MULTI-AGENCY WATER REUSE PROGRAMS:

Lessons for Successful Collaboration

MARCH 2022

A product of the National Water Reuse Action Plan

in association with WATEREUSE®

Prepared for:

United States Environmental Protection Agency

Prepared by:

Eastern Research Group, Inc.
PG Environmental, LLC

Multi-agency Water Reuse Programs

Lessons for Successful Collaboration

Eric Rosenblum

Felicia Marcus

Robert Raucher

Bahman Sheikh

Shannon Spurlock

In association with:

WateReuse

National Water Reuse Action Plan (WRAP)

WRAP Action 2.16: Support Local and Regional Reuse Projects by Identifying Challenges, Opportunities, and Models for Interagency Collaboration

Multi-Agency Water Reuse Programs

Lessons for Successful Collaboration

March 2022

PREFACE

"If we can figure out how to get these guys to actually work with each other, this is a no-brainer."

In 2020, the Environmental Protection Agency joined a host of other federal, state, and local agencies and organizations to develop the Water Reuse Action Plan (WRAP). The WRAP is designed to help build the nation's capacity to implement more projects that recycle wastewater and capture and use stormwater within the broader context of integrated water management. As of this writing, WRAP teams are currently implementing more than 40 actions addressing priority needs identified by our partners in the area of science and technology, policy and regulation, funding, communications, and other topical themes. Among those many important actions, none is more critical that the need build local and regional capacity to work across organizational and jurisdictional boundaries and missions.

As suggested by the above comment by the manager of a large wastewater utility, bringing the right people together in the right ways is crucial to advancing water recycling and developing sustainable water systems. Recycling proponents face many challenges and aligning the interests of multiple organizations is essential to make these projects work. This alignment is particularly difficult in the water sector, where in 2016, a coalition of experts determined that, "fragmentation of the water sector across geographies, jurisdictions, and technical standards is a critical barrier that significantly impacts the quality, quantity and efficiency of water innovation" (EPA, 2016a). While many water managers recognize the importance of collaboration, fewer understand how to overcome their competing priorities to build regional capacity. This report is intended to help fill this gap.

WRAP Action 2.16 supports implementation of reuse projects by exploring the challenges, opportunities, and frameworks for achieving effective interagency collaboration. Drawing upon extensive literature reviews and richly detailed case studies of several large-scale water recycling efforts, the project team identified the key elements required to build the cooperative engagement necessary for these projects to succeed. As explained in this report, there are predictable legal, financial, regulatory, and organizational issues that challenge interagency collaboration, and there are replicable strategies for surmounting these challenges. The report also profiles how interpersonal relationships and cultural differences can either support or undermine cooperation, and how personal vision and organizational leadership can build and maintain lasting, effective partnerships.

This report will help agencies work better together. By enabling agencies to develop a deeper understanding of what it takes to succeed in complex interagency cooperation, we hope to improve our collective capacity to pursue innovative recycling and integrated water management strategies across the nation. With sufficient attention to how organizations work together, we're far more likely to build the sustainable water futures our communities envision.

David Smith, US Environmental Protection Agency, Retired December 2021

Disclaimer:

The material presented in this document is intended solely for informational purposes and is not intended to interpret federal statutory or regulatory requirements or to convey EPA guidance or policy. The recommendations and possible actions described in this document do not represent binding commitments by EPA or other parties. This document is not intended, nor can it be relied on, to create any rights enforceable by any party in litigation with the United States. This document may be revised or updated without public notice. Mention of trade names or commercial products in this document does not constitute an endorsement or recommendation for use.

TABLE OF CONTENTS

Figures and Tables

List of Figures

List of Tables

Acronyms and Abbreviations

Agencies and Organizations

AWWA	American Water Works Association
BOR	Bureau of Reclamation
Cal-Am	California-American Water Company
CoT	City of Tucson
CSIP	Castroville Seawater Intrusion Project
DPW	Department of Public Works (City of Los Angeles)
DWU	Dallas Water Utility
EPA	United States Environmental Protection Agency
FWID	Flowing Wells Irrigation District
HRSD	Hampton Roads Sanitation District
JCSA	James City Services Authority
LACSD	Los Angeles County Sanitation Districts
LADWP	City of Los Angeles Department of Water and Power
LASAN	Los Angeles Sanitation and Environment
M1W	Monterey One Water
MCWD	Marina Coast Water District
MCWRA	Monterey County Water Resources Agency
Metropolitan	Metropolitan Water District of Southern California
MPWMD	Monterey Peninsula Water Management District
MWRSA	Monterey Wastewater Reclamation Study for Agriculture
NTMWD	North Texas Municipal Water District
OC San	Orange County Sanitation
OCWD	Orange County Water District
PARML	Potomac Aquifer Recharge Monitoring Laboratory
PAROC	Potomac Aquifer Recharge Oversight Committee
PCRWRD	Pima County Regional Water Reclamation District
SAWPA	Santa Ana Watershed Project Authority
SNWA	Southern Nevada Water Authority
SWRCB	California State Water Resources Control Board
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
TRA	Trinity River Authority
TRWD	Tarrant Regional Water District
TW	Tucson Water
UCLA	University of California at Los Angeles
VDEQ	Virginia Department of Environmental Quality
VDH	Virginia Department of Health
WBMWD	West Basin Municipal Water District
WEF	Water Environment Federation
WRD	Water Replenishment District of Southern California

Projects

CAP	Central Arizona Project
Compact	Upper Trinity Basin Water Quality Compact
RRWP	Regional Recycled Water Project (Metropolitan)
RWS	Reclaimed Water System (City of Tucson)
SHARP	South Houghton Area Recharge Project
SRDF	Salinas River Diversion Facility
SVRP	Salinas Valley Reclamation Project
SWIFT	Sustainable Water Infrastructure for Tomorrow
WIN	Water Independence Now
WIN4All	Water Independence Now—For All
WRAP	Water Reuse Action Plan

Definitions

AMA	Active Management Area
BAC	Biologically Active Carbon
CDO	Cease and Desist Order
DCP	Drought Contingency Plan
DFW	Dallas-Fort Worth Metroplex
DiPRRA	Direct Potable Reuse Responsible Agency
DPR	Direct Potable Reuse
GM	General Manager
GWMA	Arizona Groundwater Management Act (1980)
IGA	Intergovernmental Agreement
JPA	Joint Powers Authority
JWPCP	Joint Water Pollution Control Plant
LA	City of Los Angeles
MOA	Memorandum of Agreement
MS4	Municipal Separate Storm Sewer Systems
MSA	Metropolitan Statistical Area
MUM	Mutual Utility Management agreement
NGO	Non-governmental organization
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
SCADA	Supervisory Control and Data Acquisition
TBL	Triple Bottom Line
TMDL	Total Maximum Daily Load
UIC	Underground Injection Control
VAC	Virginia Administrative Code

Units

AFY	Acre-foot per year
KAFY	Thousand acre-foot per year
MGD	Million gallons per day

ACKNOWLEDGEMENTS

The project team extends its great appreciation to David Smith (EPA Region IX) for his outstanding leadership, his support in obtaining funding, and his invaluable insights and guidance throughout the development of this report. We also thank Aliza Furneaux and Greg Fogel at the WateReuse Association for their valuable support and contributions. Collin Mummert at PG Environmental coordinated this work with the EPA WRAP team, Sargon deJesus and Jenny Helmick at Eastern Research Group helped navigate contractual details and Ashley Harper (EPA) and Stephanie Buckley (ERG) provided essential editorial review.

We are very much indebted to the many water sector professionals and visionary practitioners who shared their experiences forging successful collaborations in their respective regions. We especially want to express our gratitude to the following utility and consulting professionals who contributed to our case studies:

- Mike Markus (OCWD), Melody LaBella and Roger Bailey (Central San) and Marguerite Patil (CCWD) for describing their experiences with water reuse in southern and northern California;
- Ted Henifin (HRSD), Doug Powell (JCSA), Marcia Degen and Ryder Bunce (VDH), and Scott Kudlas (VDEQ), for sharing the Tidewater, Virginia story;
- Wayne Owen, Rachel Ickert, and Nicole Rutigliano (TRWD), Denis Qualls (Dallas), Glenn Clingenpeel (TRA), R. J. Muraski (NTMWD), Louis Herrin (TCEQ), and Ellen McDonald (Plummer) for explaining how they share the Trinity River in North Central Texas;
- John Kmiec and Jaimie Galayda (Tucson Water), and Kathy Chavez and Jackson Jenkins (Pima County) for their insights into the relationship between their southern Arizona agencies;
- Paul Sciuto and Mike McCullough (M1W), Brent Buche (MCRWA), Dave Stoltz (MPWMD), Brian Frus (Salinas), Oscar Antillon (City of Soledad), and Eric Tynan (CCSA) for untangling the history and future of water reuse in Monterey; and
- Robb Whitaker, Stephan Tucker, Diana Gatza, and Ron Beste (WRD); Deven Upadhyay, Rupam Soni and Bruce Chalmers (MWD); Martha Tremblay and Sharon Green (LACSD); Traci Minamide, Hubertus Cox, and Timeyin Dafeta (LASAN); and Paul Lin and Rafael Villegas (LADWP) for unveiling their ambitious plans to “make every drop count” in Southern California.

We also appreciate the keen insights provided by technical reviewers who critiqued various portions of our draft report: Richard Atwater, Randy Bartlett, Lorien Fono, Ellen MacDonald, Melissa Meeker, Aileen O’Donnell, Michele Pla, Paul Reiter, Rick Warner, and Robert Whitley.

Finally, we acknowledge (and greatly miss) the inspiration and wisdom of the late Dr. Bahman Sheikh, one of the originators of this research effort. Dr. Sheikh was a true leader in the field of water reuse, and we hope we have helped to carry his vision forward.

Eric Rosenblum, Felicia Marcus, Bob Raucher, and Shannon Spurlock

WRAP Action 2.16 Research Team

WRAP ACTION 2.16 RESEARCH TEAM

Eric Rosenblum

Eric Rosenblum is a consulting engineer who specializes in municipal and industrial water reuse. He previously managed operations at the regional wastewater treatment plant serving the Silicon Valley area of northern California, where he was also responsible for the design, construction, start-up and operation of South Bay Water Recycling, the Bay Area's largest urban water reuse program. In addition to his work on the WRAP, Eric is co-editor (with Cheryl Davis) of Sustainable Industrial Water Use: Perspectives, Incentives, and Tools (IWA Publishing, 2021).

Felicia Marcus

Felicia Marcus is an attorney who has served in government, non-profits, and the private sector. She is currently the Landreth Visiting Fellow at Stanford University's Water in the West Program and a founding member of the Water Policy Group, a network of high-level water officials assisting developing nations and serves on the board of the WateReuse Association. Felicia previously served as Regional Administrator of U.S. EPA Region IX and as head of the Los Angeles Department of Public Works. Most recently she was Chair of the California State Water Resources Control Board during the worst drought in modern history.

Bob Raucher

Dr. Robert Raucher is a water sector economist with more than 40 years of experience guiding water utility decision-making and public policy development for water supply, water reuse, water quality, stormwater, and wastewater management. Bob's expertise in benefit-cost and triple bottom line analysis, risk management, strategic planning and adaptive management under large uncertainty supports integrated water resource management to achieve sustainability and maintain affordability in the face of climate change impacts. Dr. Raucher is an active member of the professional water community, serving on numerous expert panels and committees.

Shannon Spurlock

Shannon Spurlock is founder and principal of Ochotona Consulting. Shannon is dedicated to water and food security and views recycled water as essential to resiliency. Previously, Shannon worked with stakeholders throughout Colorado to adopt rules allowing agricultural applications of recycled water that went into effect in January 2020. Shannon has a passion for organizational development, policy advancement, and stakeholder engagement. In 2022 she joined the Pacific Institute as Senior Researcher—Public Policy and Practice Uptake.

David Smith

During his tenure as Assistant Director for Water of Region IX of the US Environmental Protection Agency, Dave Smith managed an array of Clean Water Act Programs and helped launch the national Water Reuse Action Plan where he took an active interest in guiding this Action Item. In December 2021, Dave retired from EPA to start Water Innovation Services, where he focuses on innovative, integrated water management strategies at the federal, state, and local levels.

Bahman Sheikh (In Memoriam)

Dr. Bahman Sheikh, who helped initiate this research, passed away July 28, 2020, at his home in San Francisco. A water reuse pioneer, Bahman helped communities around the world recycle water. He led the Monterey Wastewater Reclamation Study which demonstrated the safety of recycled water for irrigation of California's "salad bowl" and was the first Executive Director of the Los Angeles Office of Water Reclamation, where he helped lay the foundation for that city's strategy to reuse 100 percent of its wastewater. As an independent consultant specializing in water reuse Bahman developed recycled water programs in the Middle East, Africa, Asia, South America, and Australia.

EXECUTIVE SUMMARY

Collaboration is the gateway to greatness. Recycled water can be a safe and reliable water supply, but to develop it the agencies responsible for managing water, wastewater, and stormwater must work together. In the United States, this type of cooperation is inhibited by the challenge of aligning missions and allocating responsibilities and costs among separate organizations. Collaboration is also complicated by complex regulations, operational details, and a utility's natural inclination to maintain independent control of all projects within their jurisdictions.

Recycling wastewater effluent, stormwater, and other impaired sources is an essential element of an integrated, resilient, and sustainable water supply. However, the dominant institutional arrangements in the United States (and most other nations) today constitute a patchwork approach to water resource management. Water utilities and wastewater agencies created years ago in response to historical needs now operate as distinct entities, each with its own legal mandate, service area, professional staff, management team and personality, governance and public oversight structure, regulatory and technological challenges, and financial and economic constraints. While these institutions were well-suited to solve last century's water problems, they are less able to address today's challenges that require integrated water management—including water reuse.

Despite this fragmented institutional landscape, many agencies have found ways to work together to create successful regional water reuse programs. By focusing on their common interests and forging durable working agreements, they have joined together to create "virtual" water utilities adding recycled water to their portfolio of supplies to complete the water cycle and achieve greater resilience for their communities. While the challenges are great, these examples of successful partnerships around the United States offer many important lessons.

The National Water Reuse Action Plan Action Item 2.16 was initiated to support the development of multi-agency water reuse programs by identifying "challenges, opportunities and models for interagency collaboration." This project consists of 1) a framework for evaluating interagency relationships in the water sector (including an annotated bibliography); 2) five case studies of multi-agency reuse projects in the United States; and 3) a summary of "lessons learned," references, and exercises to help agencies develop more productive collaborations.

Analytical Framework

Literature relevant to multi-agency water recycling projects was analyzed from the perspective of five characteristics: 1) governance; 2) regulation; 3) economics; 4) management; and 5) leadership. Among other findings, this analysis revealed:

1. Despite their distinct governance structures, agencies can create joint recycled water projects when they agree to work together to serve the public interest. Utility managers who define their responsibilities too narrowly should broaden their understanding of the benefits of water reuse and revise their charters, if necessary, to include water recycling. Once they agree to work together, agencies can document their collaboration through various legal frameworks ranging from bilateral agreements and memoranda of understanding (MOUs) to joint powers authorities (JPAs) and consolidation into a single agency. However, the form of the agreement is less important than the trust between the parties.

2. Regulations that limit discharge of contaminants or restrict withdrawal of surface or ground water supplies can motivate agencies to recycle water. On the other hand, when water reuse regulations are unclear or cumbersome, they can discourage agencies from sharing responsibility for producing and using recycled water. Agencies that identify their regulatory responsibilities early on and consistently communicate with regulators are more likely to be able to work together to obtain their permits. For their part, regulators can help recycled water projects by setting clear standards, giving greater certainty to local agencies, encouraging reuse, and helping local agencies navigate the permitting process.

3. One common **economic** barrier to collaboration results from a failure to recognize the many benefits offered by water reuse. At first glance the benefits of reuse appear long-term and diffuse compared with its costs which fall immediately to a specific utility. Agencies can more readily justify these projects to their ratepayers by clearly identifying, quantifying, and communicating the many overlooked benefits of reuse. Advantages of reuse include the avoided cost of acquiring alternate water supplies and constructing wastewater discharge upgrades; the value of drought-resistant supply reliability; quality of life enhancements including aesthetic and recreational opportunities; and ecological benefits such as wetland creation and enhancement of in-stream flows. Once they have agreed to jointly pursue reuse, collaborating agencies must also agree on how to share costs and revenues. (For nonpotable projects, they should also agree on who will subsidize the project in order to keep the price of recycled water below the cost of potable supplies.) These agreements will change as regional needs evolve, and as utilities adjust their allocation of costs to align with beneficiaries. In addition, by working together agencies may be better able to access funding from outside sources.

4. **Management** and operational issues can get complicated when agencies jointly build and operate recycled water projects. Jurisdictional boundaries often determine who owns or operates different parts of the system, and who is responsible for capital improvements. Along with clarifying ownership and assigning responsibility for operations and maintenance, interagency agreements should also specify how liability is assigned. To support these arrangements, agencies must have a mutually acceptable source of information about system performance and must ensure that staff are qualified and certified to take on their responsibilities. These same requirements also apply to the execution of "user agreements" with commercial, industrial, and institutional nonpotable water customers.

5. All successful collaborations require **leadership** by individuals and groups that understand the value of recycled water and its importance to their communities. In many cases, leaders invest personal time and effort to engage members of their own agency, even as they build relationships with external partners. By understanding the conditions which foster leadership and cultivating "champions of change," agencies can promote these attributes and establish environments to sustain them. Nonagency actors can also promote reuse including advocacy groups that recognize reuse as a solution to environmental problems and professional associations that encourage agency members to explore reuse opportunities through appropriately themed conferences and workshops.

Case Studies

The applicability of the lessons derived from the Analytical Framework is illustrated in the case studies:

- A regulatory mandate to remove nutrients from Chesapeake Bay encouraged Hampton Roads Sanitation District (HRSD) in **Eastern Virginia** to reuse effluent. Federal regulators allowed HRSD, the regional wastewater authority, to recharge 100 MGD of highly treated water into the aquifer as an alternative to separately treating wet weather sanitary sewer overflows and stormwater runoff by municipalities across the region, reducing the cost of regional compliance for the combined issues by $1 billion. HRSD developed credit exchange agreements with more than a dozen local agencies and established an oversight committee to address health concerns associated with ground water augmentation.
- In response to a change in state water rights governance (including wastewater discharges), agencies in **North Central Texas** adopted a variety of legal structures to facilitate their collaboration, including MOUs and bilateral and multilateral agreements. By coordinating their claims to return flows the City of Dallas, Tarrant Regional Water District, North Texas Municipal Water District, and Trinity River Authority collaborated to maintain local control of water allocations. They also developed individual partnerships to reduce the total cost of their individual water reuse projects.
- **Pima County in Southern Arizona and its largest city, Tucson**, share responsibility for managing water in this water-stressed area of the desert southwest. For economic and related reasons, Tucson supplies water and reclaimed water, and Pima County treats wastewater for the majority of area residents. Together they recycle effluent for landscape irrigation, environmental enhancement, and ground water

recharge. Through this collaboration Tucson Water provides their arid region with a reliable and sustainable water supply and Pima County efficiently manages and operates their wastewater treatment facilities. Their award-winning partnership (US Water Alliance, 2021b) has qualified their communities to receive significant federal funding

- An innovative program supplying nonpotable recycled water for farmland irrigation in Central California's Monterey Bay region added new sources of water—and new partners—to recharge the region's potable aquifers. Monterey One Water's "Pure Water Monterey" program recycles municipal wastewater, irrigation tailwater, agricultural washwater, and stormwater for potable reuse. The complexity of the many economic and operational relationships was facilitated by pilot-scale work, which allowed agencies to resolve a number of technical issues and develop a management strategy to ensure reliable operation of the facility as a whole.
- The largest water and wastewater agencies in the Los Angeles area of Southern California are building on past successes to develop audacious new projects to respond to climate change by reusing more than 390,000 acre-feet per year (AFY) of treated effluent. Along with elected officials and the environmental community, individuals in each of the participating agencies assumed leadership roles, facilitating participation by other agencies beyond their own needs to get these projects going "for the common good."

Words of Wisdom from Successful Practitioners

Collaborating utilities can be guided by the experience of the principals involved in these case studies. This advice will benefit all public agencies who aim to work together to respond to the pressures of population growth, resource depletion and climate change.

1. *Necessity is the mother of collaboration.* Take advantage of forcing events to move beyond old institutional barriers and roles and into new collaborations for sustainability. Water supply reliability problems exacerbated by climate change can serve as a driver (Arizona), as can regulatory authorities who can motivate reuse through discharge and withdrawal limits and other water management requirements (Virginia).

2. *Turn lemons into lemonade.* Many challenges also provide opportunities for creative solutions to regional problems. For example, the imposition of stringent nutrient limits opened a pathway for an agency to turn effluent into a regional resource by restoring an overdrawn aquifer (Virginia). In another instance, the need to invest in water reuse to meet regulatory limits on surface water withdrawals also had the added benefit of allowing some agencies to postpone the cost of expanding their water treatment facilities (Central California). Agencies contemplating reuse need to engage with regulators early and enlist their support to translate regulatory mandates into creative opportunities to reuse water.

3. *Recognize opportunities to serve "the greater good."* Regional reuse projects often enhance water supply resiliency and reliability, provide environmental benefits, and reduce overall costs. These benefits, however, must be clearly articulated to encourage multi-agency cooperation and even then, one agency may still need to shoulder a larger share of the costs for the benefit of all (Virginia, Southern California). Recognize that your agency ultimately serves many of the same customers and shares a regional identity with other cities and utilities. Think in terms of "the big picture" and embrace the responsibility of explaining the benefits of a collaborative water reuse program.

4. *Get it in writing!* Long-term partnerships require written agreements with clearly defined roles, responsibilities, and shared objectives to succeed beyond the terms of the original partners. Expect these agreements to be revised and amended over time to reflect changed conditions and the evolving needs of the community at large (Arizona). Ongoing communication is key to the operation of joint facilities. When staff from multiple agencies are collectively responsible for a project, they must take time to get to know each other and keep each other up to date on their activities.

5. ***Reuse projects proceed at the speed of trust.*** On the other hand, legal agreements do not create mutual trust, they only codify it. Utilities develop a level of confidence in each other that they can build upon when they recognize cultural differences and develop a common vocabulary. Encourage informal relationships between staff at different agencies to enhance communication. Move beyond your own comfort zone and be willing to initiate new relationships (Texas). Once understanding and trust are established – especially across different levels and sections of the utilities – partnerships can grow and thrive.

6. ***Those with the most to give should give the most, and they should keep on giving.*** Different agencies in a partnership will have different capacity to support reuse initiatives. This difference may be related to agency size (e.g., a large regional utility collaborating with smaller local agencies) or stem from their relative affluence or expertise. Agencies with greater resources and capabilities need to take on greater responsibility for program success (Virginia). Furthermore, relationships between partner agencies evolve over time. Managers must be prepared to re-evaluate their agreements and adjust them as conditions and related reuse opportunities and needs change (Arizona).

7. "***There is strength in numbers."*** Working together, agencies can do more than they can individually, allowing them to create more ambitious solutions. Some utilities may be structured in a manner that opens opportunities, e.g., access to funding otherwise unavailable to another individual utility, or favorable financing terms based on one utility's qualifying cash flow. As a result, the partnership group may obtain advantageous fiscal support that some individual agencies would not have otherwise obtained. Collaboration may even provide the ability to overcome to critical technical challenges to reusing water. Only when the Water Replenishment District arranged for the City of Los Angeles to store recycled water in its groundwater basin could the city commit to reusing 100 percent of its wastewater at its Hyperion Water Reclamation Plant. Collaboration is the key to greatness.

INTRODUCTION

Water management utilities are pushed and pulled by many forces, which differ based on the services they provide. In many areas of the United States, there are separate utilities for producing and distributing water, collecting and treating wastewater, and managing stormwater. Water agencies must continually supply an abundant quantity of fresh, high-quality water to a growing population at a price affordable to everyone. Wastewater agencies face a steady stream of sewage they must treat through a combination of carefully engineered physical, chemical, and biological treatment systems to meet increasingly stringent standards. For their part, flood control districts must proactively invest in stormwater management infrastructure to keep their communities safe during "worst case" weather events while preserving the health of area waterways.

Each of these agencies has its own directors and managers, its own infrastructure and operators, its own regulatory requirements, and its own budget to carry out its own particular responsibility within its separate jurisdiction. While that arrangement once suited the task, over the past few decades it has become increasingly evident that water management challenges can no longer be addressed separately. A multitude of new pressures—climate change, population growth, aging infrastructure, and environmental regulations combined with political opposition to rate hikes—now drive utilities to enter strategic partnerships to carry out their missions.

For example, as warmer winters have reduced summer river flows many water agencies now look to wastewater utilities to supplement their supplies with recycled water. Water conservation efforts that preserve those supplies also reduce the volume (but not the strength) of sewage in ways that impact both the conveyance and treatment of wastewater. As stormwater management agencies cope with unprecedented amounts of rainfall, water supply managers must weigh the need to fill reservoirs for future use against the benefit of emptying them to make room for heavy rains. These problems force water utilities to cooperate and collaborate in unfamiliar ways, while at the same time they make it harder for them by stimulating their natural inclination to maintain tight control of the projects within their jurisdictions.

This report is designed to help utilities, regulators, and others think differently—and more productively—about interagency collaboration in order to increase their capacity to recycle water. Water recycling in particular requires utilities to go beyond their historical missions and to consider their roles and responsibilities in a different light. As a way of illustrating the complexities involved, we begin with an examination of two California communities with two very different opportunities to reuse water.

A Tale of Two Communities

As a way of illustrating the complexities involved, we begin with an examination of how two California communities—one south, one north—responded to two different opportunities to reuse water.

Orange County: There's no place like home

Orange County, California's Groundwater Replenishment System (GWRS)—the world's largest potable reuse project—demonstrates the tremendous potential that can be achieved when agencies collaborate. Jointly funded by Orange County Sanitation District (OC San) and Orange County Water District's (OCWD), the project can produce up to 100 MGD (112,000 AFY) of potable water by treating effluent from OC San's treatment plant. The effluent is processed by microfiltration, reverse osmosis, ultraviolet light, and hydrogen peroxide disinfection before it is injected into the local aquifer, where it forms a barrier against seawater intrusion and supplies water to OCWD's 19 retail customers.

Figure 1. Reverse osmosis membranes at Orange County Water District GWRS (Credit: OCWD)

Located just south of Los Angeles, Orange County's development followed a pattern common in California history. This coastal plain bisected by the Santa Ana River was originally inhabited by Native Americans and colonized by Spanish missionaries. It was subsequently drained and farmed by settlers who irrigated their crops with a combination of river flows and ground water. By the beginning of the 20th century, however, local water supplies proved insufficient for both farms and cities, and civic leaders began making plans to import water. After the City of Los Angeles tapped the Owens River through an ambitious 215-mile aqueduct that skirted the Eastern Sierras (1913), the Metropolitan Water District of Southern California (Metropolitan) strung an even longer pipeline to fetch Colorado River water from Lake Mead behind Hoover Dam (1941). In the meantime, Orange County residents who were concerned about their shrinking aquifer formed OCWD "for the purpose of managing the groundwater basin and managing, replenishing, regulating, and protecting the groundwater supplies."

OCWD acquired surface water rights to replenish their aquifer and wholesaled the ground water to area municipalities. When surface water was insufficient to fill the aquifer, they bought water from other agencies, including Metropolitan. At the other end of the pipe, the Orange County Joint Outfall Sewer (JOS) conveyed Orange County's sewage a half-mile out into the Pacific Ocean (the current outfall is 5 miles long) but it would take local communities another 30 years to form the County Sanitation District of Orange County, later renamed Orange County Sanitation District (OC San). Then, in the mid-1960s, the need for more water brought the two agencies together.

The future of the two agencies began to intersect when increased demand from a growing post-war population depleted the aquifer to the point that it was vulnerable to seawater intrusion. OCWD determined they could create a barrier by treating OC San's effluent and injecting it into the aquifer. They purchased land next to the OC San plant for a pilot plant to explore the feasibility of water reuse. Dubbed "Water Factory 21," the plant was originally designed to produce a blend of desalinated seawater and disinfected wastewater (1975) but was later modified to treat wastewater alone through reverse osmosis (1977). After OC San began treating wastewater to secondary standards (1978), OCWD supplied up to 7,000 acre-feet per year of recycled water for irrigation through its Green Acres Project (1991). In a reciprocal arrangement, OCWD began analyzing OC San's wastewater samples for regulatory compliance at the water laboratory it built to support Water Factory 21, furthering their collaboration.

The promise of their robust collaboration was fulfilled in 2001 when OCWD and OC San agreed to jointly fund the design and construction of a project to treat over half of OC San's flow to drinking water standards for potable reuse through ground water injection and direct recharge. By participating in the Groundwater Replenishment System (GWRS), OC San saved $190 million— the estimated cost of building an additional outfall. GWRS continues to expand and is on track to treat all of OC San's reusable flow by 2023, bringing the program's capacity to 130 MGD (148,000 AFY). Asked about the key to the success of their program, OCWD General Manager Mike Markus cited the longstanding relationship between the two agencies and the OC San's Board of Directors strong commitment to water recycling (Markus, 2021).

Contra Costa County, California: A long and winding road

Just a few hundred miles north of Orange County's ground water basin, Contra Costa County draws its water from the tidally influenced freshwater delta formed by the Sacramento and San Joaquin rivers as they flow out to sea (CCWD, 2017). The farms and factories that developed at the turn of the last century suffered greatly when periodic droughts and upstream diversions reduced this freshwater flow, bringing salt water from San Francisco Bay upriver and making the water too brackish to use. During the 1920s, at the peak of a 13-year drought, farmers were forced to stop irrigating and factories had to bring in water by tank car.

In 1933 local citizens created the Contra Costa Water District (CCWD) to provide a reliable source of water less susceptible to incursion from salty seawater. They proposed building a canal to bring fresh water to the community from fifty miles inland, and in 1937 the Contra Costa Canal was included as a part of the massive federal Central Valley Project. It began delivering water in 1940, just in time to serve the post-war population boom. The federal water slaked the thirst of the newcomers, but their wastewater soon exceeded the capacity of area septic systems, necessitating the formation in 1946 of the Central Contra Costa Sanitary District (Central San) to collect and treat wastewater discharged into nearby Suisun Bay.

The service area boundaries of CCWD and Central San are not identical, but they overlap, and include two large oil refineries located less than 5 miles from Central San's wastewater treatment plant. (The refineries treat and discharge their own wastewater but together receive up to 20 MGD of raw water from CCWD.) In the late 1960s, when it appeared that new more stringent rules would limit the discharge of nutrients to the bay from wastewater treatment plants, Central San and CCWD developed a plan to convey recycled water to serve recycled water to the refineries in place of Delta water. CCWD even agreed to invest an additional $6 million in an ion exchange process to soften the water before delivery to the refineries. The project was stalled by construction delays, however, and in the intervening months state regulators removed the nutrient removal requirement from Central San's discharge permit.

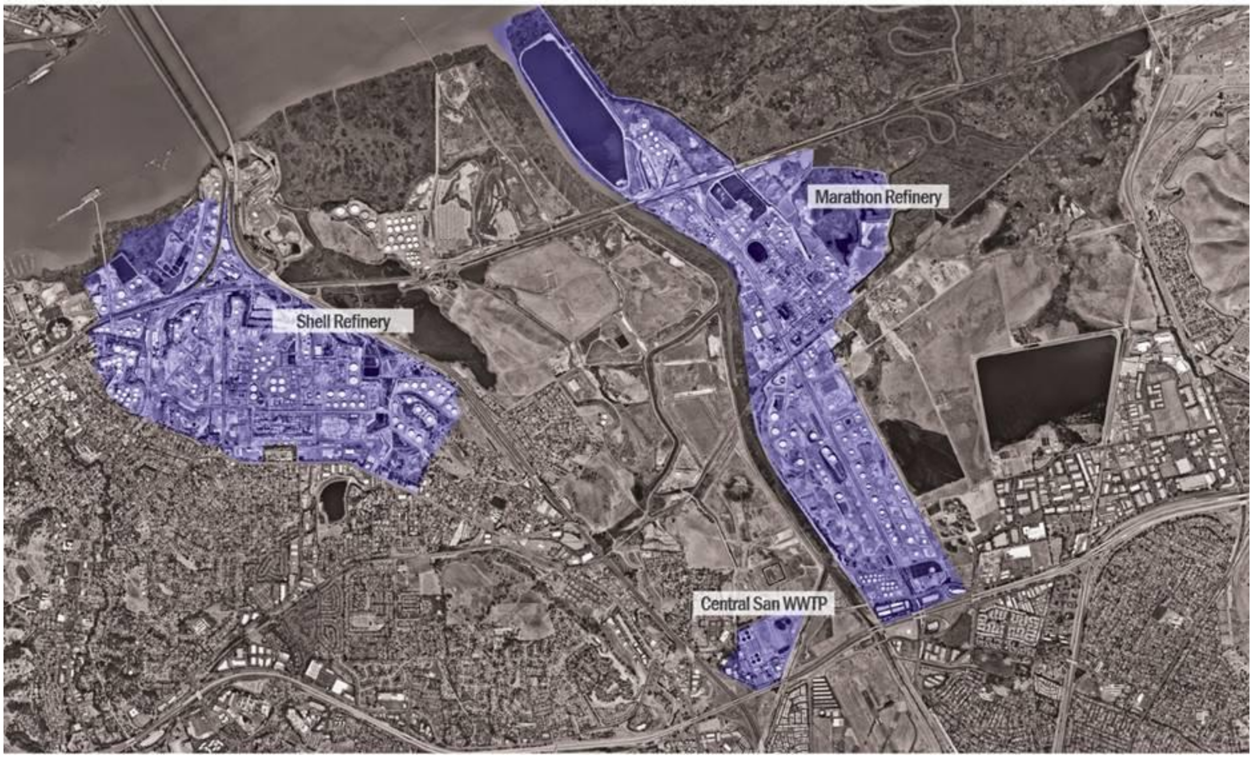


Figure 2. Location of oil refineries in the vicinity of Central San Wastewater Treatment Plant (Source: Central Contra Costa Sanitary District, 2021)

Without a regulatory driver, Central San sought to renegotiate the deal with CCWD that had been the basis for both parties moving forward with the project. The wastewater agency had previously agreed to assume nearly all of the $180/AF cost of producing the recycled water. Once the only value of recycled water reuse appeared to be for its use as an alternative water supply, Central San managers asked CCWD to share costs more equally, but here the project was stymied by two additional complexities.

The first challenge was economic. Just as Central San no longer needed recycled water to meet their permit requirements, CCWD maintained that they already had reliable, adequate, and less costly supplies to serve their customers, and they did not need to incorporate recycled water to offset existing uses. Furthermore, they had already invested significantly in pipelines, reservoirs, and water treatment plants to enhance the quality and reliability of their supplies for their entire service area. If the refineries began buying recycled water from Central San, CCWD would have reduced revenues from which to repay the bonds for past improvements.

The second problem, rooted in geography, was just as thorny. Central San discharges its treated wastewater into Suisun Bay, just upstream of the Carquinez Strait, a narrow inlet through which fresh water from the Delta flows on its way into San Francisco Bay. Over time, state authorities recognized the need to maintain Delta outflows to protect water quality for Bay and Delta water users, including fresh, brackish, and saltwater ecosystems. During dry periods, when the state limited the amount of water that CCWD could diverted from the Delta for municipal use, the 20 MGD of recycled water Central San supplied to the refineries would result in a net water supply benefit by reducing demand on water from upstream reservoirs and making more water available to maintain freshwater flows. In wetter years, however, when Delta flows were ample, the recycled water would not add to the water supply, further reducing CCWD's incentive to pursue the project.

Failing to resolve this impasse, the two agencies agreed that Central San would extend a pipeline to supply recycled water to a few large landscape irrigation customers near their wastewater treatment plant, satisfying the concerns of the EPA and the California Water Resources Control Board that provided grant funding for the project and required some evidence of Central San's use of the grant-funded facilities.

Despite these challenges, CCWD and Central San have continued to develop strategies to use recycled water, and new leadership at both agencies—unhampered by the memory of prior disputes—now see the opportunity to reuse water in a more positive light. As climate change and changing regulations have resulted in more challenges to the management of Delta water supplies, wider regional partnerships are being developed to enhance water supply reliability in the face of droughts and other emergencies. Central San and CCWD are now working with a third agency to engineer an arrangement that would allow Delta water freed up through use of recycled water by the refineries to be wheeled to the South Bay. As Roger Bailey, current general manager of Central San recently described their relationship with CCWD, "We recognize their concerns, and their desire to keep their customers whole by avoiding duplication of service with recycled water. So if they don't need this supply, perhaps we can work together to get it to people who do. Because sooner or later we're all going to need this water"(Bailey, 2021).

Motives and Methods

Reflecting on the divergent histories of these two California counties, it is apparent that many factors influenced their approach to water reuse, including their hydrology, agency history, regulatory environment, and the price of water. What lessons can we draw from their experience? What combination of physical circumstances, environmental drivers, economic conditions, and management styles supported their ability to collaborate on reuse projects? And what can other agencies do to work more effectively together to recycle water?

