize
Economics and finance	Restrictive and traditional without full cost-benefit accounting	Conventional planning approaches that address problems through large-scale investments Lack of full benefit/cost accounting including ability to monetize indirect costs Limited funds for GI/LID and small-scale solutions Cost recovery issues including uncompetitive pricing policies	SWIFT's bottom-up approach can limit regional/integrated planning SWIFT relies on project lists from five-year State Water Plan Project lists aren't prioritized by region in order of importance Larger-scale adoption of One Water can face challenges with cost of technology or pulling together financing packages Funding is available for pilots but not scaling up to mid-size ($10m+) which is beyond the scope of research philanthropy budgets
Legal and regulatory	Overlapping and inconsistent	Inconsistency and overlap in laws and policy Prescriptive versus performance based regulations Perceived higher risk of new systems with resultant onerous regulations Lack of enabling regulatory mechanisms Differing agency mandates or regulations	Laws (particularly groundwater) are not science based, which results in higher perceived risk Litigation culture and short, biannual legislative sessions result in an expanded role of the judiciary in guiding water law and policy State-level legislature may see One Water approaches as a threat and override local initiatives

Source: Mukheibir, et al. (2015) Paulson, C. et al. (2017), authors' analysis



4

TEXAS ONE WATER ACTION AREAS

4.1 | INTRODUCTION

The previous section identified areas where a One Water approach may face constraints. It is also useful and beneficial to identify where traits of One Water are present at the city, regional, and statewide levels. This section provides a summary review of findings from the research. It is not intended to be comprehensive. Rather, the findings highlight where additional attention and investment might serve to advance a One Water approach to urban water management. Considering state, regional, and city scales, a number of activities were identified in Texas as already exhibiting traits of One Water:

Collaboration across unlikely partners can also be seen in the policy and planning processes.

Fred Hartman Bridge
Houston, Texas

- Collaboration is taking place across professional disciplines, across the water management cycle, and among urban departments. For example, The Water Efficiency Network of North Texas (WENNT) brings cities within the North Texas region together to network, share, learn, and execute cooperative projects. Rebuild Houston is a collaborative effort for urban renewal that brings together engineers, planners, developers, and politicians. Collaboration across unlikely partners can also be seen in the policy and planning processes, such as Code Next, a land use planning process in Austin, and across the state, through the emergence of eco-districts and 2030 development districts.

- A few examples of financing mechanisms suggest an opening for expanded attention. These include the emergence of stormwater utilities in cities and regions where flooding is a challenge. This can also be seen in the debt-for-nature swap in the Hill Country, which resulted in the purchase of developer rights for nature and conservation and the opportunity presented by SWIFT, where 20% of funds are accessible for water conservation and recycling.

Financing mechanisms suggest an opening for expanded attention.

- Green infrastructure and low-impact development practices are common in the larger cities reviewed as part of this research, although they are not the default standard for real estate developers.

- Texas's larger urban utilities are also advancing the use of closed-loop systems, through generation of biogas and bio-solids from wastewater and through to indirect and direct potable recycling.

There are multiple possible pathways to advance One Water.

- In the built environment, use of multifunctional infrastructure appears to be most commonly understood as a connection between urban parks and watersheds, with the San Antonio Riverwalk as perhaps the most widely known.

Less common are examples where economic models are being used to advance integrated solutions or underlying conditions at city, regional, and state levels that could help to compel a shift in institutional practice from a traditional to an integrated approach. Finally, while there are examples of teams and departments working to advance One Water approaches, there was less evidence of institutional flexibility and adaptation that could cultivate, support, and accelerate a transition.

This research used the vision of achieving One Water in Texas cities, with a specific goal to alleviate pressures and risks to watersheds and their supporting ecosystems. It is apparent that the complexities of managing water across the water cycle in Texas are matched with institutional complexity at local, regional, and state levels. Because of this, there are multiple possible pathways to advance One Water. A potential portfolio of opportunities for the 2018–2028 period is presented and discussed below. While ambitious, these areas for action identify opportunities that could be undertaken by a variety of stakeholders, ideally with support from public, private, and philanthropic investment.

All of these activities are presented as possible starting points to advance One Water in Texas cities, as a way to guarantee sufficient and clean water for both economic growth and the environment. They are targeted to the water sector as a whole, and could be pursued by different stakeholders, which makes sense given the different locations and contexts. As more individuals and agencies gain experience with integrated urban water management, new opportunities will likely emerge to meet new challenges. Ideally, the creation of a clear case, strong networks, and evidence of success will support an institutional environment where such new ideas and approaches are encouraged.

4.2 | AREA FOR ACTION: ADVANCE ONE WATER THROUGH STATE, REGIONAL, AND CITY POLICY

This project identified where state and regional planning processes and policies limit advancement of One Water objectives. Notably, the legislature's attention to water issues fluctuates based on whether the state is in a cycle of drought or has recently experienced a catastrophic flood. Still, the effects of the 2011 drought, which resulted in the creation of

SWIFT and SWIRFT and which pushed regulators into action on reuse, suggests that building One Water into state and regional policy activities is possible. In particular, there is a clear opportunity to build the political, economic, and socio-environmental value proposition of One Water to state and regional policy makers to advance One Water thinking into future State Water Plans. There is a clear role for building and strengthening advocacy coalitions that represent traditional water sector and nontraditional stakeholders.

GOAL

Develop a campaign to embed One Water in the State Water Plan by 2027, with at least two regional planning processes adopting a One Water framework by 2022.

RATIONAL METHOD

A unifying vision and campaign across two, five-year planning cycles would make it easier to set targets and implement guidelines at regional and local activities.

POTENTIAL ACTIVITIES

Build an independent, credible evidence base, drawing on physical and social science, to support advocacy for One Water efforts at city, regional and state levels.

Support institutions that combine media and journalism with water science and policy to increase sophistication in reporting and communication with leaders and citizenry.

Target advocacy, such as a one-day workshop for scientists and policy makers prior to each legislative session to help raise awareness in the political process around emerging science and opportunities to advance One Water.

GOAL

Build and articulate a clear and compelling case for One Water that inspires mainstreaming into relevant public, private and civil society entities working at state, regional and local levels.

RATIONAL METHOD

One Water is conceptually diffuse and nonlinear and often incompatible with how water has been historically managed. Making the case for One Water – with clarity on costs, benefits, and trade-offs – may help to accelerate interest and acceptance of the approach among high-level decision makers.

POTENTIAL ACTIVITIES

Support for scientific research, policy research into environmental and economic regulations that support One Water, economic and financial modeling, and advocacy efforts.

Support creation of new tools and visualization packages to present data and information in an accessible way.

GOAL

Increase public and private investment into One Water approaches.

RATIONAL METHOD

Currently, One Water approaches are funded through small grant windows offered by utilities or private foundations or through utility budgets. Mainstreaming One Water at city scales and across regions will require accessing public and private debt and equity markets.

POTENTIAL ACTIVITIES

Target advocacy efforts to increase SWIFT's funding window for conservation, from 20% to 40%, and to allow SWIFT funds to be applied to a wider range of costs against an overall operating model, not just capital costs.

4.3 | AREA FOR ACTION: BUILD ACROSS SILOS – OR BREAK THEM DOWN

Professional and social networks offer a way to advance One Water thinking and approaches, as evidenced by the growth of the US Water Alliance and IWA's Water Wise Cities program. Over the last five years, numerous industry events, activities, and technical working groups have organized to advance One Water thinking. These networks have evolved from an initial, technical focus to addressing institutional and cultural issues, from legislative and policy changes like local zoning, to whether state and national policy can adapt to support the transition. As they continue to grow and evolve, discussions around finance mechanisms that can strengthen One Water approaches, and identifying future workforce and training needs, are emerging. In Texas, water sector professional networks and associations such as the Water Environment Association Texas (WEAT) and the Texas chapter of the American Water Works Association (T-AWWA) are strong. However, these tend to be disciplinarily dominated by engineers and lawyers and limit the extent to which they reflect the full spectrum of professionals required to execute a One Water approach.