While some answers may seem obvious these questions are far from simple. This report represents an attempt to answer them by analyzing the factors that influence interagency collaboration. The study includes an analytical framework based on a review of the literature and interviews with other water professionals; in-depth discussions with managers involved in the case studies profiled; and the insights that team members have gleaned from their experience managing, operating, and regulating water utilities that recycle water. As explained in the analytical framework section, the investigation focuses on five aspects of interagency relations:

- their legal structure and management (**governance**)
- the laws and rules under which agencies function (**regulation**)
- their funding sources and fiscal constraints (**economics**)
- the challenge of meeting their day-to-day responsibilities (**management**)
- their organizational culture and interpersonal styles (**leadership**)

We hope the experiences of the organizations and individuals profiled in this report will help other managers build the relationships needed to implement water reuse programs. Looking beyond reuse, we expect this advice to be useful in solving other problems as agencies race to find new strategies and solutions in the face of population growth, resource depletion, and climate change in the coming decades.

How to Use This Document

This document has been prepared to be accessible in several different ways:

- Those interested in learning about a particular aspect of interagency collaboration or who wish to gain a broader understanding of the topic from the literature are invited to read the Analytical Framework as a prologue to the regional profiles. Summaries and comments about selected references cited in the Framework are also included in an Annotated Bibliography.
- The five case studies provide examples of how agencies in different regions, facing diverse challenges, worked together to reuse water to solve shared problems. While it is instructive to compare the different regions in detail, a quick scan of the "Overview and Key Takeaways" section will allow the reader to spot issues of particular relevance. Insets provide basic information about each agency's purpose, budget, and involvement in water reuse.

- A collection of “lessons learned” follows the case studies, organized according to the five aspects of collaboration proposed in the Analytical Framework. The final section also includes exercises for agencies to facilitate a thoughtful and mutually beneficial collaboration.

Some Notes on Nomenclature

Agency/utility

The primary sponsors of reuse projects are usually the utilities responsible for managing wastewater and stormwater suitable for recycling, and the water utilities that supply recycled water to their communities. They are joined in this effort by a number of other institutions, including federal and state authorities that set criteria for water quality and regulate wastewater and stormwater discharge as well as numerous other bodies that have a say in permitting the construction of recycled water facilities. The term “*water agency*” is often used in this report interchangeably with the word “*utility*,” and should be understood to mean an organization charged with managing public water, wastewater, or stormwater. By contrast, the unmodified term “*agency*” can equally refer to regulators or others.

Coordinate/cooperate/collaborate

The intentional act of working together is defined in this report primarily through these verbs: coordinate, cooperate, and collaborate. While we have used these terms to describe various levels of interagency assistance, they are not exactly interchangeable as noted by New Zealand government policy advisors Rodney Scott and Ross Boyd (2020):

> There is a general sense in the literature that, when compared to **cooperation** or **coordination**, **collaboration** involves greater ‘depth of interaction, integration, commitment, and complexity’…**collaboration** is distinguished in part because it involves integration over a longer period, with cooperation and coordination being perhaps early developmental stages… Collaboration is distinguished by the actions that are performed together; collaboration involves shared working, rather than merely shared information or shared planning... [it] involves **shared responsibility for a common goal**, with other forms of interagency working involving cooperating or coordinating…overlap while maintaining separate responsibilities..” (Emphasis added)

With this distinction in mind, it is useful to observe how the relationships between the agencies profiled in in this report evolved, and the extent to which they were ultimately able to commit their individual resources towards the development of water reuse.

Water recycling and reclamation; indirect and direct nonpotable and potable reuse

The terminology applied to techniques for reusing treated wastewater and the types of water produced is evolving as rapidly as the industry itself. As a result, the literature—including this report—reflects both regional and historical preference. While we have attempted to describe the practice of water reuse in a consistent manner, some terms are used interchangeably.

1. **Water recycling, water reclamation, and water reuse.** In industrial settings, “water reuse” often refers to the reuse of wastewater without intervening treatment, as distinct from “water recycling” which refers to wastewater which must be treated before further use (Rosenblum, et al., 2021). Within the municipal arena, however, all water reused is presumed to have required and received additional treatment appropriate to its use. In this context, the terms water recycling and water reuse are considered to be synonymous. Similarly, **reclaimed water** and **recycled water** both describe water treated to a higher quality suitable for its end use.

2. **Direct nonpotable** and **indirect potable reuse.** As used by many Texas water agencies, these terms distinguish between types of nonpotable and potable reuse. Irrigation, industrial cooling, toilet flushing and other nonpotable applications of treated effluent are termed “direct reuse” while treatment and

distribution for potable purposes of surface water which includes a significant fraction of treatment plant effluent they term “indirect reuse.” By contrast, in California and some other states, intentionally blending treatment plant effluent with surface water supplies upstream of a potable water treatment facility is considered “raw water augmentation” and is a form of direct potable reuse (see below). In those states, conventional treatment of surface water with an indeterminate amount of treatment plant effluent has been termed “incidental,” “unplanned,” or “de facto” reuse.[1] Within the context of this report, the term indirect reuse” is used as it is by the agencies whose partnerships are described, which in Texas refers generally to the discharge of return flows from wastewater treatment plants into drinking water reservoirs and their subsequent treatment and distribution for potable purposes. Elsewhere, however, the term indirect reuse is applied only to planned reuse projects.

3. Direct and indirect potable reuse. Nomenclature developed and promulgated in California now avoids describing potable reuse with either the “indirect” or “direct” modifier. Instead, potable water reuse is described in terms of the way in which recycled water is added to the potable supplies: in an aquifer (“ground water augmentation”); in a reservoir (“reservoir augmentation”); ahead of a water treatment plant (“raw water augmentation”); or into the potable water distribution system (“treated water augmentation”). Nevertheless, many states continue to use “indirect potable reuse” to refer to the first two methods (ground water and reservoir augmentation) and “direct potable reuse” to refer to the second two methods (raw water and treated water augmentation), noting that indirect potable reuse includes an environmental buffer of some kind while direct potable reuse does not.

A note on units

Not only are water and wastewater agencies organized to accomplish distinctly different missions, but they also measure and manage their efforts differently. Where water agencies are concerned about meeting demand for water during critical dry years, wastewater utilities gear up to treat wastewater during periods of peak flow. Even the units of measurement are not the same, as water is often measured in cubic feet (CF) or units of one hundred cubic feet (CCF), whereas wastewater is measured in millions of gallons (MG) or millions of gallons per day (MGD). These discrepancies are even more pronounced on a regional basis, as many western water agencies measure their supply in terms of acre-feet (AF) or acre-feet per year (AFY), one acre-foot being the volume of water required to cover one acre of area to a depth of one foot, or 43,560 cubic feet.

For the sake of clarity, within this report wastewater volume and flows are provided in terms of millions of gallons (MG or MGD), and water supplies are presented in the units used by the utilities described in their respective case studies (generally AF or AFY). Recycled water projects may be described in either unit, depending upon whether the focus is on production of the water or its distribution and use by the community. For convenience, the following approximations may be used:

1	AF	=	0.33	MG
1,000	AFY	=	0.9	MGD
1	MG	=	3.1	AF
1	MGD	=	1120	AFY

[1] The National Research Council’s **Committee on the Assessment of Water Reuse as an Approach to Meeting Future Water Supply Needs** defined “de facto reuse” as “*a drinking water supply that contains a significant fraction of wastewater effluent, typically from upstream wastewater discharges, although the water supply has not been permitted as a water reuse project*.” (NRC, 2012, p. 3) The Committee cited the reuse of return flows in the Trinity River Basin (see *Case Study #2: North Central Texas*) as an example of an effluent-dominated surface water system where de facto potable water reuse occurs.

ANALYTICAL FRAMEWORK

The Challenge of Interagency Collaboration

Key Takeaways

- While water-related challenges today require integrated solutions, U.S. water supply, wastewater treatment, and flood control services have historically been accomplished by separate utilities organized to fulfill those separate missions. Cooperation between agencies is influenced by their individual governance and management structures, as well as the regulatory and economic environments in which they operate.
- Successful collaboration between utilities requires mutual sensitivity to their distinct motivations and responsibilities, and leadership to see beyond the traditional limits of their organizations.

While water-related challenges today require integrated solutions, US water supply, wastewater treatment, and flood control services have historically been accomplished by separate utilities organized to fulfill those separate missions. Fragmentation of utility operations, each one focused on an isolated part of the urban water cycle, challenges the development of integrated water management (Mukheibir et al., 2015) (WERF Exploratory Team, 2011). Even in communities where water and wastewater services are provided by a single entity, different departments may compete to achieve their individual goals. This competition has prompted some to define water management as a “wicked problem” for which no single objectively optimum solution can be found (Dentoni, et al., 2018). Nonetheless, “separate but connected” agencies can work together to adopt a “One Water” approach, operating as a single virtual utility (Paulsen, et al., 2017) (US Water Alliance, 2021a).

The roots of fragmentation

How did this fragmented approach to managing water develop, and how does it impact the ability of agencies to reuse water?

Fragmentation of water management has deep historic roots. Iraqi *qanats* and Roman aqueducts brought water to ancient farms and cities, and communal wells have been part of the urban landscape for centuries. Wastewater treatment was not common until the 20th century when the effects of pollution became too intense to ignore (Sedlak, 2014). In short, our current mosaic of water agencies reflects the piecemeal development of a water infrastructure constructed to serve our urban centers as our population and economies have grown. These institutions were created to satisfy the water needs of communities at a specific time and place, and as such they were shaped by the environmental, social, and political circumstances in which they emerged (Sehring, 2005). In a nutshell, the insitutional challenge of water reuse results from the fact that community water needs evolve more quickly than the agencies themselves.

On the other hand, there is nothing immutable about the way agencies manage water today. History has shown that people regularly create new institutions in response to changing conditions (Blomquist, 1992). In California, for example, land reclamation districts formed in the 19th century to drain land for agriculture were followed by irrigation districts created to water the reclaimed farmland. As the state became more urban,municipal water districts were formed to provide drinking water to growing communities (Henley, 1957). Following this trajectory, as communities realize the cost-effectiveness of integrated water management, one can expect that agencies will work more closely together, or else they will be forced to reorganize to allow for the implementation of more holistic solutions.

The challenge of collaboration

Despite the organizational challenges to the development of cross-jurisdictional projects, there are many examples of agencies both large and small, working together to reuse water (Gallet, 2019) (Howe, 2019) (LADPW, 2020) (SAWPA, 2020). As the case studies in this report demonstrate, there are several factors that contribute to successful collaborations.

Public policy experts distinguish between different types of intergovernmental teamwork that vary depending upon what motivates agencies to work together. While “coordination” may describe sharing information in order to better align the outcome of their activities, agencies “cooperate” when they work together on a joint project, sharing staff and resources as well. By contrast, “collaboration” involves integration over a longer period of time and shared responsibility for a common goal (Scott & Boyd, 2020).

Raucher et al. (2008) identified several barriers to cooperation between utilities collaborating on joint water supply projects. These barriers include loss of autonomy; differences in service population; geography; and confliciting regulations and management goals. Henderson and Raucher (2019) identified eight steps to overcome those barriers (Table 1).

Table 1. Eight steps to creating utility partnerships (after Henderson and Raucher, 2019)

Step	Activity
Step 1.	Identify the people and organizations needed to create a successful partnership.
Step 2.	Identify partnership objectives, values, and drivers.
Step 3.	Explore options for utility partnerships.
Step 4.	Review common legal structures for partnerships.
Step 5.	Identify potential benefits (“The Business Case”).
Step 6.	Review potential partnership issues and concerns.
Step 7.	Think conceptually about legal provisions to include in a contract.
Step 8.	Communicate about partnerships to build support.

Following these steps involves addressing challenges in at least five distinct areas: 1) governance and legal requirements; 2) regulatory issues; 3) economic factors; 4) management considerations; and 5) leadership and interpersonal dynamics.

Despite the growing popularity of the “One Water” concept, water agency **governance** is commonly constrained by the original mission, structure, and culture of the utility. If a water agency was created to provide ratepayers with clean, low-cost water, it may be reluctant to participate in expensive “used water” projects. Similarly, a wastewater agency may determine that it is legally unable to invest in a reuse project whose primary purpose is water supply. By focusing on their common goals, however, utilities can often justify their participation in a water reuse project. Collaboration between agencies can be formally codified through appropriate legal agreements (Step 4 in Table 1), but it takes foresight, vision, leadership, and determination to overcome these structural and cultural barriers.

Collaboration between agencies can also be complicated by the need to comply with the many **regulations** related to production, transmission, and use of recycled water (NRC, 2012). Regulatory limits may constrain a treatment plant from discharging membrane treatment concentrate into the receiving water; other regulations may prohibit customers from accidentally allowing recycled water to run off into the storm sewer. Conversely, limits on effluent quality or quantity may create a driver for reuse. To complicate matters further, recycled water regulations may be promulgated in different codes (e.g., drinking water, wastewater) using different terminology. Since permit compliance has legal and political consequences, assigning responsibility for compliance may be even more divisive than allocating costs.

Economic issues must be handled carefully so the full array of benefits is recognized, and no party bears an unfair share of the cost. The unit cost of recycled water is almost always higher than the rates charged for its use (especially for nonpotable applications), so a cross subsidy from another water service is often required (Cristiano & Henderson, 2009) (AWWA, 2019) (Raucher, et al., 2019)). On the other hand, the risk of natural disaster, regulation, or climate change disrupting supply may make it prudent to spend more now to assure the availability of water later. A detailed benefit-cost analysis, including non-market benefits may be needed to justify the project and help align cost recovery with the beneficiaries (De Souza, et al., 2011) (Raucher, et al., 2019). By identifying the benefits of reuse to the community as a whole, agencies may find other opportunities to collaborate as well (Diringer, et al., 2019). Likewise, opportunities to access favorable financing for reuse projects may be enhanced through water agency collaborations and partnerships.

A host of **management** issues confront agencies working together to design, build, start up and run a water reuse system. Along with the usual technical matters pertaining to design, specification, and construction, joint projects may involve questions related to ownership, real estate, and infrastructure. Operation and maintenance responsibilities must also be assigned, and expectations specified for key parameters including water quality and pressure, flow rate (peak daily and annual), and temperature as well as response to pipe breaks, partially treat ed water, and other non-optimal situations (Rosenblum, 2016).

In virtually all cases, both individual and organizational **leadership** is needed to implement a recycled water project. Although interpersonal and cultural issues can interfere with cooperation, a perceptive "project champion" can inspire others to keep the project on track and build trust across agencies. Directors, managers, and agency staff can advance leadership by identifying, setting, and incentivizing shared, common goals rooted in the larger context of sustainable water use (Scott & Boyd, 2020). They can also encourage others to adopt this perspective by ensuring that each agency is aware of the other's issues (Rosenblum & Anderson, 2009).

By working together to recycle water, agencies can create multiple benefits that contribute to economic, environmental, and community livability. However, they face a variety of legal, regulatory, economic, technical, and leadership challenges. The following sections discuss these factors in detail and describe the strategies agencies can employ to align governance with mission, work cooperatively with regulators, make economic decisions based on long-term goals, assign tasks to the most capable parties, and encourage both individual and organizational leadership.

Governance Strategies and Legal Tools

Key Takeaways

- Water utilities were created to solve problems in a specific time and place, but their problems evolve faster than their governance structures.
- While agency boundaries can create barriers to cooperation, they can also function as points of connection, presenting opportunities to increase resilience.
- Water, wastewater, and stormwater agencies work together best when they each recognize how their goals intersect and how water reuse supports their missions.
- Legal structures from agreements to joint authorities can be used to formalize agency partnerships.

This section explores tools and strategies to overcome the barriers to collaboration arising from the legal structures that govern how agencies operate. These structures can narrow a government agency's vision and sense of mission, and interfere with productive cooperation. Some utility managers openly declare that their mission is limited to providing basic water services reliably at as low a cost as possible. To them, investing time and resources in pursuit of objectives outside the bounds of their narrowly defined mission is not good business. Other managers recognize the role they play in promoting the greater good, and actively pursue an agenda that includes social and environmental objectives. In some cases they lead this effort; other times they simply reflect the "green" values held by their communities. In a report for the Global Water Partnership, Rogers and Hall (2003) concluded that institutions responsible for all aspects of water use should be structured and operated to support integrated water resource management, and a number of institutional frameworks have been proposed for reforming the governance of water agencies to achieve that goal (Grafton, et al., 2019).

Challenges to interagency cooperation are not unique to the water industry, and many agencies in various sectors have found ways to work across jurisdictional boundaries. Law enforcement agencies commony cooperate across jurisdictional boundaries (Tannian, 2017) and "mutual aid" agreements allow fire departments to share personnel and equipment. In California, federal, state, and local fire supression agencies regularly update a detailed plan to coordinate their efforts to respond to wildfires in the state (CWFCG, 2017), and the Federal Emergency Management Agency (FEMA) has published templates for mutual aid agreements to allow states and municipalities to collaborate effectively in case of emergency (FEMA, 2017).

The Government Accountability Office (GAO) defines interagency collaboration as "any joint activity by two or more organizations that is intended to produce more public value than could be produced when the organizations act alone" (GAO, 2005). They cited eight steps to "enhance and sustain" interagency collaboration, all of which are applicable to facilitating water reuse:

1. Define and articulate a common outcome.
2. Establish mutually reinforcing or joint strategies.
3. Identify and address needs by leveraging resources.
4. Agree on roles and responsibilities.
5. Establish compatible policies, procedures, and other means to operate across agency boundaries.
6. Develop mechanisms to monitor, evaluate, and report on results.
7. Reinforce agency accountability for collaborative efforts through agency plans and reports.
8. Reinforce individual accountability for collaborative efforts through performance management systems.

Rather than a formula, Quick and Feldman (2014) propose a "stance of inquiry" towards boundaries that allow managers to see them as "porous" and the source of potential points of connection. Based on their research in a variety of municipal settings they contend that *"An orientation to boundaries in collaboration as junctures enables efficient resilience by supporting an ongoing capacity to adapt to emerging circumstances."*

Types of governance structures

Responsibility for providing safe and reliable water is normally assigned to local city and county governments, general or special purpose districts, or private companies subject to public regulation (Beutler, 2008). According to Green (2007), in California (as in many states) there are five different types of water agencies: 1) water suppliers; 2) ground water management agencies; 3) wastewater management agencies; 4) stormwater management agencies; and 5) water quality agencies. Green pointedly adds that, "*Nothing in the law requires them to talk to one another or to plan in an integrated way*." The features of these agency types are described further in Table 2. Even when they are housed as departments within city and county governments, the thousands of agencies that provide drinking water, wastewater, and stormwater services in the United States are often operated with their own mission-specific goals in mind. When enshrined in an agency's enabling legislation, this single-mindedness can present a barrier to the development of recycled water projects, which may require them to share responsibilities with another entity. As an independent utility, a water agency tasked with distributing clean, safe water will most often look to expand its current supply of fresh water before considering the reuse of treated effluent, especially when those freshwater supplies are available at a low cost. Similarly, a wastewater agency facing discharge limits will invest in additional treatment before entering into a complicated agreement with a water agency to use its nutrient-rich effluent for irrigation, unless the latter is more cost-effective.

Table 2. Types of water agencies

Type of Organization	Governance	Jurisdiction	Features
City or county government	Publicly elected council or board, district or at-large	City or county limits	Departments may be supervised by appointed city or county manager or elected mayor or county executive
Special district	Publicly elected or appointed board	Set by legislation; varies with purpose	District boundaries may overlap other political jurisdictions
Private water company	Board of directors elected by shareholders	Service area franchise	May be publicly held and subject to other rules of coprorate governance
Joint powers authority	Publicly elected or appointed board	Boundaries agreed to by joint authorities	Board may consist of representatives of particpating public agencies

Within the water sector, agencies have used a number of legal strategies to enable them to collaborate. These strategies range from informal agreements and simple memoranda of understanding to bilateral or multi-party agreements. More formal arrangements may include the formation of joint powers authorities or even consolidation of existing agencies into a new legal entity capable of carrying out all the existing responsibilities of the individual authorities in a more integrated and efficient manner. Some of these approaches are described further in Table 3. Each has advantages and limitations, as further illustrated in the discussion of the case studies.

Aside from these legal strategies, agencies can work together to advance water reuse by forming "*ad hoc*" cooperative associations. In the San Francisco Bay Area, local water agencies joined together to create Bay Area Regional Reliability (BARR), a regional partnership through which they investigated alternatives to enhance their collective water reliability (Brown and Caldwell, 2017). They can also cooperate through their mutual involvement in professional associations as in Washington State where water and wastewater agencies in the Puget Sound area coordinate reuse activities through meetings with the Pacific Northwest Clean Water Association, a section of the national Water Environment Federation, and the Pacific Northwest Section of the national WateReuse Association. Less formally, the consortia of national universities funded by the National Science Foundation operating under the rubric ReNUWIt ("Renewing the National Urban Water Infrastructure") created a series of seminars designed to bring area water advocates and professionals in the San Francisco Bay Area together to consider the potential for collaboration on water reuse projects (Harris-Lovett, et al., 2019).

Table 3. Some types of arrangements to support collaborative recycled water projects

Type of Partnership	Some Advantages	Some Limitations
Informal agreement	• Easy to implement. • May arise spontaneously from professional associations. • Adaptable to changing circumstances.	• No formal legal review or approval required. • No enforcement authority. • No formal identification of responsibilities; may be inappropriate for complex projects. • May not be transparent and may not survive changes in key personnel.
Memorandum of Understanding	• Easy to implement. • Spells out reasons for collaboration and respective expectations. • Allows some specificity of actions, including permission to provide service across boundaries. • Transparent to public.	• May require formal approval. • Limited enforceability. • Responsibilities may not be adequately specified for complex projects.
Bilateral Agreement	• Identifies actions required by both parties. • Includes terms and conditions enforceable through specified remedies including venue. • Transparent to public.	• Time lag between inception and execution. • Requires legal review, formal approval. • Once executed, may not be easily adapted to changing conditions. • Only binding on two parties.
Multi-party Agreement	• Identifies actions required by all parties. • Includes terms and condition enforceable through specified remedies including venue. • Transparent to public.	• Multi-party terms require legal review after any unilateral change. • Requires formal approval by all parties. • Once executed, may not be easily adapted to changing conditions.
Contractual Services	• Allows one party to provide services required for reuse with terms of payment by other party or parties. • Identifies actions required by all parties. • Includes terms and conditions enforceable through specified remedies including venue in which future disputes might be settled. • Transparent to public.	• Does not include provisions for reciprocal participation. • Must include appropriate provisions for holding service provider accountable for meeting specified performance goals. • Requires formal approval by all parties. • Once executed, may not be easily adapted to changing conditions.
Joint Powers Authority	• Provides maximum flexibility for collaborative action while allowing participants to retain their prior agency affiliations. • Allows new agency to respond to changing conditions on behalf of signatories within limits of authority. • New agency has authority to collect fees and borrow funds Transparent to public.	• More time consuming than simple agreements or contracts for services. • May require legislative approval in addition to approval by boards of participating agencies. • Once created, authority is not readily dissolved.

Type of Partnership	Some Advantages	Some Limitations
Consolidation	• New agency takes on all duties of participating agencies, including reuse program. • Allows new agency to respond to changing conditions on behalf of signatories within limits of authority. • New agency has authority to collect fees and borrow funds. • Transparent to public.	• Most time consuming. • May require legislative approval in addition to approval by boards of participating agencies. • Requires careful accounting of all liabilities of existing entities prior to consolidation.

Consolidation or collaboration?

When two agencies serve different populations (i.e., when their service areas are not identical) it is difficult to determine how a joint water recycling project benefits their respective ratepayers. For this and other reasons, some suggest that the best solution is the formation of a single agency with jurisdictional boundaries commensurate to the watershed in which it operates. Florida regulators, for example, divide their state into five water management districts (SFWMD, 2020). In southern California, multiple agencies created the Santa Ana Watershed Protection Authority to provide integrated water management (SAWPA, 2020) after decades of lawsuits and legal decisions apportioning ground water rights and responsibilities. As an alternative to consolidation, California has encouraged interagency cooperation through legislation like the 2002 Regional Water Management Planning Act (SB 1672), the 2014 Storm Water Management Planning Act (SB 985), and the landmark 2014 Sustainable Groundwater Management Act (SGMA) which requires coordinated local management of all medium- and high-risk ground water basins.

Creating agencies with watershed boundaries may bring in a different set of problems however. For one thing, people living in different communities within a common watershed may have very different interests not readily reconciled by a single agency. Water problems do not impact everyone within the watershed equally, and a single large watershed-based agency may well give decision-making authority to upstream water users insulated from the influence of downstream problems like seawater intrusion (Blomquist & Schlager, 1999). Some problems extend beyond the boundary of a given watershed, prompting some to use the term "problemshed" to define the population struggling with the same issues (Cohen & Davidson, 2011). From a philosophical perspective, Franco-Torres et al. (2020) also recommends a more decentralized governance structure involving "*partnerships between diverse actors through interactions to find synergies and negotiate conflicting interests" which include both formal relationships and "informal (shadow) networks."*

The "One Water" approach endorsed by the American Water Works Association (AWWA), the Water Enviornment Federation (WEF), the WateReuse Association, the US Water Alliance, and other national water organizations supports integrated water management while leaving existing agency jurisdictions intact. The key to this approach is joint planning which includes "*collaboration among multiple departments and agencies, each with separate missions [to establish] an overarching vision and…broadly define what your team intends to accomplish*" (Paulsen, et al., 2017). As an example, the City of Pittsburgh Water and Sewerage Agency and the 83 municipality members of ALCOSAN, Allegheny County's regional wastewater facility () are currently working together to address a range of water-related issues, including flooding and pollution from combined sewer overflows (Howe, 2019). In this example, it is worth noting that stormwater and flood control agencies take center stage in leading their respective communities towards sustainable water management.

Working with Regulations and Regulators to Make Water Reuse Projects Sing

Key Takeaways

- It is important to understand the regulatory landscape specific to a project within a jurisdiction rather than to rely on general assumptions or lore. Mapping out regulations and regulatory strategies early on in planning a project enables proactive engagement with regulators to enlist them as partners.
- Successful projects engage with regulators early on—during the development of regulations so the adopted rules are consistent with their practices, and during the development of their projects to assure that they comply with applicable regulations and to avoid surprises.
- Regulations can drive, enable, or stymie projects. Regulators can do a lot to help make them enablers of good projects rather than hindrances.

There are a host of regulatory issues to be considered in developing a water reuse project and multiple ways to approach them. Concern about regulations (which carry both economic and legal consequences) can impede collaboration and delay the development of recycled water projects. On the other hand, water use and wastewater discharge regulations collectively define the challenge of water management in a way that has led to a recognition of the benefits of reuse as a means of making more sustainable use of water resources. This section examines how approaching regulations thoughtfully is an essential element of interagency cooperation, and how agencies and regulators together can use the regulatory structure to create successful recycled water projects.

Regulations as drivers to reuse

Regulations can frequently be a driver shaping the vision of a recycled water project. For example, nutrient discharge requirements can be set so low that it may be cheaper for a wastewater agency to recycle water for irrigation than to further reduce ammonia and nitrogen concentrations. Alternatively, limits on withdrawal of ground water or surface water can drive interest in reuse as a reliable source of water for ground water recharge, or as a means of leaving water in streams for environmental purposes. Recycled water regulations can also *enable* water reuse projects when they provide uniform standards that give a level of certainty to the permitting process. As described below, strategically and collaboratively developed regulations can inspire agencies to envision bigger projects. This was the case in California where statewide indirect and direct potable reuse regulations encouraged agencies to set more ambitious goals than those achievable with non-potable use (Marcus, et al., 2020) (Metropolitan, 2015). Regulations based on watershed-wide permits can even encourage local agencies to reimagine their roles as integrated water resource managers.

On the other hand, regulations can at times be a source of frustration, surprise, and delay. A recent survey indicated that, “eight out of ten clean water agency managers said regulatory inflexibility is ‘very important’ or “’the most important’ factor that needs to change to create more innovation in the sector” (NACWA, 2013). State recycled water standards vary, and as state agencies become more supportive of recycled water some are considering a new suite of standards.[2] Wastewater agencies that are used to thinking only in terms of environmental water quality are often surprised to encounter water rights rules they consider overly conservative or complex. Utilities solely familiar with conventional drinking water treatment rules who are unexpectedly confronted by residual discharge limits may be discouraged by increased costs and delay.

[2] In addition to Texas’ historic projects in Big Springs and Wichita Falls, California, Colorado, Florida, and Arizona, are working on direct potable reuse (DPR) regulations. California and others have implemented state level standards for other indirect uses such as groundwater augmentation and reservoir augmentation in recent years and interest is growing in many states across the nation. (Clayton, 2021)

Misunderstandings about regulations like water rights and residuals discharge can distract agencies from thinking creatively about reuse projects. Furthermore, since the rules regulating water supply and wastewater agencies differ substantially in form, language, and substance, they can also be a source of friction between potential partners. Water reuse project managers can help themselves in the face of these regulatory challenges in three ways: they can work together to influence the rules that govern their projects; they can make sure they understand the rules; and they can carefully monitor project performance to ensure they comply with all pertinent regulations.

Successful project managers engage early to influence standards at the state and local level to assure that the rules that are ultimately adopted are implementable and not overly burdensome in achieving their desired objectives. (Ulibarri, et al., 2017). Interagency partners should decide early how they will share responsibility for involvement in policymaking and must devote the staff time and budget needed to engage effectively. To save time in the long run they should understand the steps of the process, develop a road map, and establish working relationships with regulators. A clear understanding of the nature of regulation and the role of regulators can help reuse proponents successfully navigate the regulatory process.

For their part, regulators and regulatory agencies can also do much to help or hinder recycled water projects. Just as water reuse agencies need to assess and coordinate their approach to regulations and engage with regulators as early as possible when envisioning the project, regulators need to see themselves as partners who are helping local agencies achieve the water resilience they seek within the regulatory process. While this may be a departure from a more traditional "hands off" approach, it is an essential element in the successful creation of recycled water projects.

What follows is a more detailed discussion of the nature of the complex regulatory framework water reuse projects must address, tips for reuse agencies to navigate (and even influence) the regulatory space, and suggestions for regulators to make the process more conducive for reuse projects and thereby help to create more resilient communities (Marcus, et al., 2020).

Assessing the regulatory environment and deciding how the team will manage it

Regulations relevant to water reuse projects cross a wide range of jurisdictions and disciplines. Rules are promulgated at the federal, state, and local levels, and cover all aspects of water management including water rights; environmental review of construction projects; protection of public health and the environment through standards and discharge requirements; and compliance with plumbing and building codes. Table 4 below presents some examples of the types of rules and regulations that agencies should consider as they plan and pursue recycled water projects. Local agencies may also have rules for facility construction with specific requirements for the types of recycled water use permitted in their jurisdictions.

The regulatory landscape is changing rapidly as interest in recycled water grows throughout the nation. Moreover, rules regarding recycled water use vary from state to state. The wide range of recycled water rules are reflected in the National Research Council's compendium of these regulations (NRC, 2012) and in the EPA's "2012 Guidelines for Water Reuse" which includes suggestions for how to develop a statewide regulatory framework for water reuse (EPA, 2012). In 2021 the WateReuse Association published an online summary of current state regulations that is both timely and instructive (WateReuse, 2021). In addition, under the Water Reuse Action Plan (WRAP) EPA is currently implementing Action 2.1, "Compile Existing State Policies and Approaches to Water Reuse," that will result in an up-to-date listing of state reuse regulatory programs and policies. These references give a good overview of the rules, but for any given project, the project proponents must do a site-specific assessment.[3]

[3] The WRAP also includes an action (Action 3.1) to compile existing specifications of fit-for-purpose treatment appropriate for different sources of water and end-use applications. In addition to streamlining the design of

In view of the extent of regulation and the number of permits required, agencies contemplating a reuse project should discuss the process together as early as possible. When envisioning a project, a wide variety of questions should be asked, including (but not limited to) the following:

- What is the regulatory environment in general terms, and where are the opportunities for collaboration, synergy, and success?
- Who will engage with state and local regulators for siting, development of recycled water and residual quality standards, and other purposes? How will this responsibility be divided?
- Who will take the lead in getting each of the necessary permits?
- How will the permitting process be tracked at various stages of project development?
- Who will pay for the permitting process, or how will the costs be shared?
- Who will be responsible for communicating with stakeholders, regulators, the public, government officials, the business community?
- Who will be responsible for compliance with these rules, or how will that responsibility be shared?
- How will compliance be monitored, who will be responsible or how will responsibility be shared?
- How will emergencies or unexpected occurrences be handled?[4]

Table 4. Types of Permit Requirements for Reuse (by Level of Authority)

Authority	Type of Requirement	Notes
Federal and/or State	Recycled water use and residual discharge permits; water quality standards for surface and ground water.	• Federal National Pollutant Discharge Elimination System (NPDES) permit issued to agency responsible for treatment and reuse. • Usually delegated to a state permitting authority. • Includes monitoring and reporting requirements waste discharge requirements, or other state level discharge requirements. • Underground injection control (UIC) permits regulate ground water injection.
State	Water rights permits or rules on inter-basin transfers	• Required where recycled water use may impact availability of water to other users or the environment upon which they have come to rely or which is protected by law, regulation, or legal agreement (e.g., reduction of downstream flow).
State	Recycled water quality regulation	• Depends on type of use: ○ Direct potable = raw water or treated water augmentation. ○ Indirect potable=ground water or reservoir augmentation. ○ Nonpotable reuse (irrigation, indoor plumbing for toilet flushing, etc.). • Depending upon state organizational structure, permits may be in a single agency or may be spread between water quality/environmental regulators and drinking water regulators.

treatment facilities, these specifications may also promote regulations that acknowledge best practices and facilitate broader implementation of reuse projects.

[4] "In a world where 'resilience' and the need to rebound from the unexpected is becoming more apparent, planning in advance for the unpredicted occurrence is prudent." (Brown & Trussell, 2018)

Authority	Type of Requirement	Notes
Federal and/or State	Reuse treatment discharge regulation	• Restrictions on concentration of brines and other treatment residuals of recycled water treatment vary depending on location of discharge and relevant water body classifications (e.g., impairment for specific constituents).
State	Recycled water use regulation	• Includes site specific requirements by application, e.g., cooling (use of drift eliminators); irrigation (restrictions on overspray); indoor use (signage, backflow prevention and cross-connection testing).
Local	Recycled water use	• State permits may require local agencies to issue permits for individual uses, including monitoring and reporting requirements. • Local environmental health agencies may set their own requirements.
Local	Land Use and Construction permits	• Required for the construction of infrastructure for recycled water treatment, distribution, and use. • Multiple permits may be required for facilities and pipelines spanning different jurisdictions.
Local and State	Environmental assessment	• Evaluation of environmental impacts may be required by local agencies for construction of facilities and/or use of recycled water depending on the scale of the project and types of permits needed. (Local entity serves as lead agency.)

As noted in the case studies, each set of partners may go about the permitting process differently. For example, one may take the lead on permitting the entire project, or the partners may divide responsibilities according to their relationships with the regulators. The important thing is to have the conversations early and coordinate consistently along the way.

Engaging the regulators

Agencies can work together even before the permits are issued by influencing the regulations that govern their project. Successful project proponents engage when the regulators are considering standards at the front end of the project. In some cases, the proponents can drive the setting of uniform regulations at a statewide level that can give clear targets to plan projects around. Others prefer to work with local permit writers on a case-by-case basis. Rather than designing the project in a vacuum or trying to change regulations to facilitate a specific project under construction, the best advice is to engage with regulators when the project is conceptual and ask the best way to comply with applicable regulations in the most streamlined way possible. Whether engaging in the policymaking or just seeking to comply with rules and regulations, interagency reuse partners need to decide early on how they will allocate responsibility and costs related to regulation, and they need to dedicate time and staffing to these important issues. They must also work together to ensure that their project complies with all regulations and that their monitoring program demonstrates compliance, as early work in this area can decrease transaction costs and uncertainty. Working with regulators to navigate this thicket of rules early in the process can help avoid unnecessary delays and heartburn (Ulibarri, et al., 2017) (Cantor, et al., 2021).

The most effective project proponents understand the regulatory environment and engage creatively with regulators to achieve greater good for their communities. A well-known example at the watershed scale is the Santa Ana Watershed Project Authority (SAWPA), a joint powers agency dedicated to focus *"on a broad range of water resource issues including water supply reliability, water quality improvement, recycled water, wastewater treatment, groundwater management, brine disposal, and integrated regional planning"* (SAWPA, 2020). SAWPA was originally formed in 1968 when the water and wastewater agencies came together with regulators and stakeholders across the entire watershed to collectively optimize recycled water production and residuals discharge, stormwater capture, ground water recharge, and other beneficial uses of water. Most notably, regulators were engaged as partners in ongoing efforts to optimize water resource management across the watershed (Cantu, 2015) (Blomquist & Schlager, 1999). In addition to regulators, stakeholders were also engaged early on creating the vision, developing projects, and assuring progress, which minimized objections to projects by the time they reached regulatory permitting decision points (Cantu, 2015).