GOAL

Develop networks to identify opportunities and build connections and synergies between sources of water supply, water demands and other urban services such as energy, building design and green space.

RATIONAL METHOD

Existing professional networks will be strengthened by expanding the diversity of perspectives represented. It is critical to connect water professionals to other networks with relevance to One Water, and where there is limited natural engagement, like planning, transport and energy.

POTENTIAL ACTIVITIES

Establish and facilitate learning networks in two Texas cities/regions that include a trans-disciplinary group of water professionals, urban planners and other service providers, NGOs, business interest, developer, and academics. Initial activity could include a water-oriented city/region visioning process and development of cross-institutional/stakeholder strategic direction.[31]

GOAL

Increase knowledge exchange, discussion and debate about One Water.

RATIONAL METHOD

Use existing professional conferences and events and create partnerships with other US cities. Such water partnerships could be useful in helping to navigate potential institutional issues at state and national levels and to garner public support.

POTENTIAL ACTIVITIES

Initiate a brown bag lunch series to discuss aspects of One Water.

Formally include Texas One Water sessions in conference programming.

Develop water partnerships between Texas cities and other similar US cities that are adopting One Water approaches and have found creative ways to overcome barriers to collaboration.

31 These learning networks could include input from representatives from existing, complementary initiatives such as the Rockefeller Foundation's 100 Resilient Cities program in Dallas and El Paso.

GOAL	RATIONAL METHOD
Create a knowledge network between Texas's academic and water institutions to develop system wide tools for integrating water.	Discussion of water management opportunities is most productive if it is underpinned by a strong understanding of the local demands for and supply of available water resources. Universities and colleges in Texas have capacity to create systems to capture and share this knowledge. Collaborative practitioner and researcher networks could also help bring more science into decision-making practices.
	POTENTIAL ACTIVITIES
	Develop water balance tools that allow stakeholders to understand all existing and future water quantity and quality demands along with potential sources and locations of supply.
	Improve the science on the interactions among aquifers and between aquifers and surface water to inform modeling the positive and negative effects of pipeline projects.
	Create system-wide economic and financial tools that capture all of the direct and indirect lifecycle capital and economic costs and benefits of projects. Knowledge from use of these tools will allow learning networks to discuss and debate all potential water management options.

4.4 | AREA FOR ACTION: MAINSTREAM PILOTS AND DEMONSTRATIONS

Pilot and demonstration projects are often critiqued as being tailored to suit a specific purpose, suggesting a belief that they never fail and never scale. Often this is due to the high costs and risks to replication or as a result of selecting sites for demonstrating a product or approach. There are many reasons why even successful demonstration projects are not replicated or mainstreamed. Project managers—who are often specialist scientists—generally lack the full suite of skills to design a demonstration project with a concept of long-term viability. As a result questions about cost, revenue streams, and value proposition to different audiences are only considered if the project is successful. Many of the potential institutional hurdles to scaling are often disregarded at the pilot and demonstration stage. However, there are several activities focused on mainstreaming successful pilots and demonstrations that could help advance One Water with policy makers, regulators, and public and private funders. This first set of activities is focused on how pilot and demonstration projects are designed and managed.

GOAL	RATIONAL METHOD
Design pilots and demonstrations to include a business case and potential market size for application.	Most demonstrations are site specific and play little consideration to the advantages of uptake at a wider scale or the issues that might need to be addressed for scale to succeed.
	POTENTIAL ACTIVITIES
	One idea that surfaced in discussion with key informants during the research process was the potential impact of Dallas recycling all of its water and how that might affect Houston, which is increasingly dependent on surface water.

GOAL

Ensure marketing and communications activities are included in pilot/demo budgets.

RATIONAL METHOD

A well thought out marketing and communications plan can increase demand and financing for pilots and demonstrations to be replicated.

POTENTIAL ACTIVITIES

Develop marketing plans that inform both the experiment's design and a range of external audiences (e.g., elected and appointed officials, developers, private/commercial interests, residents and the media) about what's happening, why the research is happening, what the process is, what happened, why, and how they can learn more, in ways that resonate with them.[32]

GOAL

Increase project managers and researchers ability to develop good business cases for pilots and demonstrations.

RATIONAL METHOD

Most pilot and demonstration projects dealing with water depend on limited grant finance offered by state and federal agencies, research funding, funding sources from the utility's cash budget or philanthropy capital. The potential to be scaled through mainstream public or private debt and equity markets is limited due to barriers in those financial markets. Further, most pilot/demo projects are tightly controlled and fail to pay attention to the total costs (e.g. , installation, as well as operations and maintenance), or potential revenue stream (e.g., additional grants, equity investment, debt, or earned income). As a result, uptake is limited even if the underlying science or product is sound.[33]

POTENTIAL ACTIVITIES

Provide training and skill-building for project managers and researchers to develop a business case, particularly for projects that don't have large capital requirements, such as infrastructure.

Support training and peer-mentorship to assist project managers in how to build a business case in alignment with One Water principles.

Initiate a developer and business forum to better understand the planning and investment tools that developers and businesses use in decision making and to engage in discussions or ways to create a business case for One Water that is aligned with their incentive structure.

Prepare a regulatory updated water briefing packet with updates on policy discussion, trends and debates for mayor and elected/appointed officials.

32 Marketing activities can be multidirectional, both to inform the project's design and to share updates and information about the projects. For example, in El Paso, Texas, a public relations team was created decades ago to embed behavior change around the sources and uses of water. In Wichita Falls, the city engaged the media and residents—most notably the medical community—to help position its decision to pursue Direct Potable Reuse to the public. See: https://www.awwa.org/legislation-regulation/leg-reg-news-details/articleid/3991/how-one-utility-won-publci-support-for-potable-reuse.aspx.

Mainstreaming pilots and demonstrations requires support from consumers, investors and elected officials. This second set of activities could be undertaken with the business and political communities to accelerate uptake of innovations.

GOAL	RATIONAL METHOD	POTENTIAL ACTIVITIES
Secure support from the business community and developers to take pilots and demonstrations to mainstream practice.	Businesses and developers have their own tools and methods for planning and investment decisions. Understanding their process and collecting data in forms that they can understand is more likely to result in uptake.	*Initiate a business and developer forum to engage in discussion on ways to create a business case for One Water that is aligned with their incentive structure.*
The longer term goal is to depoliticize water. In the shorter term educate incoming elected and appointed officials who have influence and power over water management decisions.	Communication deployed statewide about One Water initiatives, including both Texas initiatives and what other cities in the US are doing, could help to raise awareness and understanding of One Water.	*Prepare a regularly updated, water briefing packet on policy discussions, trends and debates, potentially in collaboration with the US Water Alliance or other think tanks and media organizations with a water focus. The briefing packet would be targeted at mayors and elected/appointed officials.*

33 For example, see https://stateimpact.npr.org/texas/2012/08/08/why-most-texans-havent-turned-to-graywater-recycling/.

ACRONYMS

ASR	Aquifer Storage and Recovery
AWWA	American Water Works Association
CGMF	Cynthia and George Mitchell Foundation
CSO	Combined Sewer Overflow
CWB	Clean Water Branch
DPR	Direct Potable Reuse
EAA	Edwards Aquifer Authority
EARIP	Edwards Aquifer Recovery Implementation Plan
EPA	Environmental Protection Agency
GBRA	Guadalupe-Blanco River Authority
GI	Green Infrastructure
ICLEI	International Council for Local Environmental Initiatives
IWA	International Water Association
LID	Low Impact Development
MUD	Municipal Utility District
NGO	Non-Government Organization
PUB	Public Utility Board
PUC	Public Utility Commission
PUD	Public Utility District
PWD	Philadelphia Water District
SARA	San Antonio River Authority
SAWS	San Antonio Water System
SFPUC	San Francisco Public Utility Commission
SWIFT	State Water Implementation Fund of Texas
SWIRFT	State Water Implementation Revenue Fund of Texas
T-AWWA	Texas-American Water Works Association
TCPS	Texas Center for Policy Studies
TCEQ	Texas Commission on Environmental Quality
TRA	Trinity River Authority
TWDB	Texas Water Development Board
TAP	The Aransas Project
WEAT	Water Environment Association of Texas
WEF	Water Environment Federation
WENNT	Water Efficiency Network of North Texas
WERF	Water Environment and Reuse Foundation
WRF	Water Research Foundation