Other agencies have intentionally set up special oversight boards that include regulators as key stakeholders early in a project's development. For example, as described further in the case studies, Hampton Roads Sanitation District encouraged the Virginia legislature to pass legislation establishing the Potomac Aquifer Recharge Oversight Committee (PAROC) to oversee their innovative ground water recharge program. PAROC includes regulators responsible for permitting the project (EPA and the Virginia Department of Environmental Quality) and individuals with no official regulatory responsibility whose opinions and guidance ensured public acceptance of the project (Virginia Department of Health) (State of Virginia, 2021). The City of Los Angeles has included regional, state, and federal regulators on the Technical Advisory Group of their "100% Reuse" Hyperion 2035 project, including EPA, the California State Water Resources Control Board (both Drinking Water and Water Quality Divisions), and the Los Angeles Regional Water Quality Control Board. Additional examples of proactive inclusion of regulators by project sponsors are provided elsewhere in this report including both the Arizona and Texas case studies whose water agency participants came together to discuss with regulators how best to meet regulations while achieving a variety of local needs.

Local agencies with sufficient resources can engage in the development of regulations they know will apply to their projects down the road. For example, Denver Water provided resources to support the Colorado Department of Public Health to facilitate the setting of standards for the use of reclaimed water for indoor toilet flushing (Marcus, et al, 2020). The City of San Diego, the Metropolitan Water District of Southern California, and an assortment of other cities and agencies are actively engaged in a very public process to update and expand California's regulations for potable reuse. Independently and through WateReuse California and other associations, agencies participated in the numerous public hearings in which a panel of experts help produce new regulations for ground water and reservoir augmentation (sometimes referred to as "indirect potable reuse"). They are currently engaged on developing standards for raw water or treated water augmentation (direct potable reuse); the new rules are due to be finalized in 2023 (Metropolitan, 2019). Robust stakeholder engagement, coupled with the use of expert panels, can produce regulations that are both protective of public health and workable for the utilities that implement them. It can also build public confidence in the regulatory framework and help build support for innovative projects.

What regulators can do to help

State

State regulators are most directly involved in setting standards for recycled water and are frequently the permitting authority on residuals discharge. As a result, they can help expand recycled water projects by 1) setting standards proactively and with current technologies and local needs in mind; 2) encouraging reuse; and 3) helping local reuse agencies navigate the complicated permitting process and clarifying treatment and discharge goals. They can streamline permitting or set statewide standards (e.g., general permits or state policies) to give local reuse agencies greater certainty in planning over the long term.

As noted in the Southern California case study, local agencies may be reluctant to invest in large projects when they are subject to the rulings of individual permit writers in multiple agencies with an uncertain time frame or framework for decision-making (Marcus, et al., 2020) (Metropolitan, 2015).[5] Setting such explicit targets in a public process can also help with gaining public acceptance and confidence that recycled water is safe. State backing can also create what has been termed a "policy scaffolding" that can support policy and program efforts at a more local scale, in much the same way that international policies can lend support to innovative national policies, or national policies can lend support to state policies (Slatyer, 2019). As they embark upon a significant investment in

[5] Some project proponents may prefer to work with their local regulator on a case-by-case basis.

innovative water reuse, local agencies can use the fact that the state has "blessed" their particular type of reuse to bolster their outreach to the community.

State regulators can explicitly create incentives for recycling and other kinds of integrated water management practices by simplifying regulatory processes or providing communities grants and low-interest loans specifically for water recycling projects. For example, during its 2012-2016 drought California provided $1.5 billion in grants and loans for water recycling projects. State agencies can even expressly encourage recycling as part of permit conditions or enforcement proceedings (Hampton Roads, San Diego). Fortunately, some progress has been made in creating permit coordination processes to streamline the regulatory process for project requiring multiple regulatory approvals (Ulibarri, et al., 2017); (SBRA, 2020). In short, through their actions in implementing requirements, incentives, or enforcement settlements—not to mention funding—state regulators have considerable ability to encourage more reuse.

Federal

Although states usually play the leading role in permitting, there are things beyond funding that the federal government can do to facilitate partnerships and support interagency cooperation.[6] Federal agencies can help promote local and regional interagency collaboration in water management and water recycling by creating an "enabling policy environment" and improving communications and cohesion at the federal level (Meridian Institute, 2018). Currently, many federal agencies have major roles in guiding, regulating, managing, and funding water projects, including the Environmental Protection Agency, the Departments of Agriculture, U.S Army Corps of Engineers, Energy, Interior (Bureau of Reclamation and Fish and Wildlife Service), and Commerce (National Marine Fisheries Service). Historically, most of these water management program efforts have been poorly coordinated. As a result, federal agency messaging about the importance of integrated water management and water recycling has been inconsistent. At an operational level, few agencies have aligned their funding, technical assistance, and regulatory programs to communicate consistent priorities in ways that better support local pursuit of integrated water management strategies and projects.

However, recent improvements in federal agency collaboration in water management planning may help. In 2020, EPA issued the first national Water Reuse Action Plan (WRAP), a product of intensive interagency efforts to align and clarify federal agency roles in integrated water management and water recycling (EPA, 2020). EPA has actively used its unique convening power to bring together local water agencies, non-governmental organizations (NGO), academics, state regulators and regulatory associations, and others involved in water reuse in a collective effort to advance water reuse at a period of time when water recycling is gaining national acceptance and interest. As part of this plan, federal agencies are cooperating to create more consistent messaging about the importance of water recycling and integrated water management. Agencies are also working together to improve coordination of project funding, research and technology development, regulatory oversight, and technical assistance programs. The recently passed national Infrastructure Investment and Jobs Act includes substantial resources for water recycling and for creating a Federal Interagency Working Group on Water Reuse, both of which would provide extremely helpful federal support.

[6] Federal agencies have provided states with millions of dollars in state-administered grants and loans through sources such as EPA's State Revolving Loan Program. More recently the Water Infrastructure Finance and Innovation Act (WIFIA) has supported significant low-cost financing for large-scale water reuse, including Orange County's Groundwater Replenishment System.

Economic Factors that Challenge and Promote Collaboration

Key Takeaways

- *Clearly articulate all the important benefits to be enjoyed by your communities, the environment, regional businesses, and your utilities*
- *Consider a "beneficiaries pay" approach for allocating reuse costs across utilities, and across utility customers—but be open to allocating in ways that recognize a broad array of benefits to the shared set of ratepayers.*

This section reviews some of the many economic considerations that emerge when agencies collaborate to recycle water, and outlines some strategies for identifying benefits, allocating costs, and navigating the financial issues associated with collaboration.

Evaluating the benefits of water recycling

Successful water reuse projects provide a wide array of benefits to local communities. These benefits often include significant financial, social, and environmental values, as reflected in a Triple Bottom Line (TBL) perspective. Typical TBL benefits include (but are not limited to) the following (Raucher, et al., 2006) (De Souza, et al., 2011):

1. Avoided costs (cost savings) from eliminating or postponing the need to enlarge local potable water supply portfolios and treatment facilities; reducing reliance on expensive, unreliable imported supplies; or avoiding the cost of expanding and upgrading the wastewater management system to meet stringent effluent discharge limits.
2. Improved resilience and reliability in the face of droughts, floods, and other climate change impacts by tapping a local water supply less vulnerable to variations in rainfall and snowpack.
3. Ecological benefits from enhanced instream flows and created wetlands and greenspace, offering valuable aesthetic, public health, recreational, and other "nonmarket" values to the community.
4. Increased economic vitality from providing local businesses with a reliable and sustainable water supply for commercial, institutional, and industrial uses.

While many of these benefits are difficult to monetize and they are spread across multiple utilities, business sectors, and households, they nonetheless provide considerable "nonmarket value" to the utilities and the communities they serve. Added together, these diverse and valuable TBL benefits often justify the expense of a reuse program.

Unfortunately, these broader benefits (e.g., avoided costs and nonmarket benefits) are not recognized in any individual utility's accounting systems. Furthermore, the cost of reuse is rarely recovered through reuse rates, which is one reason why the California Public Utility Commission (the state's regulator for investor-owned utilities) allows utilities to spread recycled water projects costs among all ratepayers ("cross-subsidies"). In so doing they apply a "beneficiaries pay" approach, acknowledging community benefits received by those who did not directly use recycled water (CPUC, 2014).

A related challenge is the fact that even when the benefits of a water reuse program accrue to a specific utility, they are not recorded on its accounting ledger. For example, avoided costs—such as those that result from postponing the expansion of a potable water supply system or the upgrade of a regional wastewater system—may well outweigh the costs of the reuse program. However, since those avoided costs have not yet been incurred, they do not show up on the utilities' accounting books, which only record the costs of building and operating the reuse program. Those same ledgers will also indicate that the project expenses incurred are not fully recovered though the revenues generated from reuse sales (AWWA, 2019) (Carpenter, et al., 2008). As a result, ecosystem and recreational benefits from reuse programs that support wetlands or instream flows, or that enhance reliability and resilience of the regional water supply, also are omitted from the utilities' standard cost accounting.

As a result, individual utilities may find it hard to recognize the benefits generated for their agency, and have difficulty justifying to their customers the costs of the reuse program (Raucher, et al., 2006) (De Souza, et al., 2011) (Raucher, et al., 2019). For this reason, it is important to distinguish between the *financial* value of a water reuse project (i.e., cash flow of revenues compared to costs) and its *economic* value (i.e., whether accumulated benefits outweigh costs). While the financial consideration (cash flow) of a reuse project can impact the agency's balance sheet, its economic value includes the unaccounted benefits to the utility (avoided costs, reliability, and risk management), to society (aesthetic, recreation, public health, and resiliency values), and to the environment (habitat creation or restoration).

Decisionmakers can often appreciate the benefits of recycled water more clearly when water reuse is framed in terms of risk and risk mitigation (Chesnutt, 2021). By considering how development of a locally controlled, reliable, and resilient water supply might mitigate the risk of future water shortages under different scenarios it may be possible to calculate an economic, social, and environmental value upon which water and land managers, and communities and individuals can base their decisions (Rees, 2002).

The challenge for local water sector agencies, then, is to recognize these various benefits and their beneficiaries, and apply that knowledge in a collaborative effort to fairly allocate costs and any associated cross-subsidies to their respective accounts and customers. Fortunately, more and more agencies are beginning to recognize that there is a legitimate economic basis for applying a location-specific "beneficiaries pay" approach to developing and adopting cross subsidies from potable water and/or sewer service customers (AWWA, 2019)((CPUC, 2014) (Raucher, et al., 2019).

Cost recovery and recycled water rates

The issue of cost recovery—"Who pays?" and the question of who bears which share of the cost—is another economic consideration that may challenge the ability of water agencies to work together (Watson, et al., 2016) (Raucher, et al., 2019) (AWWA, 2019)The challenges revolve around:

1. How costs are allocated and billed by the different agencies, even when both serve the same customers;
2. The fact that water reuse typically requires a cross subsidy from potable water and/or wastewater programs to recover its costs (because reuse generally is more expensive than the existing, long-standing potable water supply portfolio, even though reuse often is cost-effective relative to other options to secure *new* water supplies);
3. Which entities (and whose customers) bear the expense of subsidizing reuse rates;
4. Which entity pays for periodic system renewals, upgrades, or expansions; and
5. How those periodic investments to renew, upgrade or expand the system align (or fail to align) with the primary mission of the agency paying the tab.

These points of contention may change as the community's needs change and the value of the reclaimed water program evolves. For example, a reuse program may originate as a practical solution to a wastewater management challenge and, as such, may primarily be managed (and paid for) by the regional wastewater utility and its ratepayers. Meanwhile, the distribution of the reclaimed water may be placed under the jurisdiction of water suppliers so that the wastewater agency winds up bearing the bulk of the cost, while the water supply utility collects -- and ideally shares -- the revenue from the sale of the reclaimed water.

Over time, as recycled water becomes more established as a water supply, it may be necessary to revisit this original arrangement. This situation occurred in the Silicon Valley area of northern California (Raucher, et al., 2019) as well as in the Melbourne, Australia metropolitan area (Watson, et al., 2016). It contrasts markedly with programs where reuse is driven by water supply and the water supply agency carries the bulk of the costs of upgrading the treatment process, as in the City of Los Angeles' expansion plans (Garcettti, 2019). In some cases, water recycling costs may be split from the outset between water and wastewater agencies, as in the

Metropolitan Water District of California and LA County Sanitation Districts (MWD/LACSD, 2020), described further in the case studies.

Another economic challenge to collaboration is the need to subsidize the recycled water project when recycled water rates do not cover even project operating costs, let alone the cost of amortizing capital expenses. Although new water reuse systems are relatively expensive, rates charged for nonpotable water are typically held below potable rates to incentivize customers to transition to recycled water (Atwater et al., 1998) (AWWA 2008), (AWWA, 2017). Revenues collected from these artificially low nonpotable rates are routinely less than the cost of service, so the responsible agency must subsidize those rates with funds from other sources (AWWA, 2019). This results in a fiscal loss on the accounting ledger, with reuse revenues collected being less than the cost borne by the utilities. An inter-agency fiscal challenge then arises from the discounted reuse rates, with regard to whose customers pay for the subsidy covering the revenue shortfall (e.g., who will pay a portion of nonpotable reuse costs through higher potable and/or wastewater bills).

The issue of who receives the benefits and who pays is a key topic for many communities. For example, as explored in more detail in the case studies, the reclaimed water system in the Tucson, Arizona region has provided a wide range of benefits to diverse communities in Pima County. These benefits include offsetting potable demands to avoid the cost of securing new potable supplies in a very arid, water-limited region, alleviating a severe regional ground water depletion and subsidence problem, facilitating area economic growth by providing a local, reliable, climate-independent water supply, and enhancing local ecosystems by creating wetlands and maintaining instream flows that provide recreational, aesthetic, and environmental benefits. Given the diverse and geographically dispersed array of benefits, the subsidy provided to nonpotable reuse customers can justifiably be spread across a wide array of benefiting communities and customers (Diringer, et al., 2019).

A related challenge may arise as a reuse program matures and reinvestment is necessary to maintain (or upgrade or expand) the system. For example, if a community's needs evolve over time and indicate that recycled water should transition from nonpotable to potable uses, then a significant investment will likely be required. However, if the program is principally managed by the wastewater agency, then that utility may be reluctant to invest in what is essentially a water supply upgrade (given that the wastewater problem that initiated the program has been long solved and water supply is not part of their mission). This has emerged as an issue in northern California, where South Bay Water Recycling originally distributed recycled water from the San Jose/Santa Clara Regional Wastewater Facility primarily in order to reduce effluent flows. Now that the regional wholesale water agency (Valley Water) recognizes the importance of reuse as a critical element of a reliable water supply portfolio, it has assumed the cost of enhancing treatment to produce additional recycled water for ground water augmentation (Raucher, et al., 2019).

Financing: Accessing External Funding Sources as a Collaborative

There are plusses and minuses for collaboration when it comes to financing reuse projects.

On the plus side, multiple water agencies working cooperatively may be better positioned to secure favorable financing and/or access to state or federal grants and subsidized loan programs. Multi-agency involvement can be a good sign that there is strong local stakeholder coordination and that the project is a high priority for the region. In some programs, state bond language may specifically identify collaboration as a priority, and the program will award points in its selection or prioritization process for projects that demonstrate this type of partnership. In other funding programs, multi-agency applicants do not receive priority points, but projects that provide multiple environmental benefits do receive extra points in the selection or prioritization process.

For example, the state of California has deployed a well-funded Integrated Regional Water Management funding program providing more than one billion dollars in support of regional water programs to encourage agencies to work together to propose the most cost-effective projects, including reuse. This is in addition to the State Revolving Funds that are specifically for clean water, drinking water, and recycled water projects and other state supplied grant funding to help promote such projects which are recognized as a "social good." Also, in a collaboration, one utility may be able to access a funding source for which its partner agencies may not be eligible.

External funding sources may require collaboration as a condition of receiving financial support. In the Arizona case study provided in this report, when both the City of Tucson and Pima County applied for Clean Water Grant funding to upgrade their wastewater treatment facilities, the federal grant was contingent upon their agreeing to consolidate their wastewater treatment assets. In response, Pima County assumed responsibility for the regional wastewater management authority, leaving water supply under the City of Tucson's jurisdiction. This helped forge the on-going partnership between the City and County utilities for the region's successful water reuse program.

However, the ability to successfully apply for financing support programs may be complicated by enlarging the number of utilities for which internal reviews and related Board approvals are required. For example, large collaborative projects often use a Joint Powers Authority (JPA) agreement. Each JPA agreement is unique and complex, and this often makes it a challenge to secure a loan due to the complexities of the members sharing the responsibility for the security. In most cases, working with JPA applicants prolongs the application process and requires negotiating tailored funding agreement terms. There may also be time-consuming impacts where the partnering entities wish to secure projects against multiple, separate enterprise revenue streams. Usually, entities proposing this type of security are fairly sophisticated, and have likely already promised their separate enterprise revenues in a way that potentially conflicts with financial security requirements or expectations (C. Stevens, personal communication, CA Water Boards, Jan 2021).

It is also common for external funding sources to impose additional fiscal and operational requirements on grant recipients. These additional requirements may include securing long-term customer commitments, incentivizing high levels of capacity use (e.g., avoiding large seasonal fluctuations in demand), balancing peak season demands with off-season excess production, and other conditions that entail additional costs. There are numerous strategies to help address these economics-related challenges, and these in turn require collaborative strategies across utility entities (Atwater et al., 1998) (Hanson, et al., 2017) (De Souza, et al., 2011) (AWWA, 2019) (Raucher, et al., 2019).

To enhance and help streamline financing opportunities for multi-agency reuse projects, agencies should focus on clearly articulating their roles and responsibilities and the mechanisms for formally establishing them. This might include agreements that establish:

- Access to and/or ownership of facilities.
- Sharing of capital costs and long-term O&M needs, which can equal or exceed initial costs.
- Provision of recycled or diverted water for purposes of the project.

(These and other terms and conditions found in interagency agreements are articulated further in this Analytical Framework under "Management.")

Another potential streamlining approach is having a lead agency with rate-setting authority willing to accept the financial obligation (not a JPA) and an unencumbered revenue stream (i.e., no existing debt or issues associated with pledging funds to a project that will potentially benefit an unrelated enterprise). If a lead agency can pledge net revenues and support the full loan, it would streamline credit review and underwriting. The lead agency could still share costs with other agencies, but that could be worked out separately. However, this may be challenging since the lead agency has to take on additional responsibility and risk (Stevens, 2021).

Conclusions: Recognize all applicable reuse benefits, and align costs with beneficiaries

Ultimately, all economic challenges to recycled water projects may be more readily overcome with a broad recognition that reuse provides a variety of important and valuable TBL benefits to the community, and that cost recovery and related strategies can be supported by a "beneficiaries pay" perspective. Successful multi-utility collaboration for a robust" One Water" program can be achieved if all the relevant agencies are willing and able to:

1. Recognize the full TBL benefits of reuse, including but not limited to key avoided costs for the water supply and wastewater agencies, as well as nonmarket and nonrevenue-generating values to the community;

2. Accept the proportional share of reuse costs aligned with the extent to which their agency and customers benefit, recognizing the extent to which they share the same customer base; and
3. Allocate funds and resources in support of the reuse program in proportion to the benefits received, including less easily quantifiable community benefits (De Souza, et al., 2011) (Raucher, et al., 2019).

Management and Operational Issues

Key Takeaways

- Assign roles and responsibilities for reuse projects based on agency expertise and resources.
- Develop a comprehensive list of project requirements, including acceptable recycled water pressure, flow, and quality and response to "out-of-compliance" conditions.
- Accurate, verifiable information builds confidence between partner agencies.
- Joint reuse projects can help utility operators develop new skills and advance their careers.

This section identifies some of the management and operational challenges that arise when agencies work together to create and implement water reuse facilities. As they coordinate their efforts to design, build, operate, and maintain a recycled water facility, utilities must carefully consider their roles and responsibilities so that each agency can perform its part without detracting from its existing duties. These responsibilities encompass not only technical issues pertaining to system performance, but also personnel issues and utility management.

Ownership

One of the first issues that arises when agencies begin to plan a water reuse project is determining which entity will own which part of the proposed infrastructure. While assignment of most operational tasks can be negotiated by agreement, the facility owner usually bears responsibility for compliance with regulatory requirements, so this decision has economic and legal ramifications. For this reason, some agencies choose to divide ownership of the recycled water facility to clearly indicate responsibility for operation of various reuse system components (e.g., recycled water treatment, advanced treatment, transmission, and distribution).

When agencies are separated by a jurisdictional boundary, each agency may own, operate, and maintain the portion of the recycled water system in its respective service area. For example, ownership of a pipeline conveying recycled water from one agency's service area to another may change at the jurisdictional boundary; an isolation valve may even be installed at the boundary so that the recycled water flow can be metered for billing purposes. Alternatively, the agency with a proprietary interest in the program may retain ownership of all the infrastructure and contract with the other agency to provide routine operation and maintenance, including emergency repairs if they are equipped to provide such services.

When a regional wastewater authority provides nonpotable recycled water to customers who receive potable water from a separate water agency, the wastewater agency may choose to function as the water wholesaler, selling water to the water agency who in turn sells it to their retail customers. In that case, the recycled water provider may assume ownership and accept responsibility for any or all of the distribution system up to the customer meter, which the water agency installs to bill the end user. This arrangement has the added advantage of allowing water retailers to retain their customers, especially in states where utilities are protected by laws shielding them from service duplication. On the other hand, when regulated investor-owned utilities are allowed to pass the cost of their recycled water investments to all ratepayers ("cross-subsidy"), they may prefer to build, own, and operate the recycled water distribution infrastructure within their service areas (Rosenblum, 1999).

When several agencies are involved in a project together, they may assign ownership and the corresponding operation and maintenance responsibilities through a cooperative agreement. The cooperative agreement enumerates the duties each agency will perform in each of their service areas according to the skill, ability, and preference of the participants. If the interjurisdictional issues are sufficiently complex, they may even form a JPA, in which case the new agency may take formal ownership of the project and coordinate all operation and maintenance tasks. In one nonpotable recycled water project developed by two northern California agencies, the

Dublin San Ramon Services District (DSRSD) agreed to supply recycled water from its treatment plant to customers of the adjacent East Bay Municipal Utility District (EBMUD) service area. In 1995 the two agencies formed the DSRSD-EBMUD Recycled Water Authority (DERWA), which owns and operates the recycled water system under the direction of a general manager appointed by the DERWA board which is comprised of directors from the two agencies (DSRSD and EBMUD, 1995). The flexibility of this arrangement was further demonstrated in 2014 when the City of Pleasanton agreed to add its effluent to the DERWA recycled water supply (DERWA, 2021).

Regulatory compliance

As noted above, the owner of the recycled water project will generally assume formal responsibility for obtaining permits for the water reuse program and ensuring compliance with regulations as described in the previous section. Some regulations, however, hold specific agencies accountable regardless of their role in managing the recycled water system. For example, NPDES permits may be interpreted in such a way that wastewater agencies retain responsibility for their effluent even after it is distributed by another agency as recycled water. When a leaky pipeline or other accidental release of recycled water amounts to a violation of discharge permit conditions, the wastewater discharger may wish to exercise more control over the operation and maintenance of the recycled water distribution system. Likewise, where brine from membrane treatment of recycled water is discharged to a treatment plant's outfall, the permitted discharger must ensure that the increased concentration of regulated constituents remain within permit limits.

Water agencies, too, may be required to retain responsibility in certain circumstances. Where potable recycled water rules prescribe enhanced source control measures in addition to specific treatment methods water supply agencies designated as the owners of the recycled water project may need to be more involved in oversight of wastewater treatment processes. The authority and responsibilities of the regulating agency may even be described in statutes that require agencies responsible for reuse to perform certain monitoring and reporting functions (SWRCB, 2016). In California, for example, proposed regulations for raw water augmentation include the designation of a "Direct Potable Reuse Responsible Agency (DiPRRA— a single water supply agency that holds responsibility for all aspects of the program. The determination of how these responsibilities will be carried out, however, will likely be negotiated between the regulatory agency and the permitee (SWRCB, 2021).

Operation and maintenance

The various tasks required to operate and maintain the recycled water system must be identified and delegated in sufficient detail so that all parties understand their roles and responsibilities and no duties are left unassigned. Given the range of operation and maintenance issues involved, agencies should document their respective responsibilities in a manner that spells out their collective expectations. The documentation can be as simple as a memorandum of understanding or as sophisticated as a multilateral contract, but the agencies must discuss the issues in advance and agree on which agency will take responsibility for which aspects of the program. Table 5 identifies several technical elements of water reuse system operation that may be assigned by agreement, including responsibility for permitting, water metering and billing, recycled water treatment and distribution, water quality and pressure, customer relations and public outreach. Regardless of which agency is responsible for the technical elements of the program, all partners have a role in representing the water reuse project to their ratepayers and the community as a whole. Coordinated messaging is key to effective communication, which in turn is essential to the project's success

Table 5. Some technical elements of recycled water system operation assigned by agreement

Category	Purpose	Example Terms
System Infrastructure	Describe condition, location, and ownership of system assets	• Location of mains, laterals, and turnouts • Ownership of treatment and distribution facilities • Distribution of grants and revenues (if jointly owned) • Responsibility for asset management and capital replacement

Category	Purpose	Example Terms
Regulatory compliance and risk management	Assign responsibility for compliance with regulations and liability for future events	• Permit authority for distribution of recycled water • Responsibility for monitoring and reporting water quality of produced water and residuals • Responsibility for illegal discharges • Permitting, inspection and monitoring • Mutual indemnification • Limitations on liability ("hold harmless")
Financial terms	Establish methods for determining agreed upon allocation of capital and operating expenses	• Wholesale and retail water rates and escalators (e.g., CPI, % of potable rate) • Cross subsidies from other water services • Measurement and verification of water deliveries • Other fees and charges (e.g., maintenance, training, billing, retrofits) • Invoicing and payment terms (e.g., "take or pay")
General system operation and maintenance	Assign responsibility for system operation and maintenance, including response to failure	• Responsibility for recycled water treatment, including system disinfection as required • Responsibility for water system pressure, repair of leaks and breaks and restoration of service • Notification of deviations in water quality or pressure • Supply of alternative water source during system shutdown
Specific water quantity and quality parameters	Define amount and quality of recycled water provided	• Annual, maximum daily, and peak hourly flow rates • Maximum and minimum system pressure • Treatment methods required • Recycled water quality including pathogens, chemicals and "emerging contaminants of concern"
Customer Relations	Assign responsibility for safe use of recycled water	• Onsite supervisor training in regulations and safe handling and use of recycled water • Documentation of customer use
Public Outreach	Represent reuse program issues to policy makers and public	• Responsibility for communicating to the public about project development, construction impacts, and system operation. All partners should consistently represent the necessity and safety of water reuse to the community.

Along with the various tasks required for normal system operation, agencies should also consider what remedies are required as conditions vary from the ideal. These conditions can range from pipe breaks to treatment plant failures, and while they need not be specified in every detail, the possibility of nonoptimal situations should be addressed, at least in concept. For example:

- Who is responsible for fixing pipe breaks in any of the jurisdictional areas, and how long do they have to respond?
- If recycled water provided for nonpotable use is not adequately disinfected and fails to meet regulatory standards, does the plant divert the flow from the system?
- If the system remains non-operational for a period of time to the extent that customers must be re-connected to more expensive potable water, who covers the differential in cost?

Raising these issues early in the development phase of the project allows all parties to think through their individual responsibilities and may even provide an opportunity to engineer solutions to improve the system. All issues are subject to negotiation and prior agreement, and some might even be relegated to "future consideration and agreement," acknowledging that the agencies intend to return to the topic at a later date. Certain responsibilities, however, are generally more appropriate for either water or wastewater agencies. Potable reuse programs in particular are more successfully represented by water agencies that already supply the public drinking water, rather than wastewater agencies that must continually overcome the stigma of their association with sewage.

While nonpotable water reuse programs may be managed entirely by the wastewater agency that produces recycled water, the utility may need to execute agreements with individual customers using recycled water. These customer agreements can rival interagency agreements both in scope and detail, especially when the wastewater utility serves recycled water to large industrial customers that help fund the cost of building treatment or distribution facilities, or when the companies have special water quality requirements (Rosenblum, 2021) (Sheikh, 2017).

Performance Measures and Information Management

Eventually, the collaborating agencies will need to establish performance measures to guide their responsibilities. While many of the activities identified in Table 5 can be characterized in common terms (e.g., hours to perform emergency repairs, pressure at the point of delivery in pounds per square inch), in some cases water and wastewater agencies should be prepared to discuss and agree upon the units of measurement they use to describe their operations. For example, water utilities routinely measure water volume on an annual basis in terms of "acre feet per year," and distinguish between volumes of water available in "wet" and "dry" years. Wastewater agencies, on the other hand, measure performance in terms of millions of gallons of wastewater treated per day (MGD) and average MGD per year. Although they distinguish between wet and dry weather, they use those terms to refer to individual storm events rather than annual precipitation totals. These customs of measurement have been compared to distinct languages ("Hydronics" and Sewerian"), and while all units are convertible from one to the other, agencies must take the time to establish a common nomenclature (Rosenblum, 1998).

Along with agreeing on units of measurement, the collaborating parties must agree on a system of instrumentation and record-keeping that produces a mutually acceptable source of information. While some agencies may prefer to keep their operational information private, they must overcome their reluctance for the sake of the partnership (Martz, et al., 2017). As noted by Mukheibir, et al. (2015) transparent data acquisition and management involving data sources from different programs facilitates integration of water resources management, including water reuse.

Operator training and certification

When water and wastewater agencies collaborate to reuse water, their ability to combine staff and divide responsibilities for operation and maintenance may be constrained by state certification requirements for water and wastewater treatment operators. As the skills and abilities required for water and wastewater treatment converge, some states have addressed this issue by developing a new certification for "recycled water operator," especially for recycled water designated for potable use (CUWA, 2016). These certification exams cover knowledge of membrane treatment, advanced oxidation, and other processes not generally addressed in existing state water and wastewater operator certification exams (Mackey, 2019). While many systems can be operated without this special certification, it points to the need to address institutional issues as previously separate organizations are drawn together under the umbrella of "One Water" management.

The Role of Leadership

Key Takeaways

- Climate change and population growth contribute to a future of "permanent whitewater" requiring collaborative strategies that build resilience.
- Managers who can identify future challenges and understand the "economy of scope" lead people out of their silos by showing how reuse supports their multiple missions.
- Interpersonal relationships matter. Cultivate both formal and informal approaches to enhancing communication between agency staff: it is just as important to go to lunch as to schedule a meeting.

This section presents information about the ways in which leadership—both personal and organizational—is the bedrock on which recycled water projects stand. By deciding to accept the risks and accrue the benefits of using previously impaired water supplies, utilities acknowledge that the world in which they operate has fundamentally changed. As such, the skills needed to move individuals and organizations in new directions have become central to the enterprise of water reuse.

Throughout history, cities, regions, and countries have joined together to achieve goals that they would otherwise be unable to meet on their own. They have pooled their collective assets for the purpose of overcoming their collective challenges. Daley (2008) emphasizes the role of leaders in building trust between organizations, such that if leadership falters, then collaborative partnerships will not last. Partners must be able to trust each other in order to accomplish change, whether the goals are as comprehensive as the United Nations' Sustainable Development Goals or as focused as a single project. The need for trust between organizations and the importance of leaders is also a key element of interagency collaboration for water reuse.

The contemporary idea of leadership reflects a worldview that is organic and where leaders are responsive to the social context (Franco-Torres, et al., 2020). With climate change accelerating and natural disasters on the rise, it is increasingly important that the water sector enact collaborative strategies that build resilience in the face of an unpredictable future of rapid change—what some scholars have termed "permanent whitewater" (Wolf, 2010). Many water agencies are already familiar with this type of planning environment, routinely considering the potential of both water-rich and water-scarce futures. Water reuse in particular offers cooperating agencies the flexibility to deal with these extreme conditions by providing a locally controlled, drought-resistant, and sustainable water source (Meyer, 2017).

In each of the case studies in this report, as in all successful recycled water projects, there are individual champions who shared the vision and led the challenging work necessary to implement it. Personal relationships often preceded these interagency partnerships. Sometimes they were formed during the course of the project; in all cases the leader's interpersonal skills maintained the pace and momentum of the project. This is not surprising as the biggest challenge in environmental public policy is often not the law, the engineering, or the science. It's not even the challenge of complexity in ecosystem management, but 'egosystem' management: how the people in the room listen to each other and work together (Ehisen, 2015).

There are many reasons why a leader might decide to take on a complex, collaborative project like water reuse. They may be pressed by regulatory requirements or encouraged by a growing environmental ethos in the community, or they may simply see the need to increase their water resilience. In all cases, leaders step forward when they are convinced that a project, however complicated or difficult, will pay off in important ways to enhance their community's future. This vision persuades them to invest personal time and effort to convince members of their own agency to look outside their silos and to persuade other agencies to work outside their comfort zone (Tett, 2016).

Not only the director or agency head can be the leader of an innovative project. As demonstrated in the case studies, managers at various levels in different jurisdictions have taken on the role of leader and facilitated the implementation of successful projects. In some cases, it may actually be preferable for that role to be filled by an individual more involved in the day-to-day operation of the utility. In some cases, leadership comes from outside the organization—an elected official, community advocate, or other stakeholder—or the role can even be assumed by a consultant or contractor. Agency management has to be open to developing such leaders, however, and allowing them to flourish.

To bring these collaborations to fruition, agencies must develop the skills to work together—to identify their common interests, to set collective goals (Scott & Boyd, 2020), to share risks (ANCR, 2020), and to allocate responsibilities. They must also be able to acknowledge the importance of the individuals who are at the very epicenter of this systems-level change and who mobilize stakeholders and their organizational peers around a compelling vision (Burn, et al., 2012). These individuals—at every level--are the champions of organizational change and development; their vision promotes the use of recycled water as a new sustainable water supply.

Types of champions

What are some of the drivers that motivate these champions of change? Thakhathi (2018) describes ten distinct types, or "meta-champions." As he explains, all champions are ultimately agents of organizational change, although motivated by different drivers. Of note, the "Innovation Champion" has been extensively studied and numerous individual and organizational traits have been credited to innovative leaders that enable them to envision and take action (Reibenspiess, et al., 2018). Remarkably, each meta-champion directly relates to a distinct role in and/or function of water reuse and recycling. Examples are shown in Table 6 below.

Table 6. Description of Meta-Champion Types (after Thakhathi, 2018)

Meta-Champion Type	Relevance to Water Reuse
Collaboration Champions	Facilitate collaboration within their utilities and between complementary and regional utilities to advance the collective conversation.
Human Rights Champions	Advance equality and understand that treated wastewater is a reliable source of water that can be safely used to offset growing water scarcity (UNESCO, 2017).
Innovation Champions	Foster innovations such as new and novel technologies that treat wastewater and extract valuable resources (e.g., phosphorus) from wastewater.
Product Champions	See the value in bringing a new water supply/resource to market to augment supplies in water scarce areas.
Project Champions	Initiate and/or implement collaborative reuse projects which help communities have a reliable water supply and minimize their nutrient discharge.
Service Champions	Drive improvements in the adoption of reuse through sharing research and timely communication that increases public acceptance.
Strategic Champions	Guide utilities toward a collaborative and integrated water management approach that emphasizes incorporation or expansion or water recycling.
Sustainability Champions	Advocate policies and programs that yield TBL benefits and recognize the valuable contribution of recycled water in that equation.
Technology Champions	Share information across digital platforms so that water utilities can collaborate to use their water supply as efficiently as possible and minimize waste.
Venture Champions	Back innovative strategies and support the scalability of these strategies to expand water reuse.

Notwithstanding the importance of the leader in affecting change, it is important that the leader considers "understanding, building, and sustaining culture" as part of their role (Warrick, 2017). In order to promote interagency collaboration to expand reuse, champions must consistently create an organizational culture that thrives during rapidly changing times. As Warrick (2017) states:

> An abundance of research makes it clear that building strong cultures can play a significant role in the success of organizations and that, conversely, neglecting cultures can have many costs to organizations and their employees, customers, and stakeholders.

Cultivating champions is directly linked to the health of the organizations (in this case water utilities) and their ability to collaborate across service areas. As defined by Warrick, a high-performance culture, is characterized by teamwork, collaboration, and involvement. Collaboration must be internalized and externalized through processes and agreements. By collaborating, water utilities are able to maximize their assets and minimize their risks. The Alliance for National & Community Resilience's (ANCR) tool, *Community Resilience Benchmarks: Water Benchmarks* suggests how communities and regions can collaboratively assess their resiliency (through 19 benchmarks) for drinking water, wastewater, and stormwater:

> ANCR encourages communities to view water management as an integrated process across systems (e.g., a "one-water" approach). Service providers should collaborate and share results with other water systems to identify common vulnerabilities, investigate potential solutions and assure that they are planning based on the same scenarios. This collaboration should also extend regionally to help ensure that water resource planning considers water for the environment, and that there are adequate environmental flows to sustain the area's ecology. The benchmark is intended to facilitate a community/municipal government-driven assessment in collaboration with the owner(s) of the system, be they public/municipal, private/investor-owned, or another model. (ANCR, 2020)

Though tailored to drinking water, wastewater, and stormwater, specific recommendations for each water resource include:

- Identify and document risks.
- Develop and document responses/solutions.
- Collaborate with others that share risks or can enable solutions.