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Onion Creek at McKinney State Falls
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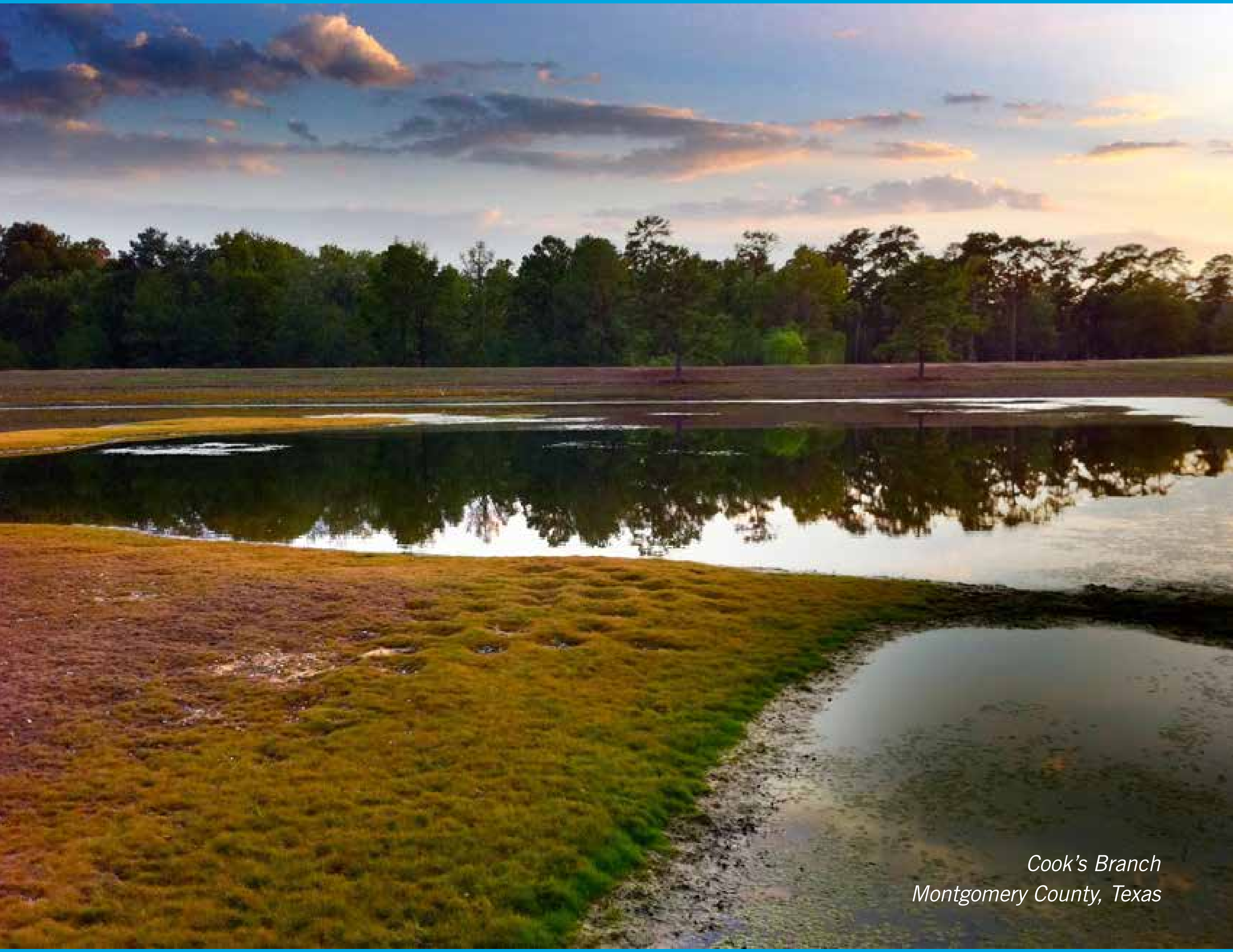

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