The ANCR tool directs water agencies and utilities to work together to identify common opportunities and risks, as well as collectively identifying synergistic solutions. The purpose of this recommendation is to ensure resiliency in a community's water supply and protect community health.

The importance of adopting a community-wide perspective sensitive to long-term risks was affirmed by several of the utility managers profiled in this report. In fact, many of them framed the question in the same words: *"Each of us had our own individual responsibilities, but we asked, 'Is this the best use we can make of this water, that we all know will be precious in years to come?"* (McCullough, 2021). Sometimes leadership consists simply in asking the right question and stating the obvious truth.

Leadership from other quarters

Along with the champions of water reuse in participating agencies, individuals in supporting institutions can also provide leadership. For example, as noted in the section on regulation above, federal agencies continue to provide millions of dollars in state-administered grants and loans for water reuse projects while EPA developed the Water Reuse Action Plan specifically to increase the nation's capacity to recycle water. In a recent report, the Meridian Institute (2018) identified several ways government can provide leadership by creating an enabling "policy environment" that promotes local interagency collaboration through several discrete actions:

- Create and disseminate clear policy statements supporting the implementation of integrated water management strategies at the local and regional levels and discouraging retention of stove-piped water management approaches.
- Prioritize funding of recycling and other multi-benefit water projects that are the outgrowth of local and regional scale integrated, interagency collaborations.
- Improve coordination among federal funding agencies to better enable local agencies to assemble funding needed for integrated water management projects and make it easier for agencies to partner in applying for funding.
- Build capacity of federal and state regulatory agencies to issue permits that accommodate and incentivize water recycling and integrated water management approaches.
- Prioritize funding for research on institutional challenges to implementation of water reuse projects.
- Compile and share examples of effective interagency collaboration across different water enterprises to pursue integrated water management, highlighting the organizational and legal mechanisms used to achieve project collaboration.
- Compile and share examples of accommodating state regulatory and funding frameworks that enable and incentivize implementation of collaborative interagency approaches to water management.

Alongside federal agencies, water sector associations like the WateReuse Association, Water Environment Federation, American Water Works Association, U.S. Water Alliance, and many others provide leadership in breaking down barriers for water reuse and recycling projects by convening experts for peer-to-peer learning, developing communication and outreach materials, advocating for integrated funding, collaborating with federal agencies and state regulators, and identifying market and research needs. For example, WateReuse convened the Water Environment Federation, National Association of Clean Water Agencies, Association of Metropolitan Water Agencies, American Water Works Association, and Water Research Foundation to develop comments in partnership to help inform the content and implementation of the U.S. EPA collaborative National Water Reuse Action Plan (WRAP). The associations' leadership helped raise the voice of utilities and the water community throughout the creation of the effort. Integrated planning takes many shapes across the country and associations can bring together diverse experiences so that communities may learn from each other and so that support, federal or otherwise, can be better adapted to unique needs.

As a case in point, the WateReuse Association works to disseminate knowledge developed by the National Water Reuse Action Plan (WRAP) to its member water reuse utilities and practitioners, and serves as a convening voice for discussion of evolving water reuse needs. Outside of the WRAP, WateReuse provides the means for multiple agencies to work through state-specific sections that tackle specific integrated planning needs. For example, the Florida WateReuse Section works with the Potable Reuse Commission, a consensus driven partnership that developed a framework for potable reuse in Florida. In addition, WateReuse provides tools to educate the broader public, regulators, and local policy makers about reuse like the recent white paper on "Investing in Water Reuse for Climate Change Mitigation, Adaption, and Economic Resiliency" (WateReuse, 2020a) and "Water Reuse 101 Fact-Sheet" (WateReuse, 2020b). WateReuse also advocates for national water reuse funding priorities throughout the year and develops resources such as the State Policy and Regulations (WateReuse, 2021) map to assist communities navigating interagency cooperation throughout the reuse regulatory processes.

By understanding the conditions that foster leadership and cultivate "champions of change," agencies can promote these attributes and establish environments to sustain them. Within water utilities, there are extensive opportunities to take these lessons and use them to expand interagency collaborations and promote water reuse and recycling. When utilities create the conditions for champions to thrive, they can collectively plan for an unscripted future and create a sustainable water infrastructure that protects public health and the environment.

CASE STUDY #1: EASTERN VIRGINIA AND HAMPTON ROADS SANITATION DISTRICT

Timeline	
1940	Hampton Roads Sanitation District (HRSD) established to provide regional wastewater service and protect Tidewater oyster beds after 10 years local debate.
1940-2000	HRSD service area adds communities (e.g., Williamsburg, James City County, York County); service population increases from 300,000 to 1.5 million.
2000	Chesapeake 2000 Agreement binds five states (New York, Pennsylvania, Delaware, Maryland, West Virginia, and Virginia) and the District of Columbia to a 10-year plan with specific goals to protect habitat, manage fisheries, enhance pollution prevention, and reduce nutrient and sediment discharges to Chesapeake Bay.
2008	Virginia initiates credit trading program to support regional solutions to pollutant loading reduction efforts.
2010	EPA issues Total Mass Discharge Limits (TMDL) for Chesapeake Bay putting Chesapeake Bay dischargers on a “pollution diet” limiting nutrients and sediments from wastewater treatment plants and municipal storm sewer systems.
2016	HRSD investigates feasibility of groundwater augmentation program by piloting alternative recycled water treatment trains and a test injection well.
2017	HRSD constructs Sustainable Water Initiative for Tomorrow (SWIFT) Research Center to demonstrate feasibility of groundwater augmentation program with fully operational 1 MGD recharge facility.
2021	HRSD awards a design-build contract for construction of first full scale (17 MGD) facility in Newport News with estimated completion in early 2026.

Overview and Key Takeaways

A 2010 EPA Consent Decree required HRSD to improve wet weather capacity of the region’s separate sanitary sewer system to reduce the public health and environmental impact of occasional sanitary sewer overflows. A similar mandate from EPA (part of the Chesapeake Bay Total Maximum Daily Load limits) required local communities to remove nutrients in their stormwater flows at a combined cost to the region in excess of $2.5 billion. As an alternative, HRSD developed its “Sustainable Water Initiative for Tomorrow” (SWIFT) program to divert 100 MGD of wastewater effluent from Chesapeake Bay by treating it to drinking water standards and storing it in the local aquifer for reuse.

According to the revised Consent Decree (2017), SWIFT will 1) eliminate up to 90 percent of HRSD's direct discharges of nutrients to the Chesapeake Bay; (2) offset costly nutrient and sediment reduction requirements allocated to municipal separate storm sewers systems (MS4s) operated by localities in the Hampton Roads region; (3) mitigate local land subsidence; (4) mitigate recurrent flooding in the Tidewater area; and (5) increase resilience in the face of climate change (US et al. v HRSD Consent Decree (4th Amd.), 2017).

By implementing SWIFT at a cost of about $1.5 billion, HRSD will be able to meet the objectives of both its own Sanitary Sewer Overflow (SSO) improvement target and the Tidewater region's MS4 nutrient reduction goals at a region-wide cost savings of over $1 billion compared to the original estimated cost.

Key lessons learned include:

- Regional thinking. HRSD's status as a regional program enabled staff to see beyond mitigating their own nutrient loading limits to appreciate SWIFT's potential to help local communities meet their MS4 nutrient reduction requirements, as well as address important regional ground water and water supply challenges from overdraft and seawater intrusion.
- Engage regulators. HRSD funded a position within the Virginia Department of Health (VDH) so they could participate in the SWIFT planning process and oversee operations from a public health perspective. They also created the Potomac Aquifer Recharge Oversight Committee (PAROC) to ensure that both regulators and the public could have confidence in this innovative project.
- Calculate overall benefits. By raising their sewer rates to pay for the work required by the EPA Consent Decree, HRSD was able to fund SWIFT, providing greater environmental benefits and reducing the overall cost of nutrient removal to the entire region. HRSD effectively communicated this benefit to ratepayers who understood that HRSD's investment allowed cities to avoid raising their stormwater rates, and that collectively these fees were "two separate pockets in the same pair of pants."
- Innovative technology. To control the long-term costs and minimize the climate impact of advanced treatment, HRSD engineering staff invested in research and evaluated several alternatives before selecting biologically active carbon (BAC) treatment over reverse osmosis) for removal of organics.
- Individual leadership. Agency managers at the regional and state levels initiated the SWIFT program and supported its progress, including Ted Henifin (HRSD General Manager) and Scott Kudlas (Director, Office of Water Supply, Virginia Department of Environmental Quality). According to Ted, *"Whoever has the most to give, gives the most. And keeps on giving."*

Figure 3. HRSD's service area (Nylen, 2019)

Map shows the locations of wastewater treatment plants planned to have SWIFT facilities (1–5); conveyance of service flows to a nearby plant with a SWIFT facility (3b); and conveyance of secondary treated effluent to a nearby SWIFT facility (4b).

Setting

The Chesapeake Bay dominates the geography of the Tidewater area. Located where the African and North American tectonic plates first met to raise the Blue Ridge and Appalachian mountain chains, the bay itself was formed 35 million years ago when a 2-mile wide meteor crashed into the ocean. This uniquely formed bay has become one of the most widely studied and highly regulated water bodies in the world. The Tidewater area of eastern Virginia fringes the southern reaches of Chesapeake Bay. Home to the first English settlement in North America (Jamestown, 1607), the area is naturally abundant in seafood, especially oysters, which have been cultivated there since the mid-18th Century. The region averages over 40 inches (90 cm) of rain per year, and while communities draw most of their water from local rivers, many close to the coast pump water from the Potomac Aquifer at a depth of between 200 and 500 feet (Harsh, 1980).

The largest estuary in the United States, Chesapeake Bay's decline prompted Congress to authorize a study which identified excess nutrient pollution as the main source of the Bay's degradation. In 1983, the EPA invited Virginia and Maryland into the Chesapeake Bay Agreement, a compact acknowledging the need for a cooperative approach to restore and protect the bay. Later joined by the state of Pennsylvania and the District of Columbia, the Chesapeake Bay Agreement set numeric limits to reduce nitrogen and phosphorus entering the bay by 40 percent by 2000 (Chesapeake Bay Program, 2021). Land conservation and forest restoration efforts helped improve bay water quality, but nutrient pollution from agriculture and urban areas continued unabated, so in 2010 EPA established the Chesapeake Bay Total Maximum Daily Load (TMDL). These mass loading limits required jurisdictions to reduce discharges of nitrogen, phosphorus, and sediment by 20 to 25 percent (EPA, 2015), forcing HRSD and the communities in its service area to eliminate their sanitary overflow and storm sewer discharges into Chesapeake Bay and the James and Elizabeth Rivers.

In fact, curbing Chesapeake Bay pollution was the reason HRSD was created. At the turn of the last century, few communities treated their wastewater, discharging sewage directly into nearby rivers and streams. As a result, by 1925 the Chesapeake Bay was so polluted that the Virginia Department of Health was forced to condemn 60,000 acres of Hampton Roads oyster beds. Five years later, the Virginia General Assembly created the Hampton Roads Sanitation Disposal Commission, which recommended creating HRSD to plan "the elimination of pollution in Hampton Roads." In 1938, however, local voters rejected the new taxing authority, and did not agree to its formation until three years later. Demonstrating the challenge of interagency collaboration, one community (Portsmouth) "opted out" of regional treatment for another 30 years (Lillis, 2015).

In the twenty years following the end of World War II, HRSD constructed its first three primary treatment plants (Army Base, Boat Harbor, and Lamberts Point), and its first secondary plant (James River), followed by five more between 1969 and 1983 (Chesapeake-Elizabeth, Williamsburg, York River, Atlantic, and Nansemond). In addition to these nine major treatment facilities, HRSD now also operates and maintains seven smaller plants, all of which are connected to over 500 miles of sewer lines with a combined capacity to collect and treat about 250 MGD. They currently treat 150 MGD and service nearly 500,000 accounts (Nylen, 2019).

Hampton Roads Sanitation District

- Regional wastewater treatment agency (150 mgd avg)
- Nine major treatment facilities located in throughout region; seven smaller plants
- Eight-member commission appointed by Governor
- Service Area: 18 communities, 1.8 million population (2021)
- Annual O&M budget (2021-22): $332 million
- Capital budget: $235 million (2021-22); $2.92 billion (2021-2030)
- Water reuse: 110 kafy (planned) as groundwater injection

Multi-Agency Collaboration for Reuse in Virginia

Mass discharge limits stimulate new strategies

HRSD currently provides wastewater collection and treatment services to 18 cities and counties in the Tidewater region, treating an average of 150 MGD (HRSD, 2019). More accurately, HRSD provides wastewater collection and treatment services to the *residents* of 18 cities and counties, not the political jurisdictions in which they reside (HRSD, 2020a). This distinction is important, because—as an independent political subdivision of the Commonwealth of Virginia, governed by a state-appointed board of directors—HRSD can embrace a regional perspective and focus on protecting the bay undistracted by many of the issues faced by general purpose governments (e.g., housing, public safety, social services, etc.).

The 2010 EPA nutrient discharge limits forced HRSD to ramp up its program of repairing and replacing its 50-year-old sanitary sewer system to eliminate unplanned overflows due to rainfall. At the same time, EPA required the cities and counties in the Tidewater region to reduce runoff into area creeks and streams from MS4s. HRSD developed a Memorandum of Agreement (MOA) with local communities, taking responsibility to improve the sewer system (HRSD, 2014b), while the cities and counties evaluated strategies to reduce pollution from stormwater. Altogether, compliance with the new limits was estimated to cost the region's ratepayers upwards of $3 billion, inspiring HRSD to look for an alternative strategy.

Table 7. Nutrient credits available to HRSD partner agencies

Credits Available for Use by the Eleven Cities (all units shown in pounds)			
	HRSD Bay TMDL Allocations	HRSD Post Swift Loads (2030)	Credits Available for Use by the Eleven Cities
Nitrogen			
James River Basin	3,400,000	500,000	2,900,000
York River Basin	275,927	25,000	250,927
Phosphorus			
James River Basin	300,009	50,000	250,009
York River Basin	18,395	2,000	16,395
Sediment			
James River Basin	14,000,000	700,000	13,300,000
York River Basin	1,400,00	98,000	1,302,000

Reference: (Lang & Kane, 2017)

HRSD's previous efforts to reuse treated effluent had received little support from cities and counties in water-rich eastern Virginia. However, the ability of local communities to apply HRSD nutrient removal credits to their own MS4 nutrient reduction goals increased the appeal of water reuse. According to HRSD General Manager Edward (Ted) Henifin:

> HRSD learned a lot from earlier, unsuccessful efforts to develop non-potable reuse projects (landscape irrigation and industrial supply). Local water supply agencies had no interest in promoting the supply of nonpotable water for irrigation or industrial use, as it would reduce demand for their water services. Providing city stormwater programs with free nutrient discharge credits got them more interested. (Henifin, 2020)

A nutrient credit trading policy in place since 2008 allowed them to sell nutrient credits through the Virginia Nutrient Credit Exchange Association, a market-based trading program designed to achieve nutrient reduction goals for the Chesapeake Bay "to facilitate compliance with annual waste load allocations" (HRSD, 2008). By upgrading their treatment, HRSD had already significantly reduced the nitrogen, phosphorus, and sediment concentration in their effluent more than required, allowing them to allocate "surplus" reductions to other agencies according to the terms and conditions specified by the Virginia Administrative Code (VAC, 2017). In relatively short order, HRSD signed Water Quality Credit Agreements (Table 7) with many local communities (HRSD, 2020b) (Mayer, 2017).

Ground Water Augmentation Adds to the Value of Reuse

Around the time EPA issued its Chesapeake Bay TMDLs, the Virginia Department of Environmental Quality (VDEQ) began re-evaluating its historic ground water trends. Evidence of over-pumping— land subsidence and falling ground water levels—was reflected in a new ground water model prepared by the U.S. Geological Survey (USGS). Results of the new model suggested that the state needed to reduce its permitted withdrawals by as much as 50 percent to avoid further damage. The matter was brought to the attention of the permitees, including James City County, the largest public agency in Virginia entirely dependent on ground water. Their ground water levels had dropped by as much as 80 feet since 1980 (USGS, 2021), and they stood to lose half of their existing annual water supply to regulatory cutbacks.

HRSD had a long-standing relationship with James City Services Authority (JCSA), the environmental utility for James City County. In addition to providing wastewater treatment services, HRSD also processed their billings. They knew that JCSA had to make improvements to its MS4 program at significant expense, and they also understood how JCSA's low water rates would balloon if they had to substitute surface water for their newly limited ground water supplies (Powell, 2021). In 2015, HRSD General Manager Henifin and VDEQ Office of Water Supply Director Scott Kudlas met at an Environment Virginia meeting to discuss an idea that could solve several problems simultaneously. Unlike other potential water sources, HRSD's new recycled water supply was free of ownership claims from upstream jurisdictions. By treating HRSD effluent to potable standards and storing the treated water in the Potomac Aquifer, HRSD could not only reduce nutrient discharges to the Chesapeake Bay, but they could also help alleviate the state's ground water shortage and halt the subsidence of coastal lands threatened by climate change. According to Kudlas, "HRSD was working on the [EPA] Consent Order while at the same time we were cutting these people back. I asked [Ted Henifin] if he had ever considered groundwater injection, and he said, 'That's what I wanted to talk with you about.'" (Kudlas, 2021)

James City Service Authority (JCSA)

- Independent water and sewer collection service for James City County (pop. 76,000)
- James City County Board of Supervisors acts as governing board of JCSA
- 5 MGD brackish groundwater treatment plant, 416 miles of water main, 360 miles of sewer mains
- Wastewater treatment provided by HRSD.
- Annual O&M budget: $23 million
- Capital budget: $27 million

The following year, in September 2016, HRSD launched its SWIFT program. Instead of discharging it into Chesapeake Bay, HRSD would further treat the majority of its effluent (up to 100 MGD) and inject it into the Potomac Aquifer, reducing nutrient discharges and at the same time augmenting the regional ground water supply (HRSD, 2021b).

While the concept was simple, the implementation was complex. Numerous questions remained: How best to produce recycled water that would meet drinking water standards and match existing ground water quality? How much recycled water would it take to restore the aquifer, and how much would be available for reuse? In 2017, HRSD developed a research program to compare alternative treatment methods (reverse osmosis and biologically active carbon [BAC]) and drilled two test wells near the York and Nansemond plants. They settled on BAC treatment, and by May 2019, pilot facilities at the SWIFT Research Center had recharged 100 million gallons into the Potomac Aquifer.

Virginia Department of Health (VDH)

- State Agency responsible for serving 35 Local Health Districts
- Employees (2008): 3,192 (VA DHRM, 2018)
- Deputy Commissioners for: Community Health, Population Health, Public Health and Preparedness, which includes the Office of Drinking Water and Office of Environmental Health Services [OEHS])

"The mission of the OEHS is to protect public health by preventing the transmission of disease through food, milk, shellfish, water and sewage and to work in partnership with other agencies to protect the environment."

A New Regulatory Structure

As HRSD confirmed the technical feasibility of the SWIFT solution, the issue of public acceptance remained. Although some residents questioned the safety of ground water injection, state health officials were not technically involved in approving the process. EPA had delegated responsibility for regulating wastewater discharge to VDEQ but retained jurisdiction over ground water injection through its Underground Injection Control (UIC) program. According to Virginia Department of Health (VDH) Environmental Technical Services Manager Marcia Degen, this left the agency responsible for drinking water protection out of the regulatory loop:

> Like most health departments, VDH has a mission to protect the health and promote the well-being of all people in Virginia. When we first learned about this project, we were of course concerned about its potential impact on public health, especially on the large number of public and private drinking water wells in the area. So while we knew we did not have direct regulatory authority over the project, we still felt that we had a duty to do what we could to protect public health. But how? (Henifin, et al., 2021)

The solution devised by HRSD was to create a new regulatory structure to oversee the safety of the SWIFT ground water injection program that specifically included VDH and others whose involvement would merit the public trust. As Henifin (2021) explained,

> We knew that technically we could make SWIFT work, but we were very concerned about the public acceptance of recharging a confined aquifer with water that is tens of thousands of years old with water sourced from wastewater. We knew we needed the support – or at least acceptance – of so many elected, appointed, and respected leaders from across all spectrums.

In February 2019, the Virginia Assembly established the Potomac Aquifer Recharge Oversight Committee (PAROC), "responsible for ensuring that the SWIFT Project, including its effect on the Potomac Aquifer, is monitored independently." (COV 62.1 Ch. 26 , 2019). The committee included representations from VDH and VDEQ, the Hampton Roads Planning and Development Commission, James City Service Authority, and a practicing physician from within the HRSD service area. In addition, the legislation established an independent Potomac Aquifer Recharge Monitoring Laboratory (PARML) to "Monitor the impact of the SWIFT Project on the Potomac Aquifer by reviewing and synthesizing relevant water quality data." The laboratory is managed as a joint program of two Virginia universities (Virginia Tech and Old Dominion), and PARML's co-directors are appointed to the committee along with the director of the Occoquan Watershed Monitoring Laboratory, a similar Virginia institution that for fifty years has provided oversight to the indirect potable reuse program operated by the Upper Occoquan Services Authority (9VAC25-410-10, 2020) (Virginia Tech, 2021). Representatives from Region 3 EPA and USGS Water Science Center are also included as non-voting members.

PAROC has broad authority over the SWIFT program, and is specifically charged with asking the state water board to order HRSD to stop injecting should they find "an imminent danger to the environment, a public water supply, or public health, welfare, or safety…" In addition to funding both the committee (PAROC) and the laboratory (PARML), HRSD also funds a position within VDH that provides technical communication between the SWIFT Project and VDH managers.

> "VDH Office of Drinking Water staff was initially uncomfortable about injecting treated wastewater into the aquifer. It helped to describe how [SWIFT] was the solution to multiple problems, and that everybody was going to get something."
>
> *Scott Kudlas, VDEQ*

The value of this close coordination was demonstrated early on when the program had to resolve a question of nomenclature. HRSD had previously dubbed the advanced treatment effluent "finished water," indicating that it was suitable for ground water injection. Virginia's drinking water code, on the other hand, defined "finished water" as potable water, and the rules did not allow direct reuse of recycled water. With the help of VDH representatives, the water produced by SWIFT's facilities that meets regulatory parameters for drinking water was re-branded "SWIFT Water."

Moving Together Into the Future

HRSD staff are shepherding SWIFT through the design phase. The program involves the coordinated construction of advanced treatment and recharge facilities at five of HRSD's seven largest plants (James River, Nansemond, Virginia Initiative Plant, York River, and Williamsburg) with effluent from two others (Boat Harbor and Army Base) piped to the new treatment facilities. HRSD has invested significantly in research and development of advanced wastewater treatment methods, and improvements will include an innovative "de-ammonification" approach to reducing nitrogen piloted at the York and Nansemond plants (Bott, 2014); construction of a new SWIFT treatment train including removal of organic material with both biologically active carbon (BAC) and granular activated carbon (GAC); and disinfection with ozone, chlorine, and ultraviolet light (Hazen and Sawyer, 2021). Design of the Advanced Nutrient Reduction Improvements and SWIFT Facility at the James River Treatment Plant began in 2020, with construction scheduled to start in 2022. The James River SWIFT facility is slated to begin recharging the local aquifer in 2026.

As aggressive as this schedule is, it may not be fast enough to ensure James City Services Authority's ground water supply. While to date their previous ground water allocation allowed withdrawals up to 8.4 MGD, their current permit (which expires in 2027) reduced that to 6.4 MGD, with further cuts likely down to 4 MGD. By comparison, they currently deliver over 5 MGD of treated ground water to James City County customers (JCSA, 2021). JCSA is making "good faith efforts" to identify alternative surface water supplies, if needed, but according to General Manager Doug Powell, "We need DEQ to give us some flexibility." (Powell, 2021)

For their part, DEQ is supportive of SWIFT, and appears willing to accommodate the existing construction schedule to allow JCSA to make use of the new recycled water supply. They also look to expand HRSD's approach to aquifer restoration in the wake of recent state legislation authorizing ground water banking, as recommended by the Eastern Virginia Groundwater Management Advisory Committee (EVGMAC, 2017). As DEQ's Scott Kudlas (2021) observed,

> It was a decade from the first lightbulb to SWIFT. It takes work to accommodate other people's interests and not just your own. There are so many additional benefits to being seen as someone who can accommodate other people's interests and not just your own. You can't communicate effectively unless you can see other people as humans and have empathy and put yourself in other people's shoes. That's an obligation of the leader: to look at things from other people's perspectives.

Area Insights

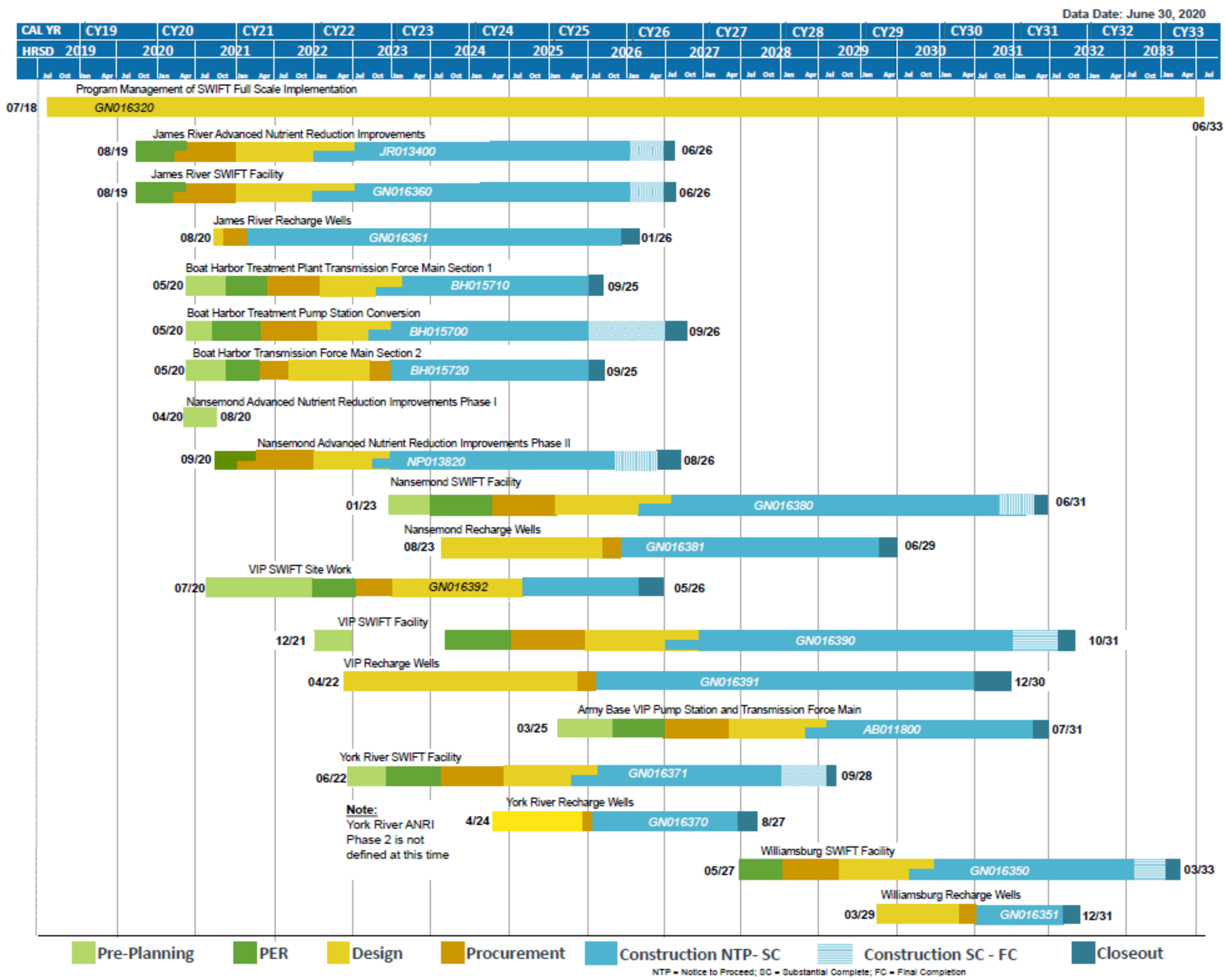


Figure 4. SWIFT project implementation schedule. Source: (HRSD, 2021a)

Governance

- **A regional entity is uniquely suited to address regional problems.** As an independent rate-setting authority under the purview of a state-appointed commission, HRSD was not only able to identify a solution benefitting the whole community, but they were also able to implement that vision by spreading the cost across all sewer ratepayers. This perspective contrasts sharply with that of individual local jurisdictions, whose focus on low rates may put more ambitious projects out of reach, even when (as with SWIFT) they offer long-term savings.
- **Not all agencies join, and those that do take time to decide.** Prior to development of SWIFT, HRSD offered to accept responsibility for designing, building, and funding improvements to the region's sewage collection system (and raising rates, as needed) in compliance with the original EPA Consent Decree, and all 14 local jurisdictions agreed to support this approach (HRSD, 2014a). This set the stage for further collaboration on the SWIFT program, but implementation still required individual agreements

with each jurisdiction to allocate nutrient reduction credits through the state trading program. Looking back to the decade of negotiation originally required to form HRSD—and the additional thirty years needed for the City of Portsmouth to join the regional entity—it is worth observing that even the best solutions may need to gain traction with limited support before all local agencies can recognize the benefit to their individual jurisdictions.

- **Each level of government has a role to play in crafting regional solutions.** Throughout its history, HRSD's success has been nurtured by leadership at the state level. It was the state that first recognized the need for regional wastewater treatment to protect the remaining oyster beds, and a half century later the Commonwealth of Virginia became one of the first signatories to the original (1983) Chesapeake Bay Agreement (Chesapeake Bay Program, 2021). These actions have proved pivotal to HRSD's ability to design and implement pollution control and ground water augmentation programs that benefit the regional environment. At the other end of the spectrum, local communities best reflect the sensitivity of their constituents, and have helped to clarify the concerns of ratepayers, whose support is ultimately needed for projects to succeed.

Regulations

- **Engage regulators early to craft mutually beneficial solutions.** Regulators play a key role in assessing and articulating environmental needs, and the Virginia regulatory agencies identified a suite of challenges including ground water overdraft, nutrient loading into Chesapeake Bay, and underground injection water quality. VDEQ in particular played a pivotal part, regulating water quality discharged into the Chesapeake Bay and managing the groundwater basin from which many jurisdictions (including JCSA) draw their water. From the outset, the project proponents included all interested regulators in developing solutions, even when (like VDH) when they lacked formal regulatory authority. The benefit of this inclusive approach was revealed when JCSA needed VDEQs permission to continue to pump from the Potomac aquifer while waiting for SWIFT water to become available.

Economics

- **Projects (like water reuse) that address multiple problems benefit from "economy of scope."** Although cheaper water supplies may be available, and less stringent wastewater treatment may be mandated, when water supply and wastewater treatment needs are considered together, water reuse often emerges as the most cost-effective solution. The benefits from this "economy of scope" should encourage agencies to "pool their problems" in order to pool their resources.
- **When calculating benefits and costs, remember that residents pay fees and taxes to overlapping jurisdictions.** HRSD began raising rates in 2010 to fund the significant investment required to meet the EPA Consent Decree to reduce sewer overflows. By agreeing to meet wet weather goals for the region while keeping lower local sewer system investments, HRSD set the stage for SWIFT. This regional perspective opened the door to regional savings through lower local stormwater costs due to reallocation of HRSD funds to SWIFT.

Management

- **Research investments pay long-term dividends.** Prior to designing their Advanced Nutrient Reduction Improvements and SWIFT Treatment Facilities, HRSD invested in extended studies of ammonia and nitrogen removal and advanced treatment and disinfection of filtered wastewater. Their support of basic research into the anamox process for reducing nutrients in wastewater led to an approach projected to reduce energy requirements by as much as 45 percent over conventional nitrification/denitrification. Similarly, by comparing biologically active carbon and reverse osmosis in pilot tests, they were able to select the alternative that not only saved energy but also produced a product water more similar to native ground water.

Leadership

- **"Those that have the most to give, give the most."** Smaller local agencies may be understandably defensive in dealing with large regional entities ("the 800-pound gorilla"). Larger agencies are often in a much better position not only to identify the most beneficial solutions, but also to arrange for financing to implement them. This is especially appropriate where local ratepayers also contribute to the regional program. By justifying expenditures as the "least cost alternative" for the community as a whole and accepting responsibility for funding most or all of the program, regional jurisdictions can "kickstart" solutions much earlier than if they needed to allocate costs separately to each local authority.

Referenced Agreements

Memorandum of Agreement between HRSD and 13 Other Hampton Roads localities for the development, financing, and implementation of the RWWMP
https://www.hrsd.com/sites/default/files/assets/Documents/pdfs/EPA/MOA/MOA_SignedFinal.pdf

Hampton Roads Water Quality Agreement for Chesapeake Bay Restoration (e.g., Fort Monroe)
https://www.hrsd.com/sites/default/files/assets/Documents/pdfs/Commission_Minutes/2020/10-27-2020_FinalCommissionMinutes.pdf

Agency Contacts

- Ted Henifin, General Manager, Hampton Roads Sanitation District, EHenifin@hrsd.com
- Doug Powell, General Manager, James City Service Authority, Doug.Powell@jamescitycountyva.gov
- Ryder Bunce, Technical Services Engineer, Virginia Department of Health, ryder.bunce@vdh.virginia.gov

CASE STUDY #2: NORTH CENTRAL TEXAS WATER AGENCIES

Timeline	
1840–1950	**The City of Dallas** (Dallas) is founded on the east bank of the Trinity River (1841) and chartered in 1856. **Dallas Water Utilities** (DWU) founded (1881). **The City of Fort Worth** is founded on the west bank of the Trinity River (1849). Torrential rains cause **massive flooding**, breaching 17 Trinity River levees and killing 10 people in Fort Worth (1922). **Tarrant Regional Water District (TRWD)** (formed as Tarrant County Water Improvement District Number One) tasked with flood mitigation (1924). Raw water supply was added to TRWD's responsibilities (1926).
1950–1975	Drought of record lasts seven years with catastrophic consequences. This drought ultimately galvanizes Texas into adopting scientific water planning (1950–1957). **North Texas Municipal Water District (NTMWD)** formed to address diminishing ground water supplies (1951). **Trinity River Authority (TRA)** formed to promote navigation, manage water quality, treat wastewater, and curb pollution in the Trinity River (1955).
1975–1995	TRA, Dallas, Fort Worth, and NTMWD sign the **Upper Trinity Basin Water Quality Compact (Compact)** to address water quality issues and develop collaborative approaches to meeting state regulatory requirements (1975). Record heat wave brings more than two months of 100 °F temperatures to North Central Texas (1980) (Myatt, 2020). **TRA** signs agreement with **Dallas County Water Utilities Reclamation District (DCWRD)** for a large-scale nonpotable urban reuse program in Las Colinas (1984). City of Dallas promotes formation of **Upper Trinity Regional Water District** (UTRWD) in Denton County, adding to the number of utilities sharing the river (1989). TRWD implements the **George W. Shannon Wetlands Water Reuse Projec**t (1992), an innovative constructed wetland (first of its kind in the U.S.) to remove sediment and nutrients from the Trinity River upstream of the Richland-Chambers reservoir.
1995–2009	The Texas Legislature enacts **Senate Bill 1 of the 75th Texas Legislature (SB 1)** to establish "a comprehensive statewide water planning process" (1997). Building on SB 1, **Senate Bill 2 of the 77th Texas Legislature (SB 2)** empowers Groundwater Conservation Districts to mandate water conservation and drought management measures (2001). DWU and TRWD sign the Interlocal Cooperation Contract (ICC), creating a partnership to jointly fund and participate in the **Integrated Pipeline Project (IPL)** (2007). NTMWD completes the 1,840-acre **East Fork Water Reuse Project,** providing up to 91 MGD of recycled water treated by the largest constructed wetland in the U.S. (2009).
2010–Present	Dallas, Fort Worth, NTMWD, and TRA again **renew and revise the 1975 Compact** (2011). In 2018, TRWD began moving water through the completed **Phase 1 IPL pipeline** system, capable of conveying up to 220 MGD (2019). TRWD can pump water from both Richland-Chambers and Cedar Creek Reservoirs into the IPL system (2020).

Overview and Key Takeaways

This is the story of how four independent, regional water agencies have learned to collaborate and scale water reuse to secure a sustainable water supply for nine million people. In an arid land that is whipsawed by catastrophic floods and pernicious drought (USEPA, 2016b), they have joined together to create a “water secure” future for approximately 40 percent of Texas’ population.

At the heart of the matter is the Trinity River and its ability to support continued growth and development in North Central Texas. The area is home to the Dallas-Fort Worth Metroplex (DFW), the fourth largest metroplex in the United States, which increased its population by 20 percent in the last decade (North Texas Commission, 2019). After decades of discharging undertreated wastewater into the Trinity River, Dallas, Fort Worth, and surrounding communities recognized the need to enhance treatment to improve water quality. Today the same effluent-dominated river is a vital source of drinking water (which is considered indirect potable water reuse), and Dallas Water Utilities (DWU), North Texas Municipal Water District (NTMWD), Tarrant Regional Water District (TRWD), and the Trinity River Authority all work together to maintain the health of the river and coordinate its allocation.

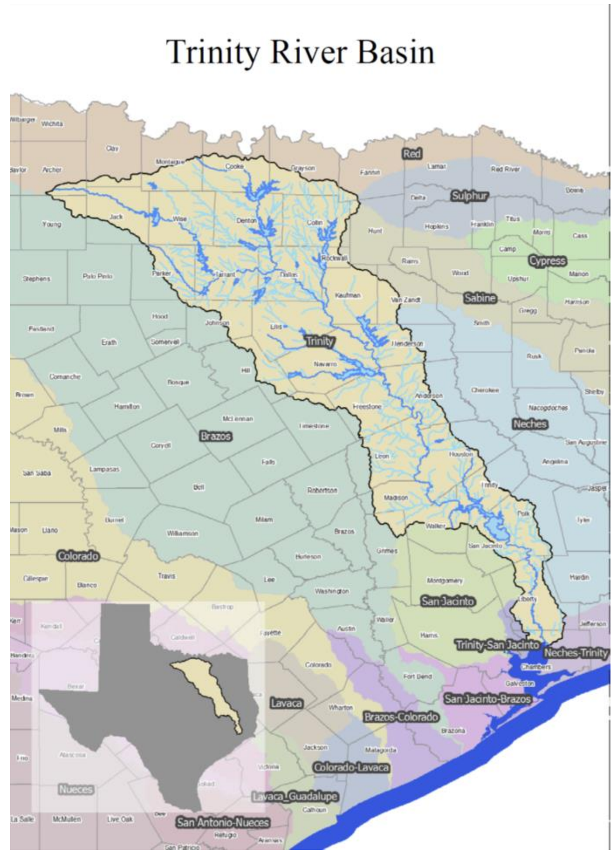


Figure 5. Trinity River Basin (TRA, 2016).

In documenting collaboration among the four agencies, we observed the following factors that supported regional expansion of water reuse efforts:

An environment that fostered interagency collaboration. A shared reliance on the Trinity River creates opportunities for agencies to collaborate **to provide water for their growing region in the face of increasingly extreme weather events.** This recognition of the value of a finite, shared water source presents itself in the way regulations, legislation, and planning activities are designed and implemented **through multi-party agreements such as the Upper Trinity Basin Water Quality Compact (Compact), and joint projects, including the North Texas Integrated Pipeline Project, the East Fork Water Reuse Project, and the Swap Agreement between Dallas and NTMWD.**

Keep planning at the local, regional level. When local agencies share a commitment to keeping decisions about water supply on a local or regional level, they are willing to make compromises to reach consensus to avoid mandates from state or federal authorities. This process can lead to a shared vision of sustainable water use for those who live, work, and play in their communities.

Evaluate projects with an eye toward multi-beneficial outcomes. The best opportunities are ones that satisfy multiple needs: they consider cost savings as well as the possibility of solving multiple challenges. For example, a project may address the need for a reliable water supply while at the same time creating an environment that enriches the community in which it is located.

Implementing large-scale water reuse projects requires strong, cross-agency relationships. Trust, perseverance, and aligned interests are required to move beyond a local mindset and scale to a level that impacts the region. Because agencies may operate under different cultural norms, both formal and informal engagement create conditions that engender trust and respect among peers.

Change is constant. Planning for a water secure future means anticipating constantly fluctuating conditions and ensuring that one's approach is geared toward taking advantage of economies of scale and scope. This requires a mindset that recognizes that greater opportunities exist when a regional, solution-oriented perspective is employed. The "Big Five" (TRA, TRWD, Dallas, NTMWD, and Houston) recently agreed to jointly fund a study to understand how to optimize water supply throughout the basin in view of climate change and other future considerations.

City of Dallas Water Utilities (DWU)

- Founded in 1881 as department within the City of Dallas.
- An enterprise fund within the City of Dallas overseen by Dallas mayor and city council.
- Surface water from six reservoirs provides the water supply for about 2.5 million people in Dallas and 27 nearby communities.
- Annual O&M budget: About $726 million (City of Dallas, 2020b).
- Water reuse: Two wastewater treatment plants, capacity 280 MGD.

Setting

The water agencies studied in North Central Texas are situated within the watershed of the Trinity River, on which about half of all Texans rely. It is 550 miles long, with an average flow of 5.7 million acre-feet per year**.** The Trinity River Basin, encompassing nearly 18,000 square miles, is one of 16 recognized basins across the state of Texas, the third largest by average flow, and the largest watershed area entirely within Texas (TWDB, 2021a) (TWDB, 2021b)**.**

The Trinity River is a unifying factor in North Central Texas, and their dependence on the river helps agencies recognize the benefit of a collaborative approach to ensure the viability of this resource and region. The Trinity River sustains the Dallas-Fort Worth-Arlington region, the fourth largest metroplex and the largest inland metroplex in the United States. It covers 12 counties—over 9,000 square miles—and is home to over 7.5 million Texans, with more coming every day (VisitDallas, 2021). As recently as 2018, DFW was the fastest growing region in the United States, adding more than 1.2 million residents over the last decade and growing by 20 percent since 2010 (Macon, 2021).

The infrastructure required to support this growing population must also be able to respond to extreme weather events, which will be compounded by the effects of climate change. The seven-year drought of record in the 1950s is still seared into the consciousness of these utilities (TSALC, 2021), as is the 1980 heat wave that established both the state's highest recorded temperature (113 °F) and the longest streak (42 consecutive days) of at least 100 °F (Myatt, 2020). Ominously, these records have all been rivaled in the last decade, with 2011 being the hottest and driest year on record, while 2015 was the wettest year on record. It is in this environment that the agencies have learned to work together to provide for their individual constituencies.

The City of Dallas was founded on the main stem of the Trinity River in 1841 and chartered in 1856, less than a decade after its neighbor, Fort Worth, settled on the river's west fork about 30 miles away. For many years the communities maintained a friendly rivalry, even after Dallas became the largest city in Texas and a center of banking and commerce, eclipsing its neighbor to the west. The separate streams allowed the two cities to manage their water supplies separately, creating agencies as needed to serve their cities' needs. Dallas assembled its Water Utilities Department in 1881. Fort Worth also supplied water to its residents, and (eventually) both cities treated their wastewater. In 1922, a major flood prompted formation of an agency that could provide flood control.

Tarrant Regional Water District (TRWD)

- Founded in 1924 for flood control management in response to the catastrophic 1922 flood.
- Overseen by a board of five publicly elected directors.
- Provides raw water to over 30 wholesale customers, including Arlington, Fort Worth, and the Trinity River Authority, serving over 2 million people in an 11-county service area.
- Annual O&M budget: $152 million (TRWD, 2021a).
- Water reuse: Secured water reuse permits at Richland-Chambers and Cedar Creek constructed wetlands totaling more than 180,000 AFY (TRWD, 2014).

The Tarrant Regional Water District (TRWD), formerly Tarrant County Water Improvement District Number One, was established in 1924 to build reservoirs to tame the river. In 1926, providing raw water supply to communities in eight north central Texas counties was added to TRWD's mission.

For nearly a century, Dallas and Fort Worth continued to withdraw water from their respective tributaries of the Trinity River, allowing the major waterway to convey their wastewater downstream. By the 1950s, however, the Trinity River was recognized to be in a "state of disrepute" (Browning, 2006). No words were minced in a 1925 Texas State Health Department report: "A stench from its inky surface putrescent with the oxidizing processes to which the shadows of overarching trees add Stygian blackness and the suggestion of some mythological river of death … A thing of beauty is thus transformed into one of hideous danger" (Wheedbee, et al., 1925).

Dallas, Fort Worth, and the other towns along the Trinity were not insensitive to the pollution and had taken some small steps to address the problem on a voluntary basis. In 1955, the Texas Legislature established the Trinity River Authority (TRA) "to promote conservation, reclamation, protection and development of the natural resources of the river basin for the benefit of the public" (TRA, 2021b). The creation of the TRA opened the door to better, more comprehensive planning. In 1958, Congress and the U.S. Army Corps of Engineers approved the Trinity River Watershed Master Plan, which included construction of the Central Regional Wastewater System. Located in west Dallas and the first regional wastewater facility of its kind, the system has now expanded to treat an average of 162 MGD and a daily maximum flow of 335 MGD (MWH, 2021).

The TRA continues to play a key part in regional planning as it relates to the Trinity River Basin. The TRA administers the Upper Trinity Basin Water Quality Compact (Compact) and is a signatory along with Dallas, Fort Worth, and the North Texas Municipal Water District. Created in 1975, this Compact brings together four regional utilities who each collect and treat wastewater for their customers. The Compact's responsibility is to facilitate "cooperative monitoring, studies and related activities by its members, and shall be primarily interested in water quality, wastewater collection and treatment, discharge and reuse of reclaimed water, and related regulatory matters in the lower West Fork, lower East Fork, and main stem of the Trinity River" (TRA, 2011). For any action to be undertaken, unanimous consent from all members must be achieved. The Compact, along with the federal Clean Water Act, are credited with the steady improvement of water quality in the Trinity River (TRA, 2021d).

As the region continued to expand, other utilities were formed to address its growing water and wastewater management needs. In 1951, during the building boom that followed WWII, the North Texas Municipal Water District (NTMWD) was created to serve water to 10 growing suburbs northeast of Dallas and Fort Worth. In 1972, they expanded their mission to also provide wastewater treatment services. In 1975, NTMWD became signatory to the Compact.

Sharing the River

TRA continues to play a significant part in maintaining water quality in the Trinity River Basin by coordinating studies to help meet in-stream water quality standards, and by participating in planning efforts with the other water supply agencies in the region. TRA completed its first master plan in 1958, and subsequent updates have confirmed the importance of coordinating municipal wastewater discharges and withdrawals to protect water quality and ensure adequate supplies (TRA, 2016). In 1997, the Texas Legislature modified the state's water planning process through the passage of SB 1. This bill divided the state into 16 distinct planning areas and provided funding to support the mandate to develop regional water plans. TRA currently facilitates the Region C Water Planning Group, which is responsible for developing a regional water management plan for this part of North Central Texas. The Region C plan

North Texas Municipal Water District (NTMWD)

- Founded in 1951 to address diminishing ground water supplies.
- 13 member cities with about 1.8 million people.
- Overseen by 25-member appointed board of directors.
- Annual O&M budget: $570 million (NTMWD, 2021b).
- Water reuse: Collaborative reuse is institutionalized in their strategic plan through "Stewardship and Partnership Strategies" (NTMWD, 2019).

is then incorporated into the State Water Plan, prepared every five years, which provides a framework for statewide water management.

SB 1 also stipulated that the state would allocate rights to all flows returned to the river. Water suppliers would have to petition the state for a water right permit to reuse wastewater treatment plant effluent. The new law also required water utilities to formally request permits to reuse their discharged wastewater effluent flows. The importance of these return flows today is emphasized in the 2021 Trinity River Basin Master Plan, which projects that reclaimed water—which currently accounts for over 300,000 AFY of Trinity River flow—will increase to over 400,000 AFY by 2070 (TRA, 2021c). The fact that summer flows of the effluent-dominated river may be comprised of nearly 90 percent treated wastewater highlights the need for utilities to coordinate their claims on return flows (USEPA, 1974).

As TRA notes in its 2021 Master Plan, "Population growth and economic activity in the Trinity Basin has necessitated extensive development of water supplies to get through the dry periods" (TRA, 2021c). In response, the primary Trinity River water agencies agreed to allocate their return flows amongst themselves to retain local control of their regional supply. Practices of note include the following:

- Agree in advance on allocations. Each of the four water agencies highlighted in this case study maintain bilateral and multilateral agreements with their utility agency partners across North Central Texas, and some also hold agreements with the City of Houston, in South Central Texas. These agreements are multi-beneficial and offer outcomes that benefit local customers as well as the regional effort to secure clean, reliable water supplies.
- Protest each other's permit applications to ensure equitable treatment and a seat at the table. When agencies file to obtain permits to reuse return flows, their peers sometimes amicably protest their permits. Why? By protesting, each agency is assured a seat at the regulatory table when allocations for reuse are determined. As it relates to regulatory requirements, the process of collectively protesting with agency peers ensures that any regulatory requirements are shared by all agencies and that no one agency will bear disproportionate responsibility.
- Honoring handshake agreements. The four main agencies discharging water into the Trinity River Basin have made a "handshake agreement" whereby they have agreed to limit their withdrawal of return flows. As they all take water from multiple sources, the utilities calculate the percentage of their discharges that originated as Trinity River water and have agreed (with and without contracts) to leave 30 percent in the river to maintain and improve in-stream conditions. While these flows are not diverted from the river for use, the utilities still retain ownership of their rights to use them, and they are not counted towards meeting environmental requirements (Owen, 2020).

Trinity River Authority

Trinity River Authority of Texas (TRA)

- Founded in 1955 by Texas Legislature (HB20) to establish a master plan for basin-wide development, and to serve as a local sponsor for federal water projects (TRA, 2021b).
- Overseen by a 25-member board of directors, appointed by the governor, who represent 17 counties.
- Annual O&M budget: $367 million (TRA, 2021c).
- Water reuse: Supports "the use of highly treated wastewater for beneficial purposes, including both direct and indirect potable and nonpotable applications" (TRA, 2021d).

Originally created to protect Trinity River water quality by treating wastewater prior to discharge, TRA currently functions as both a water and wastewater utility, managing wastewater treatment plants and distributing water from the river. TRA also administers the Trinity River Basin Master Plan, which is collectively updated every five years by area agencies. TRA's dedication to interagency collaboration is demonstrated through the regional agreements in which they participate, including buying raw water from TRWD and operating Lake Livingston, the second largest lake located wholly within the state of Texas, which provides a sustainable water supply to the City of Houston. TRA optimizes partnerships that contribute to a water secure future for the DFW Metroplex.

Beginning in the early 1980s, TRA began to intentionally reuse water (distinct from its earlier de facto reuse) for landscape irrigation and other nonpotable purposes as a less costly alternative to meet the needs of a growing population (Clingenpeel, 2020). While this type of reuse was feasible with some new planned communities, providing separate infrastructure for nonpotable water proved to be an expensive proposition. On the other hand, water from upstream effluent discharges recycled by conventional water treatment was more cost-effective and was generally viewed as part of the total water supply. As a result, when TRA compared the cost of increasing withdrawals of effluent flows returned to the Trinity River against the higher cost of extending a pipeline eastward to the Sabine River or building a new reservoir for east Texas water, recycling return flows proved to be the most economical alternative.

TRA currently administers the Upper Trinity River Water Quality Compact that ensures each of the signatory agencies uphold the Doctrine of Equal Treatment, in which all parties equally benefit and/or share the risk when actions are decided by unanimous consent. TRA plays a similar role in coordinating activities among the water agencies profiled in this case study (plus the City of Houston) that rely on Trinity River for their water supplies. These agencies, collectively known as "the Big Five," have agreed (both formally and informally) to allocate only 70 percent of their return flows for reuse, allowing the other 30 percent to flow downstream to maintain levels in Lake Livingston, Houston's drinking water reservoir (Clingenpeel, 2020).

To help NTMWD keep pace with population growth, in April 2016 TRA entered into an agreement to sell rights to 56,000 AFY of return flows to the District, increasing the reliability of its water supply. The 50-year agreement gives NTMWD the option to extend for an additional 50 years, enhancing the stability of the region and increasing water security (NTMWD, 2016).

City of Dallas Water Utilities

For almost two centuries, people have flocked to the east bank of the Trinity River to settle in the City of Dallas. This rapidly growing metropolis faces the challenge of ensuring that its supply of natural resources meets the demands of a growing population. Dallas Water Utilities (DWU) has gone to great lengths to ensure that its populace will have a reliable supply of clean water. This is apparent in the diligence and regional approach required to secure a sustainable water supply. With partnerships that are regional in purview, DWU must balance how to best serve its customers, while at the same time seeking win-win solutions that benefit the DFW Metroplex. Such partnerships can activate strategies that are efficient and economical in their pursuit of securing a reliable water supply.

DWU is different from the other major water providers in that they provide both retail and wholesale water and wastewater service. Additionally, they are the only major water provider in the DFW Metroplex governed by a mayor and city council. This model of governance has supported the achievement of two major milestones, which have regionally scaled water reuse efforts:

1. A partnership with North Texas Municipal Water District to "swap" and withdraw an equal amount of effluent.
2. A partnership with Tarrant Regional Water District to plan, design, construct, and operate the Integrated Pipeline Project (IPL).

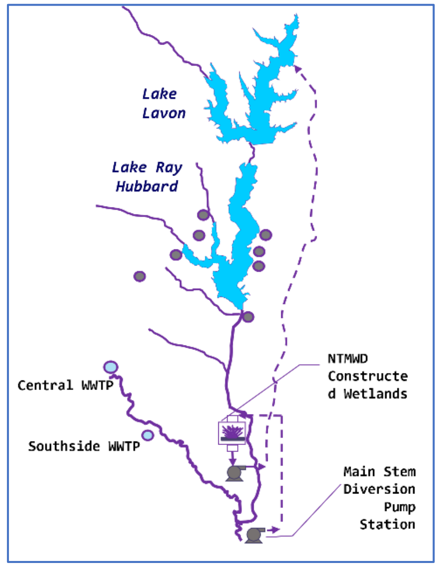


Figure 6. Diagram of swap agreement between DWU and NTMWD (Qualls, 2021).

The Swap Agreement in particular highlights a principle that is emphasized in the 2021 Trinity River Basin Master Plan (TWDB, 2021b): "Wastewater treatment plants are focal points for planning reuse systems." This tenet is actualized in the Swap Agreement.

The Swap Agreement refers to the arrangement between the City of Dallas and NTMWD to exchange their return flows in order to reuse them more efficiently. Both agencies had planned to reuse the return flows from their own treatment plants: 1) DWU, by moving water from its Southside Wastewater Treatment Plant to Lake Ray Hubbard and moving water from its Central Wastewater Treatment plant to Lewisville Lake; and 2) NTMWD, by sending water from its own wastewater treatment plants that discharge into both Lewisville Lake and Lake Ray Hubbard to its constructed wetlands project on the east fork of the Trinity River. After joint consideration of their collective infrastructure costs and operational requirements, they determined that they could accomplish their goals more efficiently and economically by exchanging their water supplies.

During the Regional Water Planning Process (mandated by SB 1), Dallas and NTMWD recognized the similar timing of the two projects and developed the Swap Agreement to provide a common solution. Key provisions include the following (Qualls, 2021):

1. DWU and NTMWD will swap an equal amount of flow from their respective treatment plants. In exchange for flow discharged by NTWMD's plants into Lake Lewisville and Lake Ray Hubbard, which it will direct to its water treatment plants, DWU will send water from its Central and Southside Plants to NTMWD's East Fork Wetland's Project for their natural treatment and reuse.
2. Return flows will be provided at no cost to each party.
3. Each agency agrees to accept the return flows "as is," produced as required by their respective NPDES permits, and each will be responsible for maintaining and making any changes to their respective discharge permits.
4. DWU will construct, operate, and maintain facilities required to pump flows from its treatment plants to NTWMD's East Fork Wetlands Project. In the interim, prior to the operation of these facilities, DWU will release NTMWD's return flow through Lake Ray Hubbard to the wetland.
5. Either party can terminate the contract with a five-year written notice.

Before the execution of the Swap Agreement in 2008, Dallas delayed implementation of the Main Stem Pump Station because effective water conservation reduced the need for additional water. The agreement remained in effect, however, and NTMWD constructed the pump station facilities. The agencies are currently amending the contract to reflect the new implementation schedule and revise Dallas' costs and share in the pump station capacity.

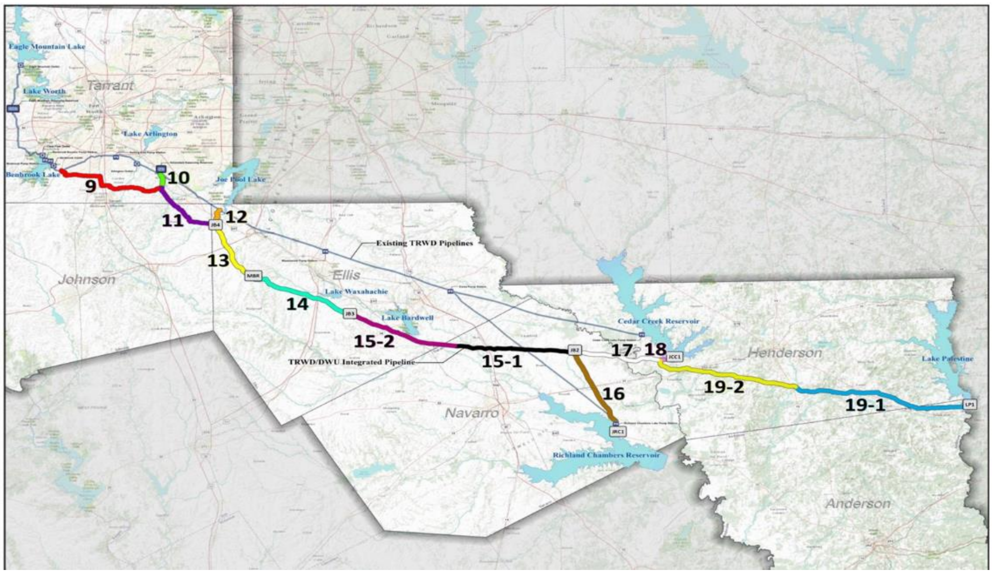


Figure 7. Diagram of DWU and TRWD's Integrated Pipeline Project (Qualls, 2021).

In another example of interagency collaboration, Dallas partnered with TRWD on the construction and operation of the Integrated Pipeline Project (IPL). Dallas approached TRWD in 2006 with an idea for how to collaboratively access a reliable water supply for their combined base of 4.1 million customers. Both utilities needed to secure supplies for future growth, and the IPL provided a workable strategy for each; this shared approach streamlined the effort and saved each utility billions of dollars. As TRWD's former planning director, Wayne Owen, put it, "Why build two pipelines instead of one?" (Owen, 2020). Economists "forecast ratepayer savings of $500 million in capital expenses and $1 billion in projected energy and other operational costs over the pipeline's expected 100-year life cycle" (Graves, 2019).

Subsequently, this project launched in 2007 with a price tag of $2.3 billion. The pipeline, which is 108 inches in diameter and spans 154 miles, will connect three drinking water reservoirs to the DFW Metroplex. When complete, "maximum delivery capacity of untreated water will more than double to 350 million gallons a day (MGD): 200 MGD to Tarrant and 10 other counties, and 150 MGD to Dallas and Denton counties" (Graves, 2019). During contract negotiations, Dallas and TRWD agreed that TRWD would design, finance, and own the pipeline. Multi-beneficial facets of this project include:

1. Dallas will connect to Lake Palestine.
2. TRWD will receive an additional connection to Richland-Chambers and Cedar Creek reservoirs that will enable them to access their whole, allowable capacity, including the reuse portion.

Dallas' involvement in this project was not driven by reuse, but by the ability to access a reservoir to which they had water rights since the 1970s and connect it to the City (Qualls, 2021). Nevertheless, their collaboration in the IPL was bolstered by their history of coordinating their use of return flows to the Trinity River as an efficient form of indirect potable reuse.

North Texas Municipal Water District

The East Fork Water Reuse Project, also known as the East Fork Raw Water Supply Project, began operating in 2009 and is an indirect reuse project that includes 1,840 acres of wetlands, the John Bunker Sands Wetland Center, and is designed to deliver an average of 91 MGD (NTMWD, 2021a). This project diverts water from the east fork of the Trinity River, uses the wetlands to polish the water, and then sends the finished water to Lake Lavon for storage and blending before being diverted, treated to drinking water standards, and finally distributed to North Central Texas residents.

This strategy will help meet the goals set forth by the 2022 Texas State Water Plan, “About 58,000 acre-feet per year in indirect reuse strategies is recommended in 2020, and 739,000 acre-feet per year is recommended in 2070” (TWDB, 2021c).

As noted earlier, in addition to the East Fork Water Reuse Project, NTMWD also contributed to the reliability of regional water supplies through their Swap Agreement with the City of Dallas. As a testament to the strength of regional partnerships, as described earlier NTMWD and Dallas plan to amend the agreement to reflect current practices that differed from those originally envisioned. After the original agreement was reached, for various reasons it was decided that NTWD and not Dallas should build and operate the Main Stem Pump Station. Amending the contract to fit the practices of both agencies will require both parties to deliberate on the financial share for each party and consider the capacity of each agency in this project.

NTMWD is also responsible for the creation of the largest constructed wetland in the United States, the East Fork Water Reuse Project. The Texas Water Resources Institute notes that “if location and planning for a project like this permit, a constructed wetland is a cost-effective alternative to building a new reservoir or extending the life of current reservoirs. Wetlands delay the need to construct additional water supply projects, have a smaller footprint than reservoirs and can be implemented in a fraction of the time. These projects are critical for maintaining a sustainable water supply for the growing population of North Texas” (Richardson, 2019).

Figure 8. NTWD East Fork Water Reuse Project Wetland Education Center.
(Source: NTWD/Credit: John Defillipo.)

Tarrant Regional Water District

In 1922, on the heels of the 1908 “flood of record,” another devastating flood hit Fort Worth, killing 10 people and causing millions of dollars in damage. It also laid the foundation for the creation of Tarrant Regional Water District (TRWD, originally Tarrant County Water Improvement District Number One), whose original purpose was to mitigate floods. Two years after its inception, raw water supply was added to TRWD’s mission. Today, TRWD, of the four water providers discussed, is the only provider that provides raw water but does not provide treatment. They access more than 80 percent of their water from two east Texas lakes (Richland-Chambers and Cedar Creek Reservoirs) and extend their reach in the region through four main customers: the Trinity River Authority and the cities of Arlington, Fort Worth, and Mansfield. Through these relationships, TRWD interacts with 30 municipal suppliers who treat and supply water to over 70 cities in 11 counties, reaching just over 2 million people.

This population is expected to double by 2060, leading TRWD to develop strategies to increase its current water supply and ensure that it is reliable well into the future. Partnerships that have bolstered this goal include those with the City of Dallas and the Texas Parks and Wildlife Department, as discussed below.

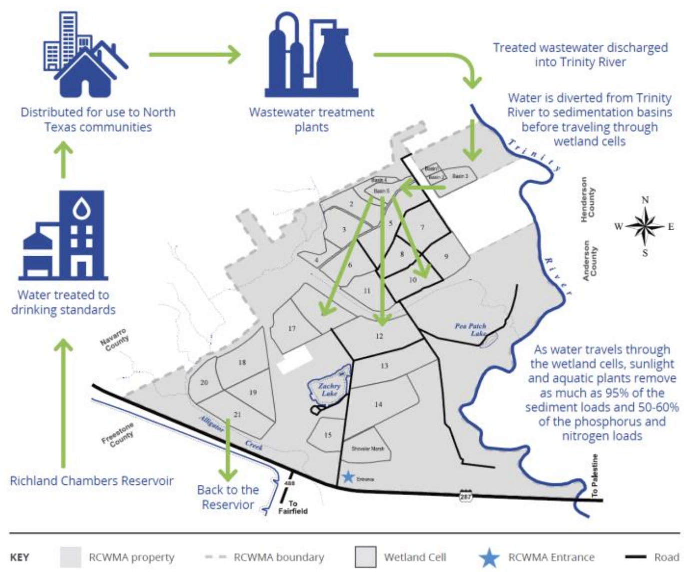


Figure 9. Joint outreach material from TRWD and City of Dallas. Source: (Texan By Nature, 2020).

Since 2007, TRWD and Dallas have collaborated on outreach and education efforts in the form of a regional advertising campaign to raise awareness about water conservation and promote behaviors that protect this limited resource. This is an efficient and cost-effective means of reaching a broader audience and ensuring that both agencies remain on message about the region's water resources. In 2019, NTMWD joined TRWD and Dallas in the regional water conservation campaign (TRWD, 2019).

As noted above, TRWD and Dallas have also fostered an innovative partnership which will result in the construction of the approximately 150-mile Integrated Pipeline Project (IPL). The result of a bilateral agreement, the IPL was launched in 2007 with the goal of conveying stored water in three separate reservoirs (TRWD's Cedar Creek and Richland-Chambers Reservoir and Dallas' Lake Palestine) to provide a secure water supply to the DFW Metroplex. During contract negotiations, it was agreed that Dallas would transfer full control of the design, financing, and operations of the pipeline to TRWD. Though the IPL is owned and operated by TRWD, the project cost of $2.3 billion is shared between the agencies. It will save both agencies a total of $500 million and increase their transmission capacity by 350 MGD. With 81 miles of pipe in the ground, in 2019 the IPL reached a significant milestone when it gained the ability to convey 220 MGD to the DFW Metroplex with significant cost savings (TRWD, 2020).

Regional partnerships can encompass more than water utilities, and other parties often participate in regional projects that promote and scale water reuse. To establish the George W. Shannon Wetlands Water Reuse Project, TRWD formed a partnership with the Texas Parks & Wildlife Department (TPWD). TRWD funded construction of the wetlands as a water supply project to meet growing water demands in its service area (TRWD, 2021b). An average of 95 MGD of effluent-dominated flow from the Trinity River can be diverted to the wetland system for treatment, where it is naturally filtered before being pumped into Richland-Chambers Reservoir then westward through a 60-mile pipeline to TRWD wholesale customers who then treat it to potable standards (Texan by Nature, 2018). TPWD donated 13,000 acres for joint use by TRWD and TPWD, designating the surrounding property for recreational public use.

Area Insights

Governance

- When a regional resource, such as the Trinity River, is vital to sustaining a region, local leaders may self-organize and create governing bodies that represent stakeholders across the region. This was the case with the formation of the Trinity Improvement Association, the citizen's group that first urged creation of TRA (TRA, 2021e). Such visible leadership serves as a unifying voice allowing the resource (i.e., the Trinity River) to be viewed regionally rather than in terms of its local impact. This in turn fosters buy-in from other stakeholders across the region who are more willing to share the rewards and risks inherent in cooperatively managing a vital asset.

- The interdependence of relying on the Trinity River leads to complementary agencies. Each agency in these case studies operates in a manner that reflects their needs, as well as those of regional counterparts. Agreements, both formal and informal, are crafted to leverage the assets that each agency brings to the table (e.g., sharing costs so that water supplies may be enhanced regionally) while also saving money by accessing reservoirs closer to the utility's service area.

Regulations

- The development and passage of Senate Bill 1 (SB 1) (1997) and Senate Bill 2 (SB 2) (2001) instituted a statewide, "bottom-up" comprehensive water planning process. The law directed stakeholders in each of Texas' 16 Regional Water Planning Areas to form Regional Water Planning Groups (RWPGs) to develop regional water plans. Each Regional Water Planning Group includes representation from 12 interest groups: public, counties, municipalities, industries, agricultural, economic, small business, electric generating utilities, river authorities, water districts, water utilities, and ground water management areas. The RWPGs identify water supply resources and water demands. SB 2 stipulated those regional plans must 1) include water conservation practices and drought management measures; and 2) align with long-term protection of the state's water, agricultural, and natural resources.
- Both legislative actions inferred a willingness to honor the experience of local leaders, if they were willing to collaborate and identify regional solutions to make Texas a water secure state. Collectively, these regional plans inform the State Water Plan, which reflects the distinct needs of each region. As Denis Qualls (Dallas Water Utilities) observed, "We'd much rather come up with the solution ourselves than be told what the solution is going to be" (Qualls, 2021).
- Applying for return flow reuse permits simultaneously engenders a shared responsibility among the major wastewater dischargers in the Trinity River Basin. By each reserving the right to lodge (and occasionally lodging) a protest against the other's reclaimed water permit request, agency leaders ensure that they have a seat at the table when reuse allocations are assigned, and regulatory requirements are further underscored. This emphasizes the importance of institutionalized transparency and fairness amongst the agencies (City of Dallas, 2020b). It also creates a collaborative environment where the concept "all for one and one for all" is demonstrated every day by these four regional entities. By working together to agree on allocations of return flows—which make up most of the Trinity River during the summer months—North Central Texas water agencies demonstrate an approach that might serve as a model for agencies located along inland rivers in other states.

Economics

- Interagency collaboration streamlines projects, building economies of scope and scale and reducing the individual price tag for agency partners. When the agencies in these case studies worked together, they were consistently able to save money and accomplish projects on a larger scale that would have most likely been otherwise unachievable. A prominent example includes the North Texas Integrated Pipeline Project, a partnership between DWU and TRWD. Economists predict inflation could increase the estimated overall $2.4 billion price tag to $3 billion by the time the last pipe is laid in 2035. Nevertheless, they have forecast ratepayer savings of $500 million in capital expenses and $1 billion in projected energy and other operational costs over the pipeline's expected 100-year life cycle (Graves, 2019).

> By giving up control of the [IPL] project to Tarrant Regional Water District, it was estimated that Dallas, over the life of the financing, would have a cost avoidance of over $2 billion due to bond coverage requirements."
>
> *Denis Qualls, Dallas Water Utilities*

- Economies of scale occur when local agencies collaborate to take a regional approach. The Swap Agreement between DWU and NTMWD was actualized after the conclusion of a collaborative reuse study that determined the feasibility of a joint project in lieu of two independent projects in the same vicinity of the Elm Fork of the Trinity River. The study identified a combined cost savings of a joint project of between $58 million and $126 million, and reinforced the partnership between the agencies, leading to this successful joint project (City of Dallas, 2008).

Management

- Sharing the responsibility of managing a regional asset, such as the Trinity River, allows each agency to leverage their strengths and maximize the benefits of regional projects. The Swap Agreement included joint funding of design and construction of the Main Stem Diversion Pump Station, which directs water to the wetlands.
- By discharging effluent of similar quality from their secondary and advanced secondary wastewater treatment plants, the agencies ensured the equitable implementation of waste load allocations. By developing large, constructed wetlands, they were able to improve the quality of the effluent-dominated flows efficiently and economically prior to blending with the drinking water reservoirs.
- By exchanging water NTMWD discharged into DWU's Lake Ray Hubbard Reservoir for flows from their Central and Southside treatment plants, Dallas avoided having to construct pipelines to convey effluent and could operate their reservoir more independently.

Leadership

- The North Central Texas agencies' longstanding cooperation demonstrates the importance of passing the baton from one generation to the next. Creating opportunities for intergenerational champions to emerge benefits each agency, as it preserves institutionalized understanding of the region and the partnerships that have been fostered over time.
- Formal and informal leadership opportunities are essential to building trust and credibility across agencies. They build the foundation for near-term and long-term actions to be considered and acted upon. It is just as important to share a meal with a colleague as it is to schedule a meeting.
- Creating a culture of mutual understanding and a shared vocabulary is essential to clear communication. During IPL contract negotiations, TRWD asked if DWU thought their City Council would approve the contract. DWU replied that any council member could pull an item which made TRWD uncomfortable, since when their board members pulled an agenda item, it meant that it was indefinitely suspended. DWU explained that for them pulling an item only meant that it may be pulled from the consent agenda, giving a Council member the opportunity to ask detailed questions.

Referenced Agreements

The Upper Trinity Basin Water Quality Compact (2003 Update to "An Agreement among the City of Dallas, the City of Fort Worth, the North Texas Municipal Water District, and the Trinity River Authority of Texas Continuing the Upper Trinity Basin Water Quality Compact").

City of Dallas-Tarrant Regional Water District Interlocal Cooperation Contract (2007) and Water Transmission Facilities Financing Agreement (2010).

Contract ("Swap Agreement") Between City of Dallas and North Texas Municipal Water District (2008).

Agency Contacts

- Glenn Clingenpeel, Trinity River Authority, ClingenpeelG@trinityra.org
- Nicole Rutigliano, Tarrant Regional Water District, nicole.rutigliano@trwd.com
- Ellen McDonald, Principal, Water Planning, Plummer Associates, emcdonald@plummer.com

- R.J. Muraski, PMP, Assistant Deputy, CIP and Planning, North Texas Municipal Water District, rmuraski@ntmwd.com
- Wayne Owen, San Jacinto River Authority (formerly TRWD), wowen@sjra.net
- Denis Qualls, Planning Division Manager, City of Dallas Water Utilities, denis.qualls@dallascityhall.com

CASE STUDY #3: SOUTHERN ARIZONA—TUCSON AND PIMA COUNTY

Timeline	
1920s	Ground water extraction's adverse impacts become evident with drying up of the Santa Cruz River, the region's only perennial surface water body. Regional aquifer is the only available water supply source.
1950–1980	Population grows sixfold, from 77,000 to 450,000, accompanied by rapid economic growth and associated growth in water demands from 10,000 AFY to 80,000 AFY. Ground water table experiences severe declines and costly subsidence issues emerge. By the latter part of the 1970s, with a strong regional desire to continue growth, the need to develop a sustainable water source is widely recognized at local and state level.
	Inter-Governmental Agreement (IGA) established. Pima County assumes responsibility for wastewater treatment for City of Tucson and transfers rights to 90 percent of effluent to Tucson; City of Tucson transfers its wastewater treatment plants to Pima County to facilitate access to federal grant moneys, and Tucson takes on potable and reclaimed water service responsibilities for the city and portions of the surrounding county (1979).
1980–2000	Arizona Groundwater Management Act establishes the Tucson "Active Management Area" and requires Tucson to document ground water pumping levels and identify plans to reach "safe yield" for the regional aquifer by 2025 (1980).
	City of Tucson begins design and construction of tertiary treatment facility and 8-mile pipeline to supply nonpotable water to La Paloma Golf Course and Resort, sharing cost with Pima County; Pima County provides effluent to Tucson at fixed cost (1984).
	Pima County and City of Tucson amend IGA to create a Conservation Effluent Pool of up to 10,000 AFY for approved riparian projects within the Santa Cruz River and elsewhere. (2000).
2020-Present	Tucson/Pima County recycled water program recognized as an instrumental part of reliable and largely sustainable regional water supply portfolio that collectively serves about 800,000 city and county residents. Cost allocation and related equity issues continue to be part of ongoing discussions between City of Tucson and the portions of Pima County it serves.
	Tucson Water receives the 2021 U.S. Water Prize for Outstanding Public Sector Organization by the U.S. Water Alliance for its work (in partnership with Pima County) advancing sustainable, integrated, and inclusive solutions to water challenges (2021).

Overview and Key Takeaways

For at least the past 40 years, the City of Tucson and Pima County have together faced the dilemma of a growing population and a declining ground water table. By the 1970s, the regional aquifer—the area's only local water supply—had been depleted to the point that ground water levels dropped significantly with noticeable subsidence.

The two southern Arizona jurisdictions (Pima County surrounds and includes the City of Tucson) had each historically run their own wastewater treatment plants, but in 1979 they agreed to divide their water and wastewater responsibilities. The County took over the treatment of all wastewater, and the city assumed responsibility for further treatment of effluent as well as the production and distribution of recycled water. They codified this arrangement with a formal intergovernmental agreement, reviewed regularly, which has stood the test of time. The agreement was most recently amended in 2000 to reflect changes in infrastructure and allocate water for approved riparian restoration projects. The two agencies together recover the cost of service through recycled water, potable water, and wastewater charges. The City manages the combined billing for water, sewage, and environmental services for the customers they share.

Necessity is the mother of cooperation: Dire circumstances (significant groundwater depletion) made the need for a large reuse program very apparent. Although each entity could have tried going its own way, Pima County and the City of Tucson worked out a collaborative IGA that continues, after more than 40 years, to serve the region well.

You can lead a horse to water, but money will help make them drink: Fiscal incentives from the federal Construction Grants program helped the entities accept specific exclusive roles (wastewater for county; water service, including reuse, for city), contributing to the absolute necessity for collaboration on reuse.

Blurring the political jurisdictional boundaries: Four of the five Pima County supervisors) represent both City of Tucson residents and voters residing in unincorporated areas of the county. This contributes to the perspective that everyone is in the same boat and that, ultimately, both the city and county serve the same households. The city and county have an informal policy of staggering years in which each imposes rate increases to avoid a double rate impact on customers. However, Tucson has questioned subsidized reuse for golf courses outside city limits, and it is considering implementing differential billing for water service it provides outside of city limits.

Sharing a vision of community values and aesthetics: All Pima County residents appreciate the necessity and value of water and there is wide support for developing water-related opportunities to enhance their community and environment (e.g., ecologic streamflow augmentation).

Cross-collaboration, including informal meetings across staff levels helps build and maintain trust, information sharing, and successful collaboration.

Shared participation and two degrees of separation: Staff from both agencies serve on or participate in local and regional organizations, and many of the agencies' professionals are well acquainted with each other.

Setting

The Tucson metropolitan area in eastern Pima County is in the hot, arid Sonoran Desert of southern Arizona. Pima County covers 9,200 square miles (about the size of the state of New Hampshire) with a 2020 population of approximately 1.1 million people. The vast majority of the residents (approximately 1 million persons) live within the Tucson Metropolitan Statistical Area (MSA) (ASU, 2021). Annual precipitation in the county averages less than 10.6 inches, and there are few remaining natural surface water supply sources in the region. Apart from intermittent stormwater-fed flows, the region's major perennial river, the Santa Cruz River, has not experienced sustained natural surface flows since the 1920s.

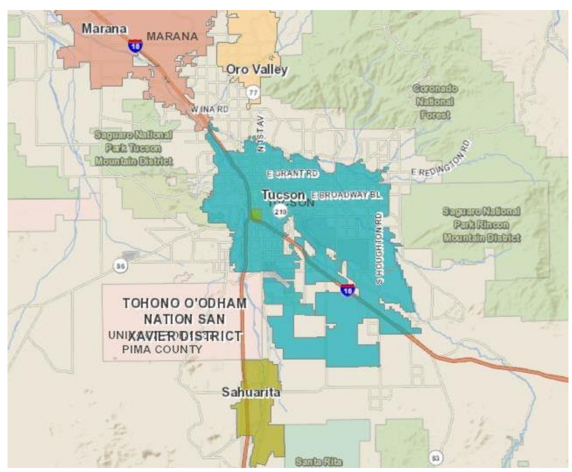


Figure 10. Tucson and Pima County (Kmiec, 2021).

The Tucson region experienced very rapid population and economic growth following World War II, as people flocked to the warm sunny climate to retire, recreate, and/or pursue the economic opportunities afforded by the area's rapid development. The region's population was 77,000 in 1950, growing nearly sixfold to more than 450,000 people by 1980, and then more than doubling again to reach approximately 1 million people by 2020, more than half of whom live in the City of Tucson. Until the beginnings of the Reclaimed Water System (RWS) in the 1980s, the only viable water supply was the regional ground water basin, the Tucson/Avra Valley Aquifer.

Tucson's rapid population and economic growth significantly increased water demands. Total water production in the 1940s was less than 10,000 AFY, grew to approximately 80,000 AFY by 1980, and peaked at over 130,000 AFY by 2000. Due to rapid growth in water demands multiple water providers pumped the regional aquifer at unsustainable levels and ground water levels declined by as much as 400 feet in some areas. Land subsidence and related ecosystem damages became a growing concern.

The City of Tucson (CoT) is currently home to approximately 550,000 people. Tucson Water (TW) is a department of the city of Tucson (CoT). The mayor and council make policy decisions and provide staff direction, but the city manager handles day-to-day departmental management. The utility's service area extends into neighboring communities and portions of unincorporated Pima County. TW provides potable water and nonpotable recycled water to customers not only within city limits, but also to residents in portions of unincorporated Pima County. TW's service area population nearly doubled from approximately 420,000 in 1980 to 780,000 in 2021. Approximately 30 percent of TW customers reside outside of city limits. Smaller water providers serve unincorporated Pima County, perimeter towns in the basin, and even some pockets within the city itself.

Pima County's wastewater agency, the Pima County Regional Water Reclamation District (PCRWRD), treats wastewater for the City of Tucson and the other communities in the region. (Two smaller wastewater agencies also deliver wastewater service within the basin.) PCWRD is governed by the county supervisors. Four of the five county supervisors represent areas that include both Tucson residents and Pima County voters residing outside the city limits. This gives the board ability to look beyond narrow "city versus county" differences and keep an eye on the broader shared regional interests.

Working Together to Survive

A Call to Action: Arizona's 1980 Groundwater Management Act

By the late 1970s, local and state officials recognized the need to take action to protect the regional aquifer and develop a more sustainable water supply to maintain the desired level of growth. In 1979, Pima County instituted a countywide ordinance requiring the use of a sustainable water supply for turf irrigation at any new development. In 1980, the state of Arizona passed its Groundwater Management Act (GWMA), which prohibited the development of turf sites without renewable water.

The major reason behind the county's ordinance was to prevent further subsidence due to over-pumping. At the time, many in the region believed they were facing an environmental disaster and a critical limit to desired growth. State-level action on the GWMA was stimulated, in part, by the need to ensure that Arizona's ground water use met federal requirements for access to Colorado River water under the Central Arizona Project (CAP). CAP was designed to bring Colorado River water to southern Arizona, beyond Phoenix and on to Tucson. Using recycled water allowed the city to quickly alleviate a portion of the regional subsidence and ground water depletion problems while waiting another 12 years for the CAP water to be delivered in 1992.

City of Tucson and Pima County

- Located in southwest U.S. Sonoran Desert, averaging about 10 in rain/year.
- Service population: 1 million (2020).
- Tucson Water: Regional water supplier (130 KAFY).
- Pima County: Countywide wastewater treatment (55 MGD).
- Water reuse: 14–20 KAFY nonpotable reuse for landscape irrigation (some industrial cooling).

Origins of the Reclaimed Water System (RWS)

In anticipation of the 1980 state-level ground water management legislation, in 1979 the city of Tucson and Pima County developed an Intergovernmental agreement (IGA). The IGA designated the City of Tucson as the primary regional water supplier and assigned to Tucson all Pima County's regional water supply assets (City of Tucson and County of Pima, 1979). The IGA also assigned to the county sole responsibility and ownership of the region's wastewater collection and treatment systems. This was done largely to access federal funding. Both city and county wastewater plants needed reinvestment, and prior to execution of the IGA both agencies were in the process of applying for federal assistance under EPA's Construction Grants wastewater funding program. EPA would only consider funding one wastewater entity in the area, however, which led to consolidating the wastewater facilities under Pima County. Under a Mutual Utility Management (MUM) agreement, the city transferred its wastewater assets to the county, and the IGA assigned rights to 90 percent of Pima County's effluent to TW (which, in 1979, amounted to 68,000 AFY).

The IGA forged the beginnings of the Reclaimed Water System (RWS), in which the City of Tucson further treats wastewater effluent from Pima County and distributes it for reuse. Since 1984, the RWS has provided nonpotable recycled water to the region's golf courses, parks, and other large users of landscape irrigation. Ecological restoration and ground water recharge have been added as additional valuable applications of RWS water in more recent years.

The Arizona GWMA established five Active Management Areas (AMAs), and water management goals were created for the Tucson AMA. Tucson's Assured Water Supply Program included requirements to monitor and record ground water pumping in all areas, and to identify goals and practices to help the AMA to reach a "safe yield" and avoid future ground water overdraft, which had already caused subsidence in areas of significant ground water decline.

City and county both had several incentives to reuse water. In addition to compliance with the GWMA and the need to gain access to CAP water, local officials were motivated by their desire to promote growth. The city of Tucson was surrounded by a large unincorporated area, which allowed for tremendous growth in nearby suburbs. To serve them, Tucson Water expanded beyond city limits to become a regional water utility, just as Pima County already had regional wastewater treatment responsibilities. The city and the county saw expanding the region's water supply as a means of enabling desired growth for the region.

TW's effluent entitlement under the IGA has been reduced by several actions since the 1979 IGA assigned rights to 68,000 AFY from the Pima County wastewater treatment plant to the City of Tucson. The federal 1982 Southern Arizona Water Rights Settlement Act (SAWRSA) reallocated a large portion of TW's effluent rights to Native American tribes in exchange for tribal rights to CAP water. The effluent awarded to SAWRSA is subtracted from the total available effluent, so both TW and PC contribute a proportional share of their effluent. This reduced the City's rights to Pima County effluent to 28,200 AFY. The City's allocation was further reduced in 2003 when water rights were transferred to Oro Valley and other localities based on of the amount of wastewater they produced. Consequently, the City of Tucson now has rights to about 20,000 AFY of Pima County effluent.

Evolving to Meet Emerging Needs and Priorities: Restoring the River

Several revisions have been made to the original IGA over the following decades to accommodate changing conditions and emerging opportunities. These modifications reflect a recognition that cooperation between the city and county entities was a more productive avenue for meeting shared objectives for the region than lawsuits and other battles.

For example, the City of Tucson and Pima County signed a Supplemental IGA in 2000 to resolve issues related to recharging effluent in the Santa Cruz River and similar environmental purposes (City of Tucson and County of Pima, 2000). The Supplemental IGA contained numerous agreements, including the following:

- The City of Tucson and Pima County agreed to establish a Conservation Effluent Pool for use on riparian projects.
- The City and County agreed to cooperatively plan and establish recharge projects to store recycled water.
- The City would no longer control effluent from existing non-metropolitan plants.
- The County could use its allocation of effluent for any public use (Malcolm Pirnie/Arcadis, 2013).

The 2000 Supplemental IGA also established that the City would grant other local water providers ownership of wastewater effluent proportional to the amount of wastewater produced by its potable water customers. The amount of effluent would vary depending on how much potable water the providers delivered in any given year and subject to other provisions of the effluent IGA governing the city of Tucson and Pima County. Tucson Water staff also worked collaboratively with these other water providers to develop agreements to convey their water through Tucson Water infrastructure (Malcolm Pirnie/Arcadis, 2013).

Overview of the RWS today

TW's RWS currently delivers recycled water to customers within its potable water service area (see Figure 11) and to the service areas of the University of Arizona, Davis-Monthan Air Force Base, the town of Marana, the town of Oro Valley, and the Flowing Wells Irrigation District (FWID). These service areas are located within the governmental jurisdictions of the city of Tucson, town of South Tucson, town of Marana, town of Oro Valley, and in unincorporated Pima County. The program is designed to serve nonpotable recycled water to irrigate golf courses in the metro area and service is extended to parks, schools, and other large turf areas along the way. The RWS began in earnest in 1984 with development of the La Paloma golf course. The program now delivers approximately 14,000 to 20,000 AFY of total recycled water, with more than half purchased by golf courses (Figure 11 and Figure 12). Current RWS customers currently include 17 golf courses (11 private, six public), 62 schools, and 37 parks (Kmiec, 2021).

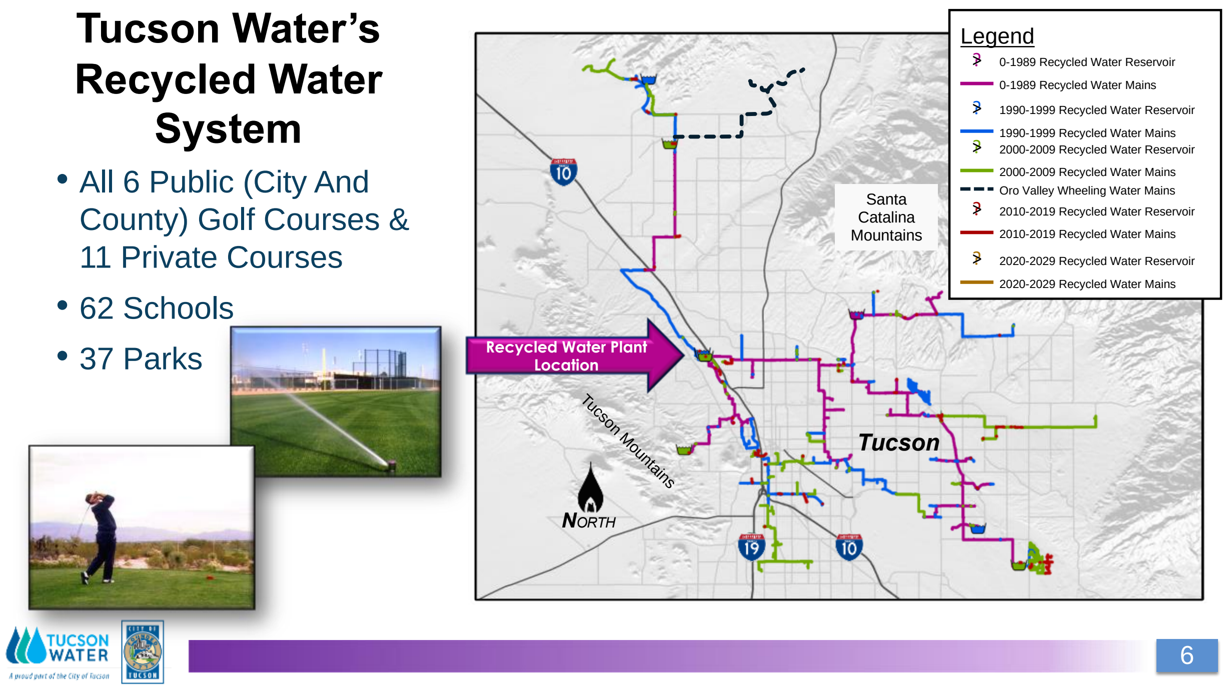


Figure 11. Diagram of Tucson's Recycled Water System. Source: (Kmiec, 2021).

Economic Considerations and Benefits

There are several key economic considerations relevant to the way in which PCRWRD and TW collaborate to provide recycled water in the region. The program enjoys broad support and the many benefits RWS provides throughout the region are widely recognized. Nevertheless, periodically the agencies differ in their opinion regarding who should pay how much to support the program. Like many nonpotable reuse programs, the RWS sells recycled water to its customers at less than its full cost of service in order to attract irrigation customers (Raucher, et al., 2019). Typical annual total costs for the RWS ($13 million) exceed sales revenues ($9 million) by about $4 million (Kmiec, 2021). This necessitates a “cross subsidy” from other utility customers, even though these potable water customers do not receive reclaimed water.

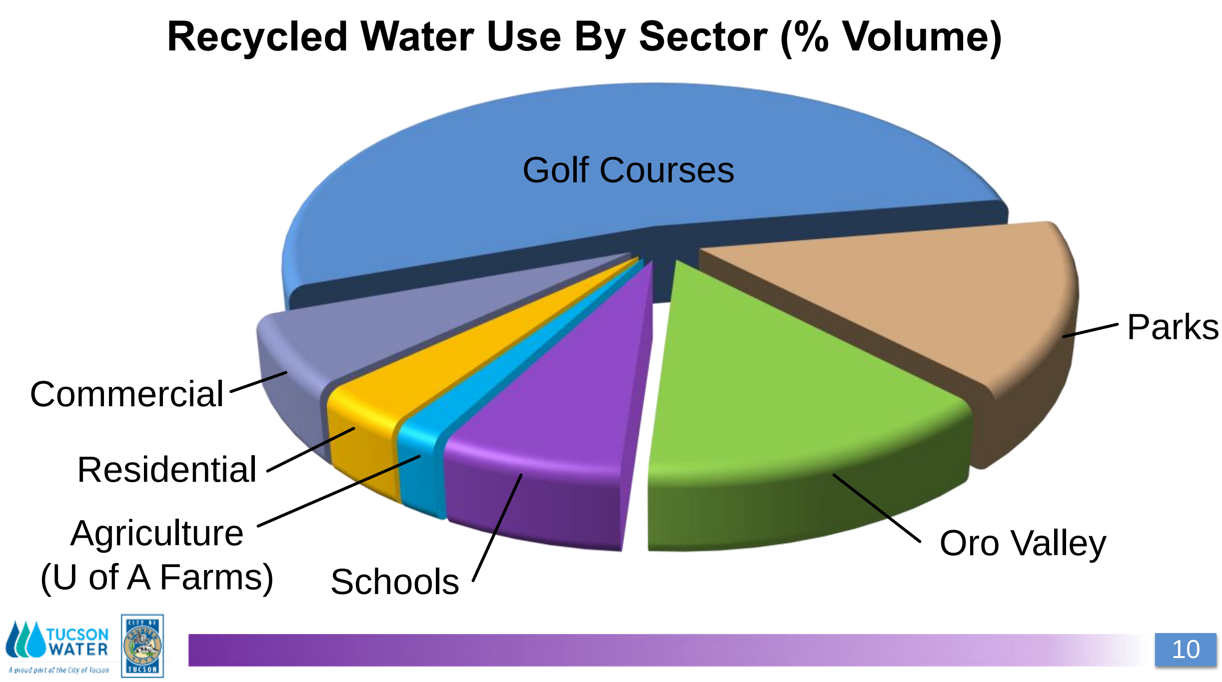


Figure 12. Tucson/Pima County recycled water use (by sector) (Kmiec, 2021).

In the case of Tucson, this cross subsidy may be justified by the benefits received, based on the wide array of benefits to the businesses and households in the greater Tucson region. Pima County communities would not have been able to support their population and economic growth if they relied only on their over-tapped ground water supplies, even when augmented (after 2001) by CAP allocations. Locally controlled, sustainable, and climate-resilient recycled water has diversified and helped stabilize the region’s water supply portfolio, providing considerable economic value for the community.

Another benefit is the avoided costs of expanding the potable supply by the additional 35 MGD to meet the current peak recycled water demand. A recent study pegs the value of this (cost savings) for an average Tucson single-family residence at around $90 per year (2021 U.S. dollars) (Mayer, 2017). This is considerably more than the estimated $10 per year per household cross subsidy to cover the shortfall in recycled water revenues.

In addition to cost savings, regional economic benefits accrue from TW’s active ground water recharge program, which has been enhanced by its use of the RWS to provide the region with a more reliable and sustainable supply. Net ground water recharge attributable to the RWS averages between 8,000 and 9,000 AFY (Scully, 2021). If replaced with CAP water (at a cost of $372/AF), the value of recycled water to the community equals an additional $3–$3.4 million per year. Through 2020, Tucson Water has stored over 35,000 acre-feet of reclaimed water underground for future use (Malcolm Pirnie/Arcadis, 2013).

Despite the value of increased reliability and the avoided costs that appear to outweigh the cost of the cross-subsidy, for Tucson potable water customers to subsidize the cost of water sold to golf courses outside city limits remains controversial and will likely be a topic of discussion in upcoming rate-setting deliberations. Such discussions will require Tucson and Pima County managers to draw on the relationships they have developed over the past several years to reach a mutually acceptable resolution.

Other benefits

In addition to avoided costs and water supply reliability benefits—which are highly valuable in their own right—several other aspects of recycled water use benefit the region, although these are more difficult to quantify. Among these are ecosystem, recreation, and related social "quality-of-life" benefits. Recently, the U.S. Water Alliance awarded the city of Tucson its 2021 prize for Outstanding Public Sector Organization, recognizing the importance of these nonmonetized benefits. The Alliance specifically cited Tucson's recycled water and "green stormwater" programs in recognizing the city for its work advancing sustainable, integrated, and inclusive solutions to water challenges (US Water Alliance, 2021b).

Ecosystem restoration and recreation are both accomplished with recycled water through three notable projects. Originally, filter backwash flow from recycled water production at Tucson Water's Sweetwater Recycled Water Facility was used to create and maintain Sweetwater Wetlands (Figure 13). With improved water quality from the Pima County WRS, the filters are no longer required, so the Sweetwater Wetlands are maintained with water from the recycled water system. A prime birdwatching habitat, the Audubon Society alone sponsors more than 50 fieldtrips there annually for some 1,500 participants (Safford, 2021). Based on a nonmarket valuation of $74.50 per person, the economic value of this feature alone exceeds $100,000 per year (Oregon State University College of Forestry, 2016).

Another notable ecological benefit is the Santa Cruz River Heritage Project. Launched in June 2019, the Heritage Project reintroduced perennially flowing water into the otherwise dry Santa Cruz River after an 80-year absence. The restored river is not only vital to the environment, but also Tucson's history, culture, and identity. In addition, the South Houghton Area Recharge Project (SHARP) is a 40-acre recharge and recycled water project comprised of three recharge basins receiving recycled water from the Houghton Reclaimed Reservoir. This water recharges an area of the aquifer that has declined in the past several years. SHARP also provides opportunities for community recreation and interaction, providing the public with green space for walking, running, and biking (US Water Alliance, 2021b).

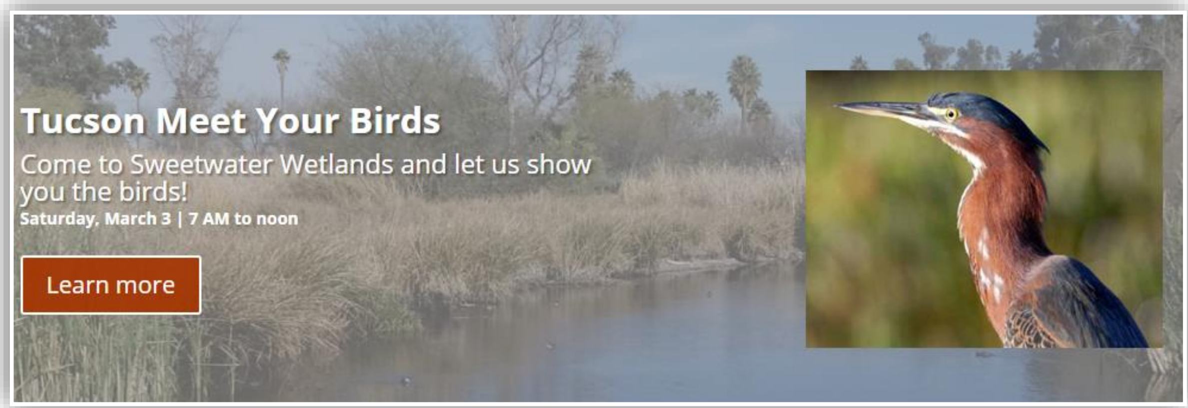


Figure 13. Tucson's Sweetwater Wetlands (Credit: City of Tucson).

While difficult to express in monetary terms, the benefits provided by the Sweetwater Wetlands, Santa Cruz River Heritage, and Southeast Houghton Area Recharge projects represent considerable recreational, aesthetic, and educational value for the community. Compounding the value provided by recycled water, these projects also help alleviate the "heat island" impact from urban hardscape, which is predicted to intensify public health risks under changing climate conditions.

Moving forward

With a successful partnership spanning more than 40 years, Pima County and the city of Tucson have provided their residents and businesses with a highly valuable, reliable, and sustainable recycled water program. The partnership was initially forged out of absolute necessity by the region's severe and unsustainable ground water depletion, and driven by a combination of statutory, regulatory, and economic development pressures to respond to that crisis. Through cooperation, recognition of shared values, and the vision and capacity to let the IGA evolve with changing needs and opportunities, the region's utility leaders and elected officials have enabled the RWS to provide value to the community.

TW and PCRWRD may have been joined out of necessity, but their managers and other professionals have built a successful long-term relationship. While challenges and debates periodically surface—such as ongoing deliberations about cost allocations and water rates for city and noncity potable and recycled water customers—the foundation established by the IGA provides a basis for meeting new challenges and providing important benefits to the community.

Area Insights

Governance

Revisit and revise agreements to meet emerging needs and evolving priorities. The terms in the IGA and the willingness and ability of the parties to amend it periodically provide a strong governance foundation for clarity and collaboration. Clearly written, specific bilateral agreements help agencies overcome concerns about independence and loss of control. Circumstances change, however, and the agreements need to be modified regularly "to grow with the program." Subsequent amendments to the IGA have each been more detailed and specific than the ones that came before, as knowledge and experience help the parties identify and address issues more explicitly and proactively.

Identify and work toward your shared visions and regional identity. Managers at both TW and PCRWRD recognize the necessity of collaborating to provide water services that support a livable city/region within the harsh, arid setting of the Sonoran Desert. Collaboration extends from senior managers down to midlevel staffers, including joint participation in several regional initiatives and organizations (e.g., the Sonoran Institute), and routinely scheduled informal meetings over breakfast or lunch.

Regulations

Statutory requirements and regulations can help promote sustainable "one water" programs. The state of Arizona's GWMA is a key legislative and regulatory framework reinforcing the need for wastewater and water utilities to collaborate to serve recycled water, protect the Tucson AMA, and meet the city's ground water-related protection and sustainability targets.

Recognize how effluent treatment requirements factor into cost shares. Pima County produces the water that meets the most stringent Arizona requirements for nonpotable use (A+ treatment suitable for residential, schoolground and other open access irrigation without restriction (Arizona Administrative Code, 2021)), regardless of whether it is discharged or recycled. The investment to meet A+ treatment requirements has added considerable expense for PCRWRD, while potentially saving money for Tucson Water, which may now scale back its filtration step. Since both entities largely serve the same customers, they recognize that combined billings to most customers would not change regardless of how costs are allocated. On the other hand, since both utilities also serve other customers as well, equity remains an important consideration.

Water rights are another key regulatory consideration. Rights to the PCRWRD effluent have been adjusted downwards over the past several decades because of settlements and legal/regulatory requirements associated with CAP water allocations, tribal rights, and other factors. TW can still produce enough reclaimed water to meet their customers' irrigation demands and support several ecological, recreation, and aesthetic needs, with the remaining recycled water contributing to ground water recharge. No significant increases in demand for nonpotable irrigation recycled water are anticipated for the RWS (Malcolm Pirnie/Arcadis, 2013).

Economics

Different pockets, same pants. While managers may recognize a divergence of interests between Pima County residents who live inside and outside the Tucson city limits, both utilities largely serve the same set of customers. As such, they informally aim to stagger their rate increases so that they do not impact customers within the same year. TW provides joint billings that help convey to regional residents a sense of unified regional water services provision.

"Issues can arise regarding which agency pays for what, but ultimately we now recognize that all costs ultimately are borne by the same customers."

Kathy Chaves, Pima County

What goes around, comes around. Jurisdictional overlap also influences relationships. Tucson Water distributes its nonpotable recycled water at the same subsidized rate to customers both within and outside the city limits. The difference is made up by potable water ratepayers in both the city and unincorporated Pima County, and concerns about equity continue to surface between the agencies.

Recognize and communicate the many monetary and nonmonetary benefits from water reuse. While recycled water appears to be relatively expensive, the RWS provides a wide array of highly valuable benefits. Benefits in the form of avoided costs (cost savings) may not be found on any accounting ledger, yet they often outweigh the cost of developing and operating a reuse program. As a drought-independent supply, reuse also provides important water supply reliability and resiliency benefits for regional businesses and households, including ground water recharge and storage. Ecological, recreational, educational, cultural, aesthetic, urban cooling, and other "nonmarket benefits" are provided by many reuse programs. While not always amenable to valuation in dollar terms, these benefits are extremely valuable and need to be recognized.

Align who pays with who benefits. Although the benefits derived from the recycled water are considerable, widely recognized, and justify the expense associated with the RWS, agencies may still have differences of opinion regarding who pays, and how much, to support the facility. Benefits to potable system customers—in the form of avoided potable system costs—may justify cross subsidies based on the principle "beneficiaries pay" for reused water pricing and cost allocations.

Management

Shared vision, informal interactions, and mutual respect smooth over challenges. Under the IGA, Pima County is responsible for meeting all wastewater-related regulatory requirements for its effluent, even though the portion of its effluent directed to the RWS is not discharged to the river, and instead is conveyed to TW as source water for the RWS. The state's stricter effluent treatment standards, especially those for nitrogen, led PCRWRD to invest $660 million to remove ammonia and nitrogen along with other facility upgrades (Pima County, 2016) (Malcolm Pirnie/Arcadis, 2013). The PCRWRD upgrades provide TW with RWS higher quality source waters, allowing TW to reduce its filtration treatment for the RWS and saving TW some expense.

Leadership

Shared challenges help spawn shared remedies. The RWS partnership was borne from shared acknowledgement of a critical regionwide need. By the late 1970s, city and county officials recognized the importance of working together to develop a sustainable regional water supply to address severe ground water depletion and subsidence to support desired levels of growth

Leadership can be reinforced by governance and regulatory mandates. Anticipated state passage and implementation of the 1980 GWMA prompted Tucson and Pima County to work together to achieve and maintain their GWMA designation of "Assured Water Supply" demonstrating the availability of long-term, reliable water resources to support current and future water customers in their Arizona communities.

Get it in writing and be willing to update and amend agreements to meet emerging challenges and grasp new opportunities. For over 40 years, utility managers and elected officials in the Tucson area have accommodated the evolving needs of their communities by modifying the IGA to address a range of emerging issues. Amending agreements such as the IGA is an important way leaders can assure mutual understandings are clear and enforceable while also accommodating appropriate changes over time.

Stay in touch and find opportunities to work together. The utility leaders at TW and PCRWRD have collaborated successfully by establishing joint billings and open lines of formal and informal communication (e.g., periodic meetings of midlevel managers). Still, some tensions may inevitably arise that require collaborative attention, such as addressing the equity aspects of who pays for and who benefits from the RWS.

Conclusions

In the City of Tucson-Pima County collaboration, the initial partnership may be viewed as a "marriage of necessity" borne from the need to secure a sustainable addition to their regional water supply portfolio, facilitate desired high levels of continued growth, and comply with anticipated state requirements under the Arizona GWMA. The initial 1979 IGA secured the foundation of the collaborative arrangement between Pima County and the City of Tucson and qualified for funding from the federal Construction Grants Program which was contingent on consolidating the city and county wastewater programs into a single entity.

Across the subsequent decades, the partners have sustained a reasonably healthy, long-lasting marriage. While there have been inevitable points of stress and contention over the subsequent 40 years, the partnership has continued to function well and serve the evolving needs of the community through several revisions to the IGA. A remaining tension within the partnership is about who pays, and how these cost allocations align with who benefits, yet it is evident that the whole region benefits from the successful RWS collaboration between the CoT and Pima County.

Referenced Agreements

Intergovernmental Agreement between the City of Tucson and Pima County (1979). Codifies agreement to transfer all wastewater facilities and responsibilities to Pima County, and water supply and reclaimed water assets and responsibilities to the city of Tucson.

Supplemental Intergovernmental Agreement between City of Tucson and County of Pima Related to Effluent (2000). Clarifies and amends original IGA and establishes a set aside of reclaimed water for use in riparian reclamation projects.

***Intergovernmental Agreement between* the City of Tucson and Pima County for Treating Effluent and Wheeling Reclaimed Water (2003).**

https://www.webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Office%20of%20Sustainability%20and%20Conservation/The%20Water%20Resources%20Unit/2003-IGA-APPENDIX-A.PDF

Agency Contacts

- Kathy Chavez, Water Policy Manager, Pima County, kathy.chavez@pima.gov
- John Kmiec, Interim Director,Tucson Water john.kmiec@tucsonaz.gov

CASE STUDY #4: CENTRAL CALIFORNIA AND MONTEREY ONE WATER

Timeline

1850–1930	Monterey agriculture transitions from cattle to wheat to sugar beets before establishing itself as "the nation's salad bowl," producing high-value fruits and vegetables. The Monterey Peninsula becomes a **tourist mecca** when a cohort of railroad tycoons (including Charles Crocker and Leland Stanford) form the Pacific Improvement Company to purchase 7,000 acres there for a luxury hotel and build the first dam on the Carmel River (1883).
1930–1960	Samuel Morse acquires Pacific Improvement's assets, including water rights to Monterey Peninsula, and transfers ownership to private **California Water and Telephone Company (CW&T)** (1930). Despite rising water rates, voters decline to make CW&T a public utility (1935). CW&T builds Los Padres Dam on Carmel River over objections of local fisherman (1948). California Department of Water Resources (then "Public Works") publishes **Bulletin 52**, documenting seawater intrusion into the upper aquifers (Simpson, 1946). Declining water levels and seawater intrusion force some Salinas Valley farmers to replace lettuce and strawberries with more salt tolerant crops and look for additional supplies. **Monterey County Water Resources Agency (MCWRA)** formed (as "County Flood Control and Water Conservation District") to reduce seawater intrusion from over-pumping (1947).
1960–1980	**Marina Coast Water District (MCWD)** formed to provide water and sewer service to growing north county communities (1960). **Monterey One Water (M1W)** formed (as "Monterey Regional Water Pollution Control Agency") to treat wastewater from six cities and four special districts (1972). Encouraged by growers, M1W begins study of **using recycled water for agricultural irrigation** to reduce seawater intrusion (1976). Second public attempt to take over CW&T fails. CW&T sold to American Water Works, which forms **California-American Water Company (Cal-Am)** (1965). **Monterey Peninsula Water Management District (MPWMD)** created to serve as public water wholesaler to Cal-Am and solve over-pumping of the Carmel River (1978).
1980–1995	MCWD forced to drill new wells in the deep aquifer due to seawater intrusion (1983). **Monterey Wastewater Reclamation Study for Agriculture (MWRSA)** concludes that irrigation with reclaimed water is "safe as irrigation with well water" (1987). **Castroville Seawater Intrusion Project (CSIP)** is designed to send growers recycled water (1994)**.**
1995–2010	CSIP provides up to **20 MGD of recycled water to 12,000 acres** of Salinas Valley farmland. **California Water Resources Control Board** (SWRCB) determines that Cal-Am exceeded its Carmel River allocations and orders them to develop alternate supplies (1995), then issues Cease and Desist Order (CDO) compelling them to reduce Carmel River withdrawals (2009). Cal-Am proposes the **Coastal Water Project, an ocean desalination facility** to supplement Carmel River water and Seaside aquifer. Proposal withdrawn (2010).
2010–2020	Cal-Am files Environmental Impact Report (EIR) for the **Monterey Peninsula Water Supply Project** ocean desalination facility. M1W prepares EIR for **Pure Water Monterey** potable water ground water recharge project (2015). Pure Water Monterey begins recharging aquifer with **3,500 AFY of potable recycled water (2020)**.

Overview and Key Takeaways

For over a century, California's fertile and scenic Monterey Bay region (Figure 14) has sustained both prolific agriculture and burgeoning tourism. For the past 50 years, however, local agencies have struggled to maintain adequate supplies as water use has been limited by seawater intrusion and environmental concerns. Seawater now extends several miles inland into some coastal aquifers and pumping from the Carmel River is curtailed by a Cease and Desist Order from the California State Water Resources Control Board (SWRCB).

In 1998, Monterey One Water (M1W), in partnership with the Monterey County Water Resources Agency (MCWRA), began serving recycled water to area farmers. The idea of using recycled water to prevent seawater intrusion had been considered 30 years earlier, but it took the formation of M1W after the 1972 Clean Water Act to put the wheels in motion, and another decade to validate the suitability of using effluent to irrigate vegetables eaten raw (e.g., lettuce) for the project to gather steam. Ultimately, the project gained the wholehearted support of Monterey farmers, and for more than 20 years the Castroville Seawater Intrusion Project (CSIP) has delivered over 10,000 AFY of recycled water to local growers; some summer months M1W discharges no effluent to the ocean.

While CSIP helped the growers, the Pure Water Monterey project was designed to aid residents and businesses in Monterey, Carmel, and other coastal communities served by California American Water Company (Cal-Am). Under orders to reduce withdrawals from the Carmel River, Cal-Am had proposed to make up for that supply with water from an ocean desalination facility, but approval was delayed because of community opposition and the multiple approvals needed. In partnership with the Monterey Peninsula Water Management District (MPWMD), M1W constructed an advanced treatment facility (Figure 15), and Pure Water Monterey now recharges MPWMD's Seaside Aquifer with 4 MGD of highly treated and purified wastewater.

Figure 14. Map of Monterey County

Implementation of Pure Water Monterey was complicated, however, by the need to reconcile competing concerns of multiple agencies. Cal-Am was set on building a desalination plant, but the peninsula needed a new water supply sooner. Salinas Valley growers, meanwhile, had come to rely on recycled water and objected to diverting effluent to benefit tourist towns on the other side of "the lettuce curtain." Thinking outside the box, M1W worked with other local water managers to create additional solutions. MPWMD promised to help foot the bill for the advanced treatment facility. MCWRA, which had been supplementing CSIP with Salinas River flows, offered to redirect additional agricultural drainage to the M1W plant to bolster supply. The City of Salinas (a M1W member) found a way to add 3 MGD of agricultural process water and stormwater into the mix. Meanwhile, in exchange for a share of the water, Marina Coast Water District allowed M1W to use its new pipeline to convey highly treated and purified wastewater to the peninsula. A five-party memorandum of understanding was inked in 2014, and the project was underway.

Figure 15. Monterey One Water Regional Treatment Plant (Photo Credit: Monterey One Water)

Key lessons learned include:

- **Perseverance furthers.** The problems water utilities face have evolved over a century and can't be solved overnight. Agencies need time to adjust to new roles in order to adopt new strategies. In Monterey, it took M1W (a wastewater agency) and MCWRA (a flood management agency) 20 years to establish their partnership as recycled water wholesaler and retailer. Once in league together, they needed a 10-year study to convince themselves and their CSIP customers that seawater intrusion could be safely slowed by substituting treated effluent for traditional supplies. It took nearly another decade for peninsula interests to align with valley concerns in Pure Water Monterey.
- **Strength in numbers.** The best solutions often take the most partners. The patience Monterey agencies showed was rewarded with a robust water reuse program that will serve them far into the future. The number of bilateral, trilateral, and multilateral agreements required to implement Pure Water Monterey is a testament to the leadership of those managers. It also serves as a reminder that it takes the whole community working together to address the region's economic, environmental, and social concerns and create a sustainable water supply.
- **Invest in partnerships.** A significant portion of the cost of Pure Water Monterey was underwritten by federal and state grants and loans. Many California water grants are contingent on coordination through the Integrated Water Management Plan process, and additional evidence of collaboration in the form of interagency agreements can make projects even more attractive candidates for government funding.
- **Look beyond traditional supplies.** Only after M1W and Salinas recognized the feasibility of diverting 3 MGD of agricultural wash water to the treatment plant did Pure Water Monterey satisfy both municipal and agricultural interests. All communities faced with water shortages can benefit from considering alternative sources in the light of available treatment technologies.
- **Pilot projects build trust.** Treating a variety of impaired sources to produce a single high quality water supply presents several technical challenges. While treatment process design is guided by theory, at some point pilot plants and demonstration projects are needed to determine the best course. Pilot

projects also help staff from different agencies form long-term working relationships as they train together to operate the new facilities.

Setting

Monterey County extends from the Pacific coast to the foothills of the mountains that mark the western edge of California's Central Valley and follows the Salinas River from its mouth in the middle of Monterey Bay to its confluence with the Nacimiento and San Antonio Rivers 100 miles to the south. In many ways it mirrors the entire state: a fertile agricultural region nestled between the Santa Lucia and Gabilan mountain ranges, with the iconic California coastline (Carmel, Pebble Beach, Big Sur) drawing tourists from around the world (MCWRA, 1998). In addition to the streams and rivers that flow through the Salinas watershed, the area is underlain by aquifers usually divided into five separate zones. In the north county, water produced at depths of 180 and 400 feet in the pressure area were the first tapped by area farmers and the first to experience seawater intrusion that rendered wells too salty for agriculture. Ground water withdrawals from the Seaside Basin to serve Monterey Peninsula are limited by a watermaster to prevent contamination by seawater.

The history of Monterey County also parallels that of California. After uprooting the indigenous tribes, Spanish friars had little success in establishing agriculture until they built a 3-mile irrigation ditch from the Carmel River to the mission (Hampson, 2010). Following the American conquest, cattle and sheep production predominated until the invention of the mechanical reaper and extension of the railroad spurred wheat production (Ryan & Breschini, 2021). Then came sugar beets, irrigated from deep wells operated by steam-powered pumps that supplemented wastewater from the adjacent sugar refinery—an early example of agricultural water reuse. It wasn't until 1920 that Salinas Valley growers planted lettuce, but by midcentury they were producing more than half the lettuce consumed in the U.S. (UC Davis Cooperative Extension, 2021) (Geisseler & Horwath, 2016) (Monterey Farm Bureau, 2021). As in the state as a whole, the more farmers planted the more water they diverted from surface streams and pumped from aquifers to satisfy their demand. Coastal wells began to show evidence of seawater intrusion as early as the 1930s, and in 1947, Monterey farmers began looking in earnest for alternate sources of water.

While the Salinas Valley was being transformed into the nation's salad bowl, the scenic Monterey Peninsula became a haven for tourists with a thriving year-round community of its own. Monterey's tourist industry traces its origin to a group of railroad tycoons (including Charles Crocker and former Governor Leland Stanford) who formed the Pacific Improvement Company in order to build "a large, handsome and perfectly equipped resort to render available the extraordinary natural charms which the peculiar climate of the coast afforded" (Barrows & Luther, 1893). In 1883, the company purchased 7,000 acres—nearly the entire peninsula—and began to develop their property, but they were soon impacted by the same droughts that afflicted the area farms. They constructed the first dam on the Carmel River to stabilize their water supply, but for at least the past 50 years peninsula communities have faced periodic water shortages.

One Water for Many Purposes

Born to recycle

Monterey One Water (M1W) was destined to serve recycled water to farmers and residents of Monterey County since its inception. Prior to passage of the 1972 Clean Water Act, each town had its own sewer plant, discharging sewage into Monterey Bay with limited treatment. That same year, Monterey and a few other peninsula communities got together to plan a regional facility to meet the Act's stricter pollution limits. Within a decade they were joined by Salinas and other valley cities and formed the Monterey Regional Water Pollution Control Agency (the name changed to "Monterey One Water" in 2017) (M1W, 2021).

Even before the regional treatment facility began operation in 1990 community leaders were calculating how best to reuse the new recycled supply to supplement agricultural demand (SWRCB, 1975). The concept was cultivated by both M1W and Monterey County Water Resources Agency (MCWRA). That agency—which was formed in 1947, not long after publication of the state report warning of seawater intrusion—was charged with mitigating flooding by collecting stormwater in upstream reservoirs and releasing it into the Salinas River to replenish aquifers by percolating through the porous river bottom. MCWRA saw recycled water as a welcome addition to their portfolio of strategies for keeping seawater out of coastal aquifers.

Monterey One Water (M1W)

- Regional wastewater treatment agency (17 MGD avg annual flow).
- Service area: Provides wastewater treatment to six cities and three special districts in Monterey County, serving 250,000 residents and 7,000 businesses.
- Governance: 10-member board representing each of the member cities and districts.
- Annual O&M budget: $45 million (FY21–22).
- Capital budget: $100 million (10 years).
- Water reuse: Castroville Seawater Intrusion Project: 10 KAFY agricultural irrigation; Pure Water Monterey: 3,500 AFY aquifer recharge (expanding to 5,750 AFY).

To address concerns about the safety of reuse with high-value crops like lettuce and strawberries, MCWRA and M1W general managers Ken DeMent and Keith Israel launched a 10-year study on the health effects of using recycled water on fruits and vegetables normally eaten raw. They tapped into the effluent pipe at Castroville's 400,000 gallons per day of secondary sewage treatment plant and ran pilot-scale tertiary treatment filters to irrigate test plots of artichokes, broccoli, celery, and lettuce on 30 nearby acres. Eleven years and countless bioassays later, the Monterey Wastewater Reclamation Study for Agriculture (MWRSA) concluded that "based on virological, bacteriological and chemical results from sampled tissues, irrigation with filtered effluent or Title 22 [recycled water] appears to be as safe as with well water" (Sheikh, 1986).

According to current M1W General Manager Paul Sciuto, the MRWSA study was instrumental in changing the opinion of growers and regulators alike: "To some—including the county environmental health director—the concept of 'using sewage' on agricultural crops consumed raw was beyond belief. So we made him the head of the task force guiding the study." Demonstrating the same inclusive approach used to develop future Monterey reuse projects, the task force also included a half-dozen representatives from the agricultural community (an artichoke grower was co-chair), county planning and public works departments, state water quality and water resource boards, and even several local newspapers and TV stations.

Encouraged by these results, in 1992 MCWRA and M1W agreed to add filters to the new Regional Wastewater Treatment Plant and began planning how best to bring recycled water to the fields. As well as affirming their joint commitment to serve recycled water to growers in northern Monterey County, the 1992 agreement assigned each agency roles and responsibilities according to their individual institutional missions. Formally known as the Monterey County Water Recycling Project (MCWRP), the project was divided into two parts. As the agency responsible for wastewater treatment, M1W took the lead on the Salinas Valley Reclamation Project (SVRP), which included design, construction, and operation of the flocculation, filtration, and disinfection facilities needed to treat effluent for agricultural irrigation, as well as the transmission line to convey the water to the distribution system. With laudable foresight, M1W designed the SVRP so that their entire 30 MGD design flow could be treated to California's rigorous Title 22 standards for manufacturing water suitable for "unrestricted" nonpotable use. MCWRA, which was formed to address both flooding and seawater intrusion problems, assumed the role of water retailer to area farms. They took ownership of the Castroville Seawater Intrusion Project (CSIP), as well as the distribution portion of the Water Recycling Project, including laterals and turnouts to over 100 farms (Jones & Stokes, 1993).

Funding for the project was similarly allocated to the two agencies based on their ownership of the facilities, although the costs are primarily borne by MCWRA ratepayers. M1W and MCWRA each received separate U.S. Bureau of Reclamation BOR loans, but MCWRA ratepayers are now charged benefit assessments to repay both of them, as well as a portion of operations and maintenance costs. For its part, MCWRA charges growers who receive recycled water a delivery fee to cover the major portion of O&M costs (MCWRA, 1992). According to current MCWRA general manager Brent Buche:

> The thing to focus on is the fact that the problem was identified by the scientists, but the solution was identified by the agricultural stakeholders who paid for the project. The tertiary treatment plant and all the piping infrastructure is essentially paid for by the entire Salinas Valley, and the individuals that directly benefit from the water pay a greater percentage. (Buche, 2021)

The federal government also took an active interest in the project, supporting nearly three-fourths of the cost of the $70 million project. In addition to the $7 million EPA invested in the MRWSA study, BOR provided over $50 million in low-interest loans for recycled water treatment and distribution (Haddad, 2002). In 1998, CSIP began delivering a mixture of about two-thirds recycled water and one-third ground water pumped from supplemental wells to agricultural fields in the Castroville area. To further reduce ground water pumping, the Salinas River Diversion Facility (SRDF) was constructed in 2010 to add surface water to the CSIP supply, which now totals over 20 KAFY and is comprised of about 50 percent recycled water, 25 percent well water, and 25 percent surface water (McCullough, 2021).

Monterey County Water Resources Agency (MCWRA)

- Formed as Monterey County Flood Control and Water Conservation District (1947) "to prevent flooding and limit seawater intrusion … through storage and release of stormwater for aquifer recharge." Changed name to MCWRA in 1991.
- In addition to flood management, MCWRA can buy and sell water and prevent activities that harm the basin.
- Annual O&M budget: $24 million (MCWRA, 2020)
- Water reuse (with M1W): Castroville Seawater Intrusion Project (CSIP) supplies 13,500 AFY recycled water blended with 5–7 KAFY of Salinas River water to reduce salinity and increase supply for 12,000 acres

Peninsula Water Woes

While Salinas Valley farmers were battling seawater intrusion, the hotels, restaurants, and residents on the Peninsula were struggling with their own water quandaries. The railroad magnates who purchased the Peninsula installed the first dam on the Carmel River in 1883, followed by additional dams installed in 1921 (San Clemente) and 1949 (Los Padres). Since 1965, California American Water Company (Cal-Am), an investor-owned utility, supplied Carmel River water to Peninsula communities from 21 wells that pumped river water from the alluvial aquifer, a total of 14,000 AFY.

Unfortunately, that rate of withdrawal meant that the river would frequently run dry in summer. Lawsuits by the Sierra Club and others questioned Cal-Am's rights to the water, citing harm to the steelhead and other fish that spawned in the river. In 1995, the California SWRCB determined that Cal-Am was taking about four times more flow than it was legally entitled to, and that it would have to cut deliveries or obtain clear title to about 70 percent of its supply (SWRCB, 1995).

The SWRCB directed Cal-Am to obtain legal rights to the river or find an alternative supply. In response, Cal-Am proposed building a seawater desalination project that would provide up to 9,000 AFY, but 15 years later it is still engaged in a combative regulatory permitting process. Further aggravating the situation, in 2003, local withdrawals from the seaside aquifer were limited when the safe yield was found to be about half of then-current extractions (MPWMD, 2019). By 2009, when SWRCB issued a Cease and Desist Order (CDO) to force Cal-Am to reduce withdrawals, Peninsula residents and businesses faced significant cutbacks in their water use (MPWMD, 2011).

Cal-Am was not alone in pursuing solutions to the looming water crisis. In 1978, local voters formed the Monterey Peninsula Water Management District (MPWMD) to serve as a watchdog over the private utility. Decades of periodic water shortages, combined with growing concerns about the sustainability of peninsula water supplies, had convinced the legislature that "water problems in the Monterey Peninsula area require integrated management" and that a special district was needed "for the public welfare and for the protection of the environmental quality and the health and property of the residents therein" (State of California, 1996). Following the issuance of the CDO, MPWMD and M1W managers began discussing the potential to treat effluent from the regional wastewater treatment plant to potable standards. The result of those discussions was Pure Water Monterey, a project to supply more than 4,000 AFY of highly treated water to recharge the Seaside Aquifer.

With surface water and ground water supplies both curtailed, one might expect that Pure Water Monterey would be universally endorsed. In fact, MPWMD supported both the Cal-Am desalination and M1W reuse projects. Many in the Peninsula business community, however, preferred CalAm's plan as the surest way to support Peninsula growth by making up for all the "lost" Carmel River and Seaside Aquifer allocations. In the valley, Pure Water Monterey was opposed by growers who resented diversion of recycled water to urban water use, even though most winter flows were discharged to the ocean. Cal-Am continued to pursue its plans to build the Coastal Water Project desalination plant, but kept its options open by proposing both an 11,000 AFY facility and a smaller 6,000 AFY plant scaled to work in tandem with an expanded Pure Water Monterey project capable of adding 5,750 AFY to the local supply (CPUC, 2018).

California American Water Company (Cal-Am)

- Investor-owned utility established in 1965 by parent company American Water Works Company (AWK) after purchase of CW&T.
- Privately managed corporate structure with oversight by MPWMD; rates subject to approval by California Public Utilities Commission (CPUC).
- Cal-Am California Water Operations: $228 million in revenues from 177,000 retail customers, including 40,000 in Monterey County (AWK, 2020); (LWV, 2007).
- Water reuse: 4000 AFY purchased from Pure Water Monterey (MPWMD/M1W).

Alliance Through Abundance

It is a testament to the creativity and perseverance of agency managers responding to these conflicting interests that they were ultimately able to agree on a path forward. Dave Stoldt, who took over as general manager of MPWMD just two years after the CDO was issued, appreciated the challenge Cal-Am faced to meet the SWRCB's terms while fending off attempts by local ratepayers to take over the utility. (Despite Cal-Am's efforts, in 2018 Peninsula residents voted to undertake a feasibility study on the public takeover of Cal-Am.) At the same time, Paul Sciuto (who succeeded Keith Israel in 2015 as GM of M1W) understood that a successful project would need to satisfy growers' concerns about an adequate nonpotable water supply, especially since the City of Salinas—the largest city in his service area and a member of the M1W Board—represented a large agricultural constituency.

The solution lay in reimagining the project as a way to provide more water for both peninsula residents and Salinas Valley growers. As MPWMD GM Stoldt recalled:

> There was extra capacity in the M1W treatment plant which was designed to meet anticipated growth before we had as much water conservation. And the plant represented about $1 billion in infrastructure, so

> that amounted to a lot of stranded investment. As it turned out, there were several additional sources of water available, including agricultural drain flows, wash water and stormwater. (Stoldt, et al., 2021)

To Stoldt, a former investment banker, this represented a classic "win-win" situation.

Monterey Peninsula Water Management District (MPWMD)

- Governance: Seven-member board with five elected members and two appointed officials.
- Service area: 112,000 people in seven cities and unincorporated Monterey County.
- Annual operating budget: $18 million (MPWMD, 2020).
- Capital budget: $18 million (2020–23).
- Water reuse: 3,500 AFY ground water augmentation with Monterey One Water (Pure Water Monterey); proposed expansion to 5,750 AFY.

Charged with finding additional sources of water to augment M1W's wastewater flows, managers identified not one but three different impaired water supplies that could be treated and reused. MCWRA, responsible for managing the Blanco Drain, which conveyed about 1500 AFY of agricultural tailwater to the Salinas River, recognized that this previously "unallocated" flow might be diverted to M1W water for further treatment and reuse. The city of Salinas, meanwhile, had regularly operated a separate industrial wastewater system to collect water used to wash lettuce and other produce. Designed to treat wastewater from the manufacture of C-Rations during World War II, the system was segregated from their sanitary sewer system and conveyed relatively clean agricultural wastewater to percolation ponds. Salinas also had an additional stormwater drain that flowed to the Salinas River. By diverting both flows to M1W, Salinas could add another 3 to 4 MGD to their recycled water supply.

In July 2014, a "five-party" memorandum of understanding was signed by M1W, MPWMD, MCWRA, the City of Salinas, and Marina Coast Water District (MCWD). As set out in this preliminary agreement, M1W would fund and build the Pure Water Monterey advanced treatment facility and recharge the Seaside Aquifer, and MPWMD would purchase the stored water and wholesale it to Cal-Am. Salinas would divert flows to M1W for treatment to potable or nonpotable standards, as appropriate, and MCWRA as the wholesaler would sell the new irrigation water supplies to the growers. Marina Coast Water District—a M1W member which reserved the right to reuse all its wastewater—agreed to allow M1W the use its existing pipeline to convey advanced treated water to the recharge area in exchange for a share of the water for landscape irrigation. As MPWMD GM Stoldt recalled, "Our approach was to focus on the multi-regional, multi-benefit effects to make it possible for each of the five entities to get something they were seeking. And this initial 'agreement to agree' included off-ramps, so agencies unsure about what they were getting into might have an opportunity to back out in the future."

The agreements were finalized in 2015, and within two years environmental documentation had been submitted and financing was in place. The SWRCB recognized the value of this collaboration by providing over $130 million in State Revolving Fund loans and grants. (In a separate 30-year agreement, M1W, MPWMD, and Cal-Am set out terms for producing, conveying, and purchasing specified amounts of recycled water and assigning liability for any subsequent claims (MPWMD, 2016).) The agencies held a joint ribbon-cutting in October 2017, and by 2020 Pure Water Monterey was pumping 3,500 AFY of highly treated water into the aquifer for use by peninsula residents and businesses. In all but the driest years, the project would also provide an extra 4,500 to 4,750 AFY of recycled water for agricultural irrigation. As of this writing (2021), plans are underway to expand the advanced treatment facility from a peak capacity of 5 MGD up to 7.6 MGD and add up to 2 miles of conveyance pipelines connecting the purified water reservoir to an expanded injection well area (Duffy, 2016).

Operational challenges

Successfully operating Pure Water Monterey required the same type of close coordination of the participating agencies as developing of the initial agreements. Once discussions with the City of Salinas revealed the availability of 3 MGD of agricultural wash water as an additional recycled water supply, M1W and city staff worked together to develop a pilot program to divert and treat the waste flow. The two groups took advantage of existing infrastructure, but according to Brian Frus, Salinas Water, Waste, and Energy Manager, there were more details to be considered:

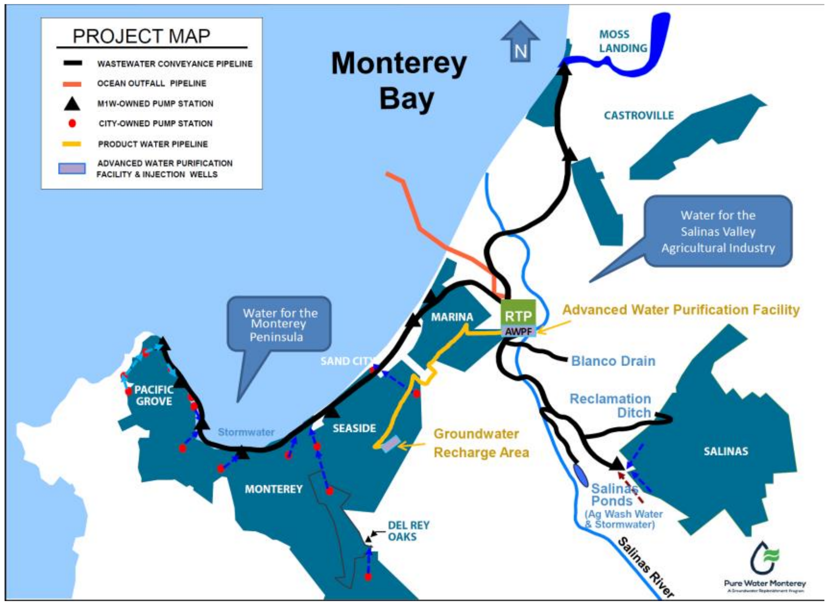


Figure 16. Map of Monterey One Water's Pure Water Monterey project.

> The infrastructure was very conveniently located, so initially we just shunted water from the industrial waste to the regional plant interceptor line. There were problems downstream, however: the wash water was hot, and had disinfectants in it, so we stored it in the ponds and blended it with the additional tailwater flows before sending it to the plant.

The joint team met weekly to identify and address issues and coordinate with the appropriate work groups in the City and at M1W. The experience of staff operating the project on a pilot scale prepared them to deal with issues of full-scale operation, as more equipment and instrumentation was needed, including combined SCADA systems to coordinate flow diversion to the plant. It is worth noting that the pilot project was started during another drought, so the water was sent to growers in place of river water. Said Frus, "The project started out 'elementary' but soon moved to 'advanced' as we added infrastructure that was built to make this process easier. It was definitely helpful to have worked together from the start." M1W and MPWMD had a similar experience, as they shared staff to enhance operation of the recharge facilities. In all cases, regular communication between work groups in different agencies has been a critical element of the project's success.

The Good Neighbor Agency

Building on its role as the county's recycled water producer, benefitting all residents and both the agricultural and tourist industries, M1W has begun to explore opportunities to work with other local agencies. For instance, the Salinas Valley city of Soledad operates its own wastewater treatment plant that uses membrane filtration. They have expressed an interest in producing recycled water, and M1W has provided both technical assistance and support for their laboratory analyses. They have been similarly forthcoming to other Monterey area cities, offering their expertise and assistance and in the process reinforcing the concept of "one water" for the entire county. As M1W GM Paul Sciuto observed, "I look at the wastewater treatment plant as a community resource, just as Monterey Bay is a community resource. And I wish I had more resources. There are many ways our county could become more resilient and more protective of our beautiful environment. Working together we can go a long way towards achieving that goal."

"There are many ways our county could become more resilient and more protective of our beautiful environment. Working together we can go a long way towards achieving that goal."

Paul Sciuto, Monterey One Water

Area Insights

Governance

The protracted negotiations among the many different agencies involved in managing water in Monterey County—public and private, urban and rural, water and wastewater—illustrates the durability of Blomquist's concept of "watershed management from the bottom up." It also further demonstrates the extent to which, insofar as Monterey's water management challenge is a "wicked" problem, the value of any proposed solution depends upon its ability to meet the needs of the different interest groups involved. From this perspective it stands to reason that Monterey One Water, with its countywide mandate, should serve as the hub of this complex network of interagency agreements, enabling the entities with a more local focus (MCWD, Salinas, Cal-Am, MPWMD) to join in creating a regional solution to the extent they are able.

M1W and MPWMD implemented a carefully crafted strategy for building agency consensus in support of the Pure Water Monterey project. With the 5-Party MOU, they were able to create a framework for the final agreement without binding any of the participants to irrevocable terms. During that time, they were able to define each party's terms and conditions of concern and reflect them in the several two- and three-party agreements from which they ultimately constructed the project.

In all cases, the general manager's task remains to walk a tightrope, suspended between the broadest notion of what is best for the entire community and the narrower notion of what is good for the agency that pays their salary. On the other hand, the solutions that engage the most partners are often the ones that provide the greatest benefits overall. As MCWRA chief Brent Buche explained, "They may describe another agency as the enemy, but the board still expects the GM to solve these problems. You have to network with people and constantly build bridges. We know that none of us get 100 percent of what our agency wants. But 50 percent is better than 0 percent."

Regulations

The wisdom of advice to engage with regulators "early and often" was also borne out in Monterey. The 11-year Monterey Reclaimed Water Study for Agriculture (MRWSA) was an essential element in the success of the Castroville Seawater Intrusion Project (CSIP). The results of the study certainly had a profound effect on Walter Wong, head of the Monterey Department of Public Health, who was originally highly doubtful of the safety of using recycled water on lettuce, celery, strawberries, and other vegetables and fruits commonly eaten raw. By including him as chair of the study's advisory board, MCWRA ensured that decision-makers would be influenced by the outcome of the research.

Economics

Monterey growers depend upon high quality water to produce their crops. Their margins are often small, however, so they are sensitive to even a small increase in the price of water. Similarly, when they have invested in a water supply (e.g., CSIP), they are wary of any plans to provide them less water for their investment. This was perhaps the primary reason growers opposed the original Pure Water Monterey proposal, which did not include any additional water for agriculture, but allocated a specific amount of existing flow to peninsula residents and businesses. Only by finding additional sources of influent, over and above traditional wastewater flows, was M1W able to persuade board members representing agricultural constituencies to support the project.

> The problem was identified by the scientists, but the solution was identified by the agricultural stakeholders who paid for the project."
>
> *Brent Buche, Monterey County Water Resources Agency*

The city of Salinas was the source of most of that additional flow, and they too were suspicious of incurring additional costs for activities that did not benefit them directly. Valley growers and Salinas residents are by and large hard-working, lower to middle income folks, while the peninsula cities are home to some of the highest per capita income neighborhoods in the country. As a result, city officials in Salinas needed to ensure that their involvement in supplying agricultural tail water drainage and wash water to M1W for use on the Peninsula did not inadvertently result in a similar flow of funds from Salinas to Carmel. Their sensitivity on this point also serves as a reminder that economic values are closely related to the social and political concerns of the communities involved.

Management

In Pure Water Monterey, just as with the MOU that preceded the final agreements, pilot projects led the way. According to M1W and Salinas staff involved in the project, the initial pilot simply involved installing a rubber plug in an industrial wastewater pipe to divert the flows into an adjacent M1W sanitary sewer line. Only after the issues of water quality were identified and resolved and staff from the two agencies became accustomed to working together did they begin to improve the infrastructure with mechanical valves and SCADA systems to facilitate remote operation.

Leadership

One consistent mark of leadership in all the projects across the country is the ability to focus different groups of people on their common interest, in this case preserving water for its highest and best use. The peninsula's looming water shortages convinced MPWMD and their ratepayers of the need for a ground water recharge project, but it was harder to make the case to valley growers with little regard for the needs of hotels and restaurants on the other side of "the lettuce curtain." However, according to valley managers, even staunch opponents to Pure Water Monterey were ultimately swayed by asking, about the flows still discharged into Monterey Bay, "Is this the best use of our water?" Once that conversation started, county residents were more likely come together to maximize water reuse.

Referenced Agreements

Amended and Restated Water Recycling Agreement Between Monterey Regional Water Pollution Control Agency and Monterey County Water Resources Agency (2015). References 1992 Agreement for implementing SVRP and CSIP, amended to allocate flows from Pure Water Monterey Project. https://www.montereyonewater.org/DocumentCenter/View/722/MCWRA-MRWPCA-Restated-Agreement-Draft-10615-for-website

MRWPCA-MPWMD Groundwater Replenishment Project Cost Sharing Agreement (2013). Amended in 2016 and 2017. Sets out terms and conditions between M1W, MPWMD, and Cal-Am for implementation of Pure Water Monterey project. https://www.mpwmd.net/asd/board/boardpacket/2016/20160718/11/Item-11-Exh-A.pdf

Agency Contacts

- Paul Sciuto, General Manager, Monterey One Water, paul@my1water.org
- Brent Buche, General Manager, Monterey County Water Resources Agency, bucheb@co.monterey.ca.us
- Dave Stoldt, General Manager, Monterey Peninsula Water Management District, dstoldt@mpwmd.net
- Brian Frus, Water, Waste, and Energy Manager, City of Salinas, brianf@ci.salinas.ca.us

CASE STUDY #5: GREATER LOS ANGELES AREA

Timeline	
1890-1950	**City of Los Angeles (City of LA)** builds Hyperion Treatment Plant to manage wastewater (1894). LA Aqueduct brings water from Owens Valley to Los Angeles (1913)**.**
	Los Angeles County Sanitation Districts (LACSD) created (1923). LACSD's **Joint Water Pollution Control Plant** constructed in Carson, California (1928).
	Metropolitan Water District of Southern California (Metropolitan) created to import water from the Colorado River (1928). Colorado Aqueduct completed (1941).
1950-1980	City of LA upgrades **Hyperion** wastewater treatment after years of deterioration (1950).
	Water Replenishment District of Southern California (WRD) formed to replenish and protect Central and West Coast Basin aquifers (1959).
	Metropolitan joins State Water Project to bring water from the northern Sierra Nevada Mountains to the Central Valley and Southern California (1960).
	WRD recharges **Montebello Forebay** aquifer with recycled water from **LACSD** Whittier Narrows treatment plant to replenish the Central Basin (1962).
1980-2000	City of Los Angeles reduces flows through the LA Aqueduct to help restore Mono Lake and mitigate dust pollution in the **Owens Valley** (1994 and 1999).
	Both City of Los Angeles and **Metropolitan** see additional constraints on imported water supplies via the State Water Project due to regulatory decisions for environmental protection.
	City of Los Angeles increases recycled water production at Hyperion, Donald C. Tillman, Terminal Island, and LA Glendale water reclamation plants (1980-2000). The City achieves full secondary treatment at the **Hyperion Water Reclamation Plant** (1998) but "toilet to tap" movement slows further expansion (2000).
	In the midst of a "100-year drought," City of LA conveys effluent from Hyperion to **West Basin Municipal Water District (WBMWD)** for **further treatment and reuse** (1991).
2000-2020	LACSD expands recycling programs at 10 inland treatment plants producing **90-100 MGD** for both non-potable reuse and groundwater recharge to achieves full secondary treatment at the Joint Water Pollution Control Plant (2002).
	WRD campaign **Water Independence Now (WIN)** commences with a goal of achieving groundwater replenishment self-reliance by 2019 (2003). WIN becomes **"WIN4All"** as WRD reaches negotiated agreement with area groundwater rights holders to free up 450,000 acre feet of additional storage space for recycled water and stormwater (2014).
	City of LA Mayor Garcetti sets goal of 50 percent reliance on local sources by 2024 (2014), increasing to 70 percent reliant on local sources by 2035 (2017). LASAN and LADWP partner in Hyperion 2035 and Operation NEXT projects to **recycle 100 percent of Hyperion effluent** by 2035 (2019).
	Metropolitan and LACSD evaluate feasibility of large-scale water recycling at LACSD's Joint Water Pollution Control Plant (2015) and open Regional Recycled Water Project (RRWP) Advanced Purification Center with 0.5 MGD demonstration project (2019).
2020-Present	Long term drought in the western U.S. leads to first ever Tier 1 shortage condition on Colorado River and second "drought of the century" in California in five years (2021).
	Metropolitan Board and LACSD build 0.5 MGD Advanced Purification Facility, and Metropolitan begins environmental review of 150 MGD **Regional Recycled Water Program** (2021).
	City of LA begins 1.5 MGD advanced reuse pilot project (2020) and starts environmental review of 217 MGD **Hyperion 2035** and **Operation NEXT** programs (2021).

Overview and Key Takeaways

The preceding case studies illustrate how diverse water agencies can collaborate to achieve something of greater value for the communities they serve than they can individually. They have very different physical settings, different regulatory and economic drivers compelling water reuse, and different operational challenges. What they all have in common, however, are individuals and groups of leaders who were able to imagine a greater good working together than they could accomplish alone. We close with an example of how leaders with vision can build on a history of successful reuse collaborations to create new projects of breathtaking scale and scope, with implications not just for the region but for the entire United States.

While California's history of competition over scarce water supplies is the stuff of lore ("Chinatown") and the source of a famously misattributed quote ("Whiskey is for drinking and water is for fighting"), in fact Southern California water agencies have a long tradition of collaborating to reuse water. Water recycling has been performed in the greater Los Angeles area since the early days of the practice. To cite just a few examples, in addition to the previously cited partnership between the OCWD and OC San (Introduction), both the City of Los Angeles and the Los Angeles County Sanitation Districts provide treated effluent for reuse to over a dozen area cities. To the east, the joint powers Santa Ana Water Project Authority (SAWPA) is currently implementing a plan to exchange recycled water for imported water flows among its five member agencies. To the south the City of San Diego "Pure Water" program is building a pathbreaking reservoir augmentation facility

Motivated by the mounting risk that climate change poses to a region already heavily dependent upon imported water, two globally significant programs are now taking shape that will affirm Southern California's place as the epicenter of recycled water progress. The City of Los Angeles has developed a plan to reuse 100 percent of the effluent that can be captured from its 450-MGD capacity Hyperion Water Reclamation Plant (Hyperion), which now averages 257 MGD due to successful conservation efforts. At the same time, the Metropolitan Water District of Southern California (Metropolitan) and the Los Angeles County Sanitation Districts (LACSD) are working together on a program to reuse 150 MGD from LACSD's largest treatment plant, which has an average daily flow of about 260 MGD.[7] Collectively these two programs will add over 350 MGD of recycled water to the region's water supplies, and both owe a debt to the vision and generosity of spirit of yet another agency—the Water Replenishment District of Southern California (WRD). Equally large to the City of LA in population served but lesser known than either Metropolitan or the City of LA, WRD's commitment to independence from imported water has enhanced the resilience of the entire region.

Key lessons include:

- Leaders who can see the greater regional good can help others realize their resilience dreams sooner than later. Leaders at the Water Replenishment District of Southern California (WRD) spent years negotiating with overlying groundwater pumpers to agree on letting others use their basin to store and stage water, allowing the City of Los Angeles to accelerate its plans to recycle 100 percent of its wastewater from the Hyperion treatment plant. Metropolitan Water District of Southern California realized that the region could recycle water from LA County Sanitation Districts' large coastal treatment plant if they stepped up to do it, so they did.
- Strategically developed regulations can enable bigger projects. A requirement to develop statewide standards for different types of potable reuse on a legislatively mandated timetable reassured water

[7] While this paper focuses on wastewater recycling, Los Angeles County voters recently approved $300 million per year for multi-benefit projects that capture and reuse stormwater, increase urban greening, protect water quality, and improve flood control all of which will further add to the region's resilience. (LA County, 2021). Combined with the recycling programs discussed here, they constitute one of the largest urban climate adaptation strategies in the nation.

reuse proponents that regulations for potable reuse projects would be available in a set timeframe which allowed them to begin planning projects. It also created a focused effort among agencies, regulators, and stakeholders with robust participation, including an expert panel. This inspired and enabled the development of two large projects that could integrate water supply and wastewater programs across a region serving 19 million people.

- **Collaboration isn't instantaneous—it is developed over time and lays a foundation for even more collaboration.** While not always in agreement on all things, water agencies in the greater Los Angeles area have a long history of collaborating with each other and with the environmental community and regulatory agencies. That created a supportive environment for taking the next big steps.
- **Existential threats have a way of sharpening the mind.** The greater Los Angeles area, like most of Southern California, is heavily dependent upon imported water sources that are subject to disruption from climate change, natural disaster, and increasing regulatory requirements. While not abandoning their imported water sources, Southern California leaders recognize the risks and have been rapidly developing resilience tools of conservation, stormwater capture, and water reuse for years, with events of the past few years accelerating the urgency of action.
- **Sometimes giving up power can get you more.** WRD realized that it would need to give up power and control over the mechanics of its groundwater basins to gain collective support for using their storage space for the greater good.

Bringing Water to LA

The greater Los Angeles metropolitan region of California is home to over 10 million people: more than 4 million reside in the City of Los Angeles proper (City of LA), while the rest live in more than 88 cities and unincorporated communities in Los Angeles County (LA County). Southern California as a whole has a population of 19 million, most of whom are served (directly or indirectly) by Metropolitan. The area is blessed with a temperate, Mediterranean climate but its burgeoning population currently relies upon water imported from hundreds of miles away. Over half of Southern California's water is imported from three distant sources: 1) the Colorado River, which crosses seven US states and Mexico; 2) the San Joaquin and Sacramento Rivers, via the State Water Project; and 3) the eastern side of the Sierra Nevada Mountains, via the Los Angeles Aqueduct.

Figure 17. Southern California Water Sources (Credit: LADWP Urban Water Management Plan 2010)

The largest wholesale water provider in the nation, the Metropolitan Water District of Southern California (Metropolitan) takes water from the first two supplies. The City of Los Angeles (City of LA) takes water from its own LA Aqueduct which brings water from the east side of the Sierra Nevada Mountains and from the San

Fernando Valley groundwater basin that it manages. What more it needs the City of LA must purchase from Metropolitan, and at times the City is 90 percent dependent upon imported water sources (Hagekhalil & Wiersema, 2016). Underlying both these agencies—in many respects literally—the Water Replenishment District of Southern California (WRD) manages the groundwater basins from which millions of LA area residents and businesses draw—and store—a portion of their water.

Metropolitan Water District of Southern California (Metropolitan)

- Established to construct Colorado Aqueduct (1928) and later to contract from the California State Water Project (1960)
- Directed by a 38-member board of directors, representing each of the district's 26 member agencies
- Annual Operating Budget: $1.9 billion
- Annual Capital Budget: $250 million
- $584 million for operations and maintenance
- $831 million for capital projects
- $176 million for purchased water

The Los Angeles Department of Water and Power (LADWP) serves as the City of LA's water utility, and Los Angeles Sanitation and Environment (LASAN) is the City of LA's sanitation agency, which is also responsible for solid waste and stormwater. In addition to serving the City of LA, LASAN handles wastewater on a contract basis for nearly thirty local agencies. Communities in LA County outside the city's limits receive water from a multitude of water supply agencies, but their wastewater service is largely provided by a confederation of 24 special districts that collectively manages wastewater and solid waste, the Los Angeles County Sanitation Districts (LACSD).

Metropolitan Water District of Southern California (Metropolitan) is a wholesaler and sells both untreated and treated imported water to its 26 member agencies. Not long after the City of LA built its aqueduct, Metropolitan was formed to bring water from the Colorado River to Southern California (based upon early work done by the City). 20+ years after the completion of the 242-mile Colorado Aqueduct in 1941, Metropolitan joined the State Water Project, which brings water from the northern Sierra Nevada Mountains to the Central Valley and Southern California urban and agricultural users. Metropolitan operates five large-scale drinking water plants, numerous reservoirs, and 830 miles of pipelines to deliver water to 26 member agencies that collectively serve over 19 million people, who rely on Metropolitan's imported water for over half their daily needs (Metropolitan, 2021b).

The Water Replenishment District of Southern California (WRD) was created in 1959 to reverse subsidence and overextraction of two large urban groundwater basins in Los Angeles County. It is the largest groundwater agency in California, responsible for replenishing two basins that cover 420 square miles. WRD provides half of the water relied upon by over 4 million people in 43 cities, including a portion of the City of Los Angeles. It is also charged with monitoring the quality of groundwater, which had long been a victim of industrial pollution as well as preventing seawater intrusion by recharging the basins with a combination of captured stormwater, desalted brackish water, imported water (from Metropolitan), and recycled water from several area wastewater facilities. In 2004 WRD formally committed to strive for "independence from imported water supplies" and in the subsequent decades it has shared both its vision and its basins with other utilities to increase water resilience in the entire region.

Water Replenishment District of Southern California (WRD)

- Created in 1959 to reverse subsidence and overextraction of LA County groundwater basins
- Governed by a five-member elected board
- Responsible for aquifers underlying 420 mi2 that provide 50% of the water relied upon by > 4 million people in 43 cities
- Annual Budget: $85 million
- Operating Budget: $70 million
- Capital Budget: $15 million

Two Grand Visions, One Big Idea

The City of LA's two-part reuse program, "Operation NEXT" and "Hyperion 2035," relies on the close cooperation between LASAN and LADWP. LASAN's role is to upgrade the treatment provided at the Hyperion plant to produce recycled water for indirect and/or direct potable reuse applications. Their part of the program (Hyperion 2035) has commenced with design of a 1.5 MGD pilot facility demonstrating the suitability of membrane bioreactors, reverse osmosis, ultraviolet disinfection, and advanced oxidation. Currently, the program's goal is to produce up to 217 MGD of advanced treated water suitable for groundwater replenishment at WRD and in the City's San Fernando Valley. Following treatment at the plant, LADWP (Operation NEXT) will take over responsibility for conveying the water for aquifer storage and higher levels of treatment (LADWP, 2021a) with the aim of eventually treating water to direct potable reuse standards at the City's drinking water treatment facilities in the North San Fernando Valley. The final location of advanced purification facilities and the allocation of responsibility may shift as the program evolves.

Figure 18. Water Replenishment District of Southern California Service Area (Source: WRD)

Just as ambitious, Metropolitan and LACSD's Regional Recycled Water Project (RRWP) is anticipated to provide an additional 150 MGD of recycled water for groundwater recharge (via both spreading and injection), industrial reuse, and eventually direct potable reuse. The recycled water will come from Metropolitan's partner agency, LACSD, which has operated its Joint Water Pollution Control Plant (JWPCP) for nearly a century. About 20 years ago the JWPCP was upgraded to provide full secondary treatment of wastewater. To produce water suitable for potable reuse, however, LACSD would need to add advanced treatment and disinfection for 150 MGD of effluent that Metropolitan would then convey to four large groundwater basins throughout Los Angeles and Orange Counties (Metropolitan, 2021a). Like Operation NEXT, future plans call for conveyance and more advanced treatment for integration directly into Metropolitan's considerable drinking water treatment and storage systems.

Both large programs build on partnerships and relationships with WRD. Long before the City of LA or Metropolitan began investing in reuse, WRD recognized the importance of recycled water to the Los Angeles area. In 1962, WRD and LACSD partnered to use secondary treated effluent from LACSD's Whittier Narrows treatment plant to recharge its Montebello Forebay to prevent seawater intrusion. Not only was recycled water less costly than imported water, but it was also less susceptible to curtailment during the periodic droughts that regularly reduced surface water supplies. Over time, WRD gradually increased the proportion of recycled water it added to the basin; today they regularly purchase 50,000 AFY of recycled water to recharge the groundwater basin through percolation and further treat for injection.

In 2003 WRD embarked on its Water Independence Now (WIN) campaign. Its goal was to become independent from imported supplies by replenishing the Central and West Coast Basins with local and recycled water. The program officially met its goal in 2019 with the dedication of the Albert Robles Center for Water Recycling and Environmental Learning, but the agency was not content to achieve self-sufficiency only within their own service area so in 2016 WRD expanded that program to make their groundwater basins available to other communities as well. To ensure the success of Water Independence Now—For All (WIN4All), WRD through then-General Manager Robb Whitaker led a multi-year negotiation with groundwater rights holders to allow the City of LA and others to use the excess capacity in the basins so they could have a secure and cost-effective place to store recycled water for future use.

Things got heated when some Central Basin pumpers figured that if WRD could make additional capacity available to others, perhaps they could sell it instead. As Whitaker recalled, "I see nothing wrong with [monetization], but we thought that the best use of the storage space was for the benefit of the entire region. WRD wasn't very altruistic in the beginning—we wanted full control of the use of the storage space—but we realized that if we all tried to get control of the biggest pieces for ourselves, we would not come to a consensus. We all had to put our desire for power aside if we wanted to make it work." (Whitaker, 2021). Whitaker's efforts were rewarded in 2014 with the creation of over 450,000 acre-feet of available storage to enhance the resilience of the entire region (WRD, 2021b). WRD's commitment allowed the Operation NEXT and Hyperion 2035 programs to commit to 100 percent recycling at Hyperion because Central Basin's aquifer is far closer than the City's own recharge facilities in the San Fernando Valley (which will also receive recycled water for recharge in future phases of the project). WRD also has significant involvement with LACSD and Metropolitan's projects including the RRWP.

Driven by Resilience: The LA Story

2021 may be the year that climate change came to the forefront of the national consciousness, or as one observer declared, "the year when the unimaginable became the unavoidable" (Brownstein, 2021) (Lustgarten, 2021). Over the past two decades local governments—more than their state or federal counterparts—have led the charge in adapting to climate change, and by the end of the century climate change may well drive local water agencies across the country to recycle water. Climate change affects agencies in various ways: drought and water shortage in some places, flooding and stranded infrastructure in others. The investments necessary to protect life and property, to provide water for sustenance and sanitation, and to protect groundwater from seawater intrusion will be enormous, but necessary.

Climate change and the water scarcity it will bring is an enormous motivating force, and a key to understanding the scale of the Los Angeles area projects. Since the drought of 1986-1992 the City of LA had already taken the lead in water conservation, stormwater capture, and water recycling. As evidence of the effectiveness of these projects, over the past 40 years LA's population has increased by 25 percent while its total water use decreased substantially (LASAN, 2021a). The same is true for Southern California as a whole (demands dropping 20 percent since 1990 despite a 30 percent rise in population). Nevertheless, the region remains extremely vulnerable to disruption of its imported water supplies. Even if the long straws that connect Southern California to its water holes to the north and east survive periodic earthquakes and wildfires, the longer and deeper Western droughts due to climate change could leave them empty far more often. With average temperatures rising, each spring will bring less winter snow, reducing the natural storage upon which the existing infrastructure relies.

LA Sanitation and Environment (LASAN)

- Department of the City of Los Angeles responsible for Solid Waste Resources, Clean Water and Watershed Protection programs
- Reports to the five-member Board of Public Works appointed by the mayor
- Collects, cleans, and recycles both solid and liquid waste generated by residential, commercial, and industrial users in the City of LA and surrounding communities
- Annual budget (Clean Water Program): $700 million
- O&M budget: $351 million
- Capital budget: $349 million

Whether it is specifically a lack of winter snowpack or a general lack of seasonal rains to replenish reservoirs, streams, and groundwater basins, the impacts of climate change threaten to upend Southern California's water supply, despite its advances in conservation and recycling (DWR, 2014). Faced with the same existential threat that a century earlier had prompted its civic leaders to bring water from Owens Valley, the Sierras, and the Rockies, in this era Southern California managers and leaders looked in their own backyard.

Bringing it All Back Home

LA Sanitation and Environment (LASAN) operates four water reclamation plants that serve over four million people, and currently treats an average of 321 MGD, out of a total capacity of

Agency Profile:

LA Department of Water & Power (LADWP)

- Established to deliver water (1902) and electricity (1916) to the City of LA
- Directed by a five-member Board of Water and Power Commissioners appointed by the Mayor
- Total annual budget: $1.59 billion
  - $584 million for O&M
  - $831 million for capital projects
  - $176 million for purchased water

580 MGD[8] (LASAN, 2021b). Of that amount, LASAN recycles 100 MGD or more, not all of which is currently reused. Approximately 35 MGD from the Hyperion plant is delivered to the West Basin Municipal Water District (WMBWD) where it is treated further for a variety of industrial uses and groundwater injection to prevent seawater intrusion (WBMWD, 2021). The other three treatment plants collectively produce an average of 56 MGD of recycled water used for landscape irrigation (Tillman Japanese Garden, golf courses and cemeteries); recreational impoundments (Lake Balboa); and environmental enhancement (Sepulveda Basin Wildlife Preserve). Effluent from these plants also constitutes the lion's share of the flow in the LA River, which supports habitat and wildlife. The impact of these flows has been so beneficial that recent proposals by LA and neighboring cities Burbank, Glendale, and Pasadena to increase reuse precipitated a study to determine optimal flow regimes to best balance water supply while protecting environmental beneficial uses.

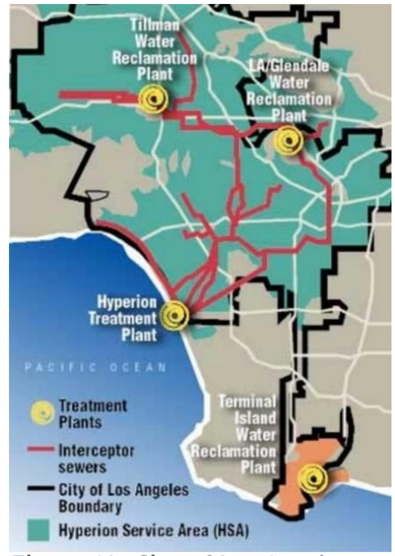


Figure 19. City of Los Angeles Wastewater Treatment and Collection System. (Source: City of Los Angeles)

One of the largest wastewater treatment plants in the United States, LA's Hyperion plant is the focus of the current effort. The Hyperion 2035 program will direct the plant's flow through a battery of advanced treatment processes rendering the effluent clean enough for groundwater injection and, potentially, for direct potable reuse after additional treatment. Hyperion has a suitably dramatic history to star in such a production. Once celebrated for advancing the cause of sanitation (In 1958 Aldous Huxley praised its ability to remove the "Malthusian flotsam and unspeakable jetsam" that once littered the public beaches) (Huxley, 2002), it repeatedly collapsed into disrepair before being reborn periodically as an advanced facility for its times. As related (in at least two versions of the story) by Sklar (2008) and Sharpsteen (2010), a period of decline in the 1980s led to a series of public battles in the media and the courts which pushed city officials to ink a consent decree with state and federal regulators mandating improvements to the facility. As the city went from garnering lawsuits to winning awards for its innovations, it increased its deliveries to WBMWD, which ran a portion of Hyperion's secondary effluent through no fewer than five distinct treatment trains to produce "designer water" for a variety of uses. Los Angeles leaders, however, were eager to recycle more of the Hyperion water for themselves.

Despite the success of its collaboration with WBMWD and its reuse at its other treatment plants, recycling water on a larger scale at Hyperion eluded the city. Like many coastal wastewater treatment plants, LASAN relies heavily on gravity to transport wastewater to the plant, and the expense of pumping that volume of water uphill where it could be used in large amounts was greater than the perceived benefit of reuse. Instead, the city focused on recycling wastewater treated at upstream facilities, but even then the cost of building separate pipeline systems for non-potable reuse rendered larger scale recycling seemingly out of reach.

The notion of reusing most of LASAN's wastewater got a boost in 2015 when the SWRCB promulgated statewide standards for groundwater replenishment. The challenge of widespread reuse was still daunting, given the expense of pumping water over 20 miles uphill from Hyperion to the city-managed groundwater basins in the San Fernando Valley (or even further north to LADWP's water filtration plants). But with the uncertainty of access to

---

[8] The capacity of the four plants is 580 MGD but conservation success has lowered the actual amount treated over the past two decades. The same dynamic is true for the LACSD system of 11 plants, who have a capacity of 600 mgd but are treating far less on average because of the far greater efficiency of fixtures, appliances, and public change in behaviors inside the home.

imported water rising and the region's survival potentially at stake, the concept of "a more droughtproof LA" began to gain traction.

In 2014, LA Mayor Eric Garcetti had announced an ambitious "water directive" to cut reliance on imported supplies by 50 percent by 2024 (later revised upward to require 70 percent reliance on local sources by 2035) through a combination of conservation, water recycling, stormwater capture, and cleanup of legacy groundwater contamination. (Hagekhalil & Wiersema, 2016)(Garcettti, 2019). In addition, once the value of WRD's WIN4All program became known, it suddenly became possible for the city to store a significant volume of advanced treated water much closer to the treatment plant. The prospect of potable reuse without underground storage was also made possible by the apparent progression of statewide standards for reservoir augmentation and eventual direct potable reuse (raw water and treated water augmentation). As LASAN's Chief Operating Officer Traci Minamide recalled, "Hyperion 2035 became reality when our mayor announced his goals for water recycling in LA's Green New Deal. The key factors for making this happen are WRD providing storage close to our Hyperion plant and state agencies moving forward with potable reuse regulations." (Minamide, 2021)

In February 2019, with LASAN's enthusiastic support, Mayor Garcetti formally announced the City's commitment to recycling 100 percent of the Hyperion's wastewater (Boxall, 2019). The project will bring Hyperion's reuse up to an estimated 217 MGD, adding to the City's already extensive non-potable reuse program and making it the largest potable recycled water project in the world. (Orange County Water District's Groundwater Replenishment System (GWRS) is currently the largest, treating up to 100 MGD, and expanding to 130 MGD (OCWD, 2021).

Operation NEXT and Hyperion 2035

The program to achieve 100 percent recycling at the Hyperion Water Reclamation Plant is called Hyperion 2035, and the distribution of that recycled water as well as future additional treatment is known as Operation NEXT. Hyperion 2035, led by LASAN out of the city's Department of Public Works (DPW), is responsible for upgrading the treatment plant to at least groundwater replenishment standards for potable reuse applications. Operation NEXT, led by LADWP, will handle the conveyance of water to the Central Basin for storage, and integration into LADWP's distribution system to local customers. Operation NEXT will also be responsible for conveying treated water in future phases to the San Fernando Valley (for groundwater recharge) and to more advanced treatment (for integration into the city's water system), eventually reaching 70 percent of the city's service area.[9] The program is operated cooperatively by the two city departments (LASAN and LADWP) which have separate governing boards and different organizational structures despite being within the same city. While historically having somewhat of a fractious relationship, at this stage the governance is collaborative, with relatively straightforward agreements and with successive agreements expected as each stage of the program proceeds over the next 10-15 years.

[9] For example, LADWP is currently developing a 1 mgd demonstration and education facility in the San Fernando Valley where they will treat tertiary polished effluent from LASAN's Los Angeles Glendale Water Reclamation Plant as a DPR Demonstration Project. The project is designed to test proven technologies and new approaches, to support the development of the state regulations, and to prove the public health and safety of DPR (Mouakkad, 2021).

The Power of Two: Metropolitan and LACSD Team Up on the Regional Recycled Water Project

Metropolitan: Diving into Reuse

The Metropolitan Water District of California (Metropolitan) was formed in 1928 to facilitate imports of water to Southern California, first from the Colorado River system, which spans seven western states, and years later (1960s) by importing water from the Northern Sierras via the State Water Project. Over the years, Metropolitan has supported its members' efforts to develop alternative water supplies (including recycled water, stormwater capture, and desalination) with grants from its Local Resources Program. Its primary role, however, has been as the protector and provider of imported water sources for its members' direct delivery to customers and for groundwater recharge.

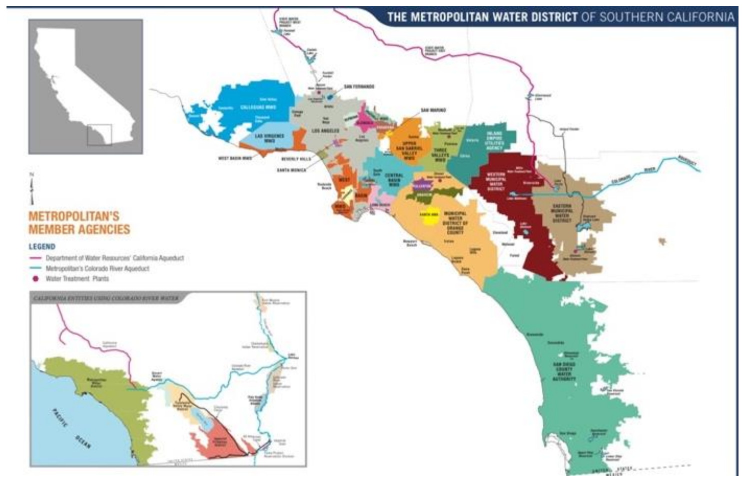


Figure 20. Metropolitan Water District member agencies (Credit: Metropolitan Water District)

> Metropolitan is well aware that the only way we're going to survive climate change and its challenges is by partnering together."
>
> *Jeff Kightlinger, Metropolitan (former GM, Metropolitan Water District)*

In the last decade, as it became increasingly evident that imported supplies were threatened, leadership at Metropolitan started looking more seriously at direct development of recycled water projects to support regional resilience. While many agencies took advantage of the Local Assistance Program, the total volume of water they recycled was not as great as they, or Metropolitan, had hoped. At the same time that available imported water supplies had dropped due to drought and increased environmental regulation, the development of new technologies for wastewater treatment and monitoring, combined with promulgation of progressive state standards for all forms of potable water reuse, made the idea of taking on a recycled water project at scale seem more feasible than before (Metropolitan, 2019). And it turned out that Metropolitan was well positioned physically and technically to serve significant volumes of recycled water to their member agencies for groundwater replenishment. Due to their size and resources Metropolitan could integrate advanced treated potable recycled water into their massive treatment, storage, and distribution system in a way that individual agencies could not. With the state standards in progress, "a regional path started to feel possible [with] a permitting path that would not have happened in a purple pipe framework." They also found great shared "sense of common purpose to pursue a world class project" with their LACSD partners (Upadyhay, 2020) (Metropolitan, 2019) (Metropolitan, 2015).

LACSD: Back to the Future

The Los Angeles County Sanitation Districts (LACSD) is a large regional wastewater collection and treatment agency serving over 5.5 million people in 78 cities and unincorporated areas within Los Angeles County. Formed in 1923 to treat the sewage and industrial waste discharged to the Pacific from the "phenomenal and unpredictable expansion" of Southern California after World War I (Rawn, 1965), LACSD was one of the earliest agencies to recycle water. Today, ten of its eleven wastewater facilities currently treat and deliver 90 MGD of recycled water

(Smith, 2021) to more than 830 sites for agricultural and landscape irrigation and industrial use, and WRD has been recharging its groundwater basins with LACSD recycled water since 1962 (Chalmers, et al., 2020). At this point only the largest of LACSD's facilities, the Joint Water Pollution Control Plant (JWPCP) does not provide water for reuse.

The JWPCP discharges full secondary treated effluent into the Pacific Ocean off the Palos Verdes Peninsula, treating an average of 260 MGD, with a capacity of 400 MGD. Lacking any specific regulatory driver pushing them to recycle water, the LACSD nevertheless wanted to make use of their treated wastewater by including their largest plant in their already extensive recycling program. Agency managers understood that ocean discharge standards would only become stricter in the future, and for the good of the region they could enhance reliability of a water supply already threatened by a variety of stressors. According to Robert C. Ferrante, Chief Engineer and General Manager of LACSD "the RRWP will bring about the full use of the treated wastewater from JWPCP. In this arid climate of Southern California, together with climate change, we cannot afford to waste any of our precious water resources." (Ferrante, 2021)

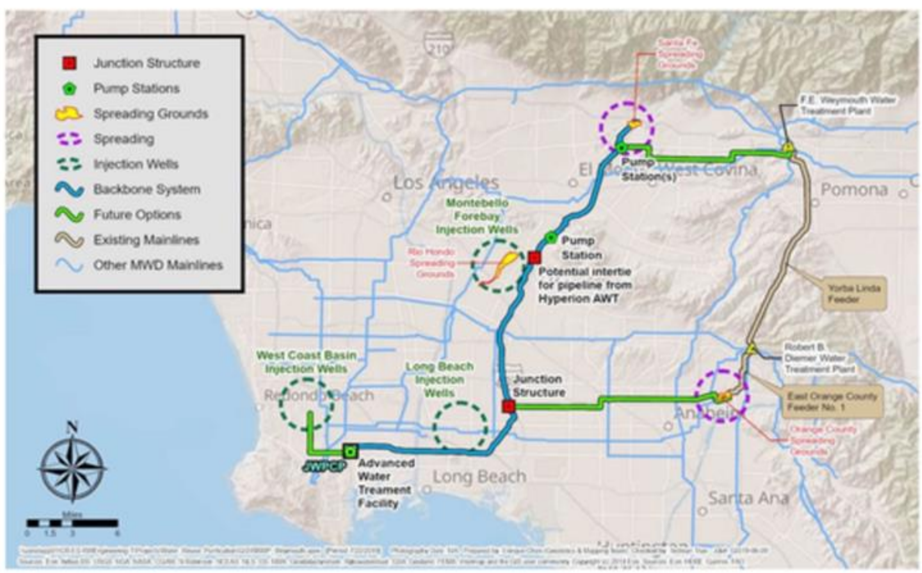
Sanitation Districts of Los Angeles County (LACSD)

- LACSD consists of 24 independent special districts covering about 850 mi.2 serving 78 cities and 5.6 million people in LA County
- Established to manage wastewater (1923) and solid waste (1950) for residents and businesses in LA county
- Annual Budget (wastewater): $627 million
  - O&M Budget: $247 million
  - Capital Budget: $180 million
- Water reuse: 135 mgd for groundwater recharge, irrigation, industrial use

Source: (LACSD, 2021a)

Regional Teamwork

In 2011 Metropolitan and LACSD began to discuss in earnest the possibility of a large-scale water reuse program that would build on their combined strengths. They conducted feasibility studies, and in 2015 they agreed to build a pilot project to demonstrate the efficacy of a treatment train that would enable the JWPCP to produce potable quality water. In 2019 they ratified a formal memorandum of understanding (MOU) to develop the 150 MGD (168 KAFY) Regional Recycled Water Project (RRWP) which would include a new advanced water treatment facility and a new regional conveyance system to deliver advanced treated water for groundwater recharge in four large groundwater basins throughout LA and Orange Counties (Metropolitan, 2019). The program is designed to be open to the



AWT—advanced water treatment, JWPCP—Joint Water Pollution Control Plant, MWD—Metropolitan Water District

The program covers a large geographic area and includes elements such as a new advanced water treatment facility, 60-mile pipeline, and pump stations.

Figure 21. LA County Sanitation Districts facilities. (Source: LACSD)

potential for even more advanced treatment for indirect and direct potable reuse through Metropolitan's enormous treatment and distribution system.

The RRWP Advanced Purification Center opened in 2019 treating 0.5 MGD of wastewater with an innovative application of membrane bioreactor that promises to save considerably on capital and operating costs. (Metropolitan, 2019). The Center also serves as an educational facility for the entire RRWP, even conducting virtual online tours during the current pandemic. WRD is also a key partner in this program through its existing interconnections and rights of way between the JWPCP and seawater intrusion barriers at the coast and spreading grounds along the route. One of the most interesting features of the RRWP from a scale and scope perspective is the inclusion of the Southern Nevada Water Authority (SNWA), the water supply and wastewater agency serving the Las Vegas, Nevada metropolitan area. Metropolitan is a key agency in negotiating the management of the Colorado River, which spans seven states and is governed at the federal level. The river, as noted earlier, is facing diminishing snowpack in its watershed and has been in a prolonged state of drought for nearly two decades.

A series of agreements have been reached in recent years on how to manage the shortages, such as the Drought Contingency Plan (DCP) prepared for water users of the Colorado River (NIDIS/NOAA, 2019). In August 2021, BOR declared a first ever "Tier 1 shortage" on the river, prompting a first level of cuts that apply largely to portions of Arizona (BOR, 2021) (Brulliard & Partlow, 2021). As droughts persist and Colorado River supplies dwindle, deliveries to Nevada and California users (including Metropolitan) will be reduced far more than they have been previously due simply to annual hydrologic variations or lesser shortage declarations. The new agreement between Metropolitan and the Southern Nevada Water Agency (SNWA) allows SNWA to participate in and help fund the programmatic environmental review for the RRWP and could lead to co-funding the RRWP in exchange for a portion of MWD's Colorado River water when available (Businesswire, 2020). Discussions along similar lines are also ongoing with representatives of the Central Arizona Project (CAP) (Smith, 2021).

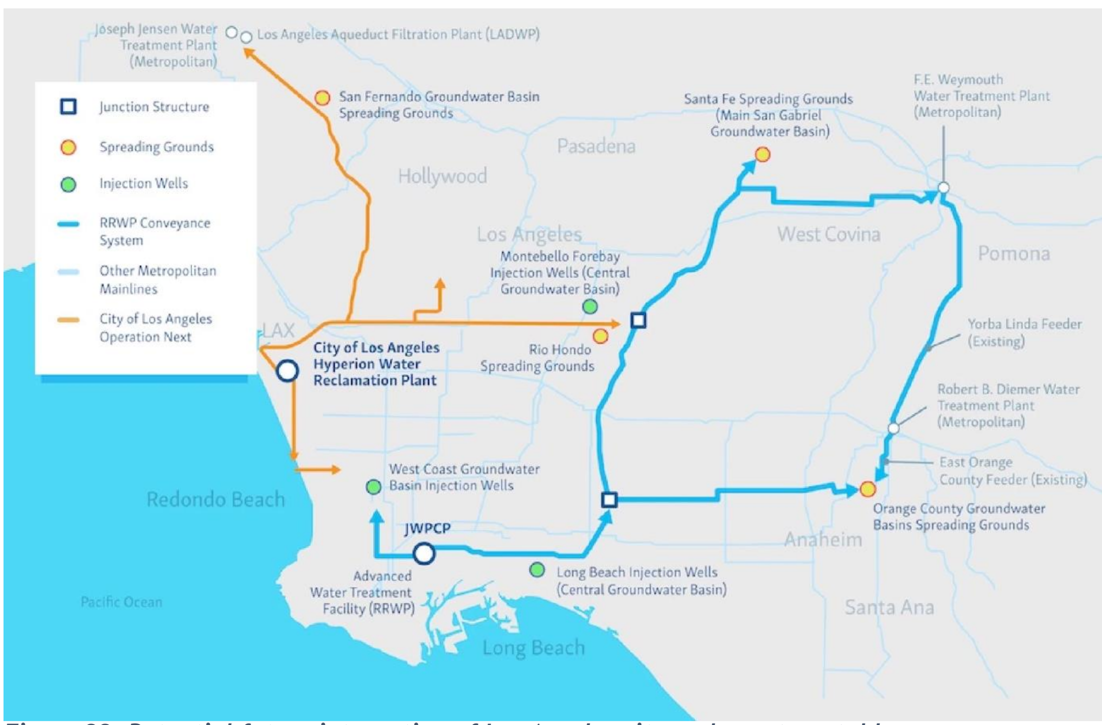


Figure 22. Potential future integration of Los Angeles city and county potable reuse programs (Smith, 2021)

As noted previously, both the RRWP and the City of LA's Hyperion 2035 and Operation NEXT programs are undergoing programmatic review over the next few years. Both involve Initial focus on groundwater replenishment for spreading or injection, with consideration of adding advanced conveyance and treatment to integrate into their larger drinking water treatment, storage, and distribution systems. (Metropolitan, 2019) (LADWP, 2021a). Together, these agencies are evaluating eventual connection of their two enormous system to create a regional "water grid" that would provide even greater resilience for this massive, populated area. (Chalmers, et al., 2020)

Area Insights

Governance

The relationship between LASAN and LADWP, as well as the partnership between Metropolitan and LACSD, is documented in a series of straightforward agreements allocating responsibility, ratified by their respective governing boards. LADWP also has a longstanding relationship with WRD as a member agency, and the two are developing an agreement to allow LADWP to store water from the Operation NEXT and Hyperion 2035 programs in the Central and West Coast groundwater basins. LACSD and WRD also have a history working together productively on groundwater recharge and seawater intrusion in the Central and West Coast Basins and many interconnected facilities, and LACSD and Metropolitan have for many years provided recycled and surface water respectively for groundwater recharge to many of the same local water agencies. This extensive history of working together, even in parallel, is a great help in forging new and expanded partnerships. This is especially important, because both Operation NEXT/Hyperion 2035 and the RRWP will have to navigate integration of the drinking water agency's oversight into the entirety of the recycled water production process.[10]

Regulations

Regulations Can Help Enable Bigger Projects

While regulations (and regulators) can hinder the speed or flexibility of recycled water projects, they can also help. In the early 2010s, a collaborative of water associations and individual agencies called for statewide standards, on a legislatively-set and therefore predictable schedule, for a range of indirect and direct potable reuse standards. The timetable and substance of those standards enabled large water and wastewater system operators to plan vastly larger projects to integrate advanced treated water into the water supply system, benefitting millions of Southern Californians and potentially water agencies in other states. Throughout this process water associations and agencies worked closely with regulators in a public process. Regulators from all local, state, and federal agencies have been brought in at the early stages of the projects as they are being shaped.[11]

Metropolitan's Board relied on this regulatory certainty to make the leap from being steward of imported water and supporting member agencies in their individual water reuse projects, to taking direct responsibility for developing a regional scale project. Similarly, the City of Los Angeles saw the opportunity to plan for groundwater replenishment (and eventually direct potable reuse) at scale because the new regulations allowed them to integrate recycled water into their overall water system. The regulations gave the City of LA, Metropolitan, and LACSD the confidence to move recycled water through their existing water distribution systems rather than building thousands of miles of expensive non-potable distribution pipelines. Knowing the state would "have their backs" in supporting the projects so long as they complied with well-defined regulations, the agencies could envision incorporating water reuse into their entire programs, sending recycled water to multiple locations for

[10] Under California's current draft framework for DPR regulation, the drinking water agency partner in a DPR project must be designated as the DiPRRA, or "Direct potable reuse responsible agency" (SWRCB, 2021).

[11] This is not to say that statewide rules are the only (or even the best) way to go. Customized and early engagement with regulators can work well in any individual permit context. The only point here is that in this case, it enabled the vision and planning for a greatly expanded set of programs and projects.

groundwater recharge and (eventually) to upstream drinking water treatment plants. With statewide regulatory requirements specified and a schedule set for their adoption, Southern California agencies did not have to guess what local permitting agencies might require, or how long they might wait to receive a permit. This is especially significant given the extensive areas their programs span which encompass multiple regional permitting offices.

Nor did Metropolitan and the City of LA sit idly by while SWRCB developed the new indirect and direct potable water reuse permit rules Sacramento. Both agencies were actively engaged in the regulatory development process through meetings and discussions and by virtue of their demonstration pilot project. The City of Los Angeles and LACSD are currently working with the Los Angeles Regional Water Quality Control Board to set conditions for discharge of treatment residuals through their NPDES permits. At the pilot plant located at their joint Advanced Purification Center, LACSD and Metropolitan are testing a unique membrane bioreactor application, and Hyperion 2035 is also developing a 1.5 MGD pilot plant to test advanced membrane technology. Operation NEXT is preparing a DPR demonstration facility in the San Fernando Valley to test technologies for direct potable reuse. Information from the facility will be available for review during the state's regulatory process, and the facility will also be used as a public education center. In addition, as their projects enter the Programmatic Environmental Impact Review stage both agencies are reaching out to regulators and to their stakeholder communities. The RRWP offers both virtual and in person tours of its demonstration facility, while the City has created a Technical Advisory Group for Hyperion 2035 and Operation NEXT that that will meet regularly through the development of the program, and includes academics, community members, and regional, state, and federal regulatory agencies.

Economics

The cost of these projects is estimated to run into the billions of dollars. The City of LA currently estimates at least $4 billion in capital costs for up to 217 MGD (243,000 AFY) of advanced treated water, and Metropolitan/LACSD estimates run up to $3.4 billion in capital costs for approximately 150 MGD. (168,000 AFY). Conveyance and additional treatment will add many billions more. On the other hand, considering the added benefit of greater reliability, these costs could compare favorably with projected future costs of imported water over time. WRD estimates that its reuse program has already saved its customers $570 million, relative to the alternative cost of purchasing imported water, in addition to being a locally reliable and resilient supply (WRD, 2021c).

When wild swings in hydrological variations due to climate change are added to the constant threat of earthquakes and other natural disasters, political leaders, and water all across the country are increasingly realizing that water recycling is the key to a sustainable future. While hard to put a price on, the value of preventing disruption of water supply has been quantified by existing research which has been instrumental in helping to make "the case for reuse" (Raucher, et al., 2013) (Raucher, et al., 2015). To further prove this point, the City of LA has commissioned the University of California Los Angeles (UCLA) Luskin Center for Innovation to provide a third-party assessment of the value of a more resilient and reliable water supply in the face of climate change, earthquake, or other interruption. The report is expected in late 2021 (Villegas, 2021).

The journey to 100 percent recycling at Hyperion became economically viable when the WRD groundwater storage negotiations allowed the City of LA to cut the cost of the project considerably by storing and staging deliveries of recycled water in their Central and West Coast Basin aquifers, which are far closer to the Hyperion Treatment Plant and LA's local water customers than LADWP'S own drinking water treatment facilities or the groundwater basins in the San Fernando Valley. Those more distant facilities may ultimately be used to take advantage of the City's larger gravity-fed water distribution system, but the closer basins allow the city to reuse water far sooner. In a similar vein, Metropolitan may reduce its costs if the early agreement with SNWA and its ongoing talks with the Central Arizona Project enable them to shoulder some of the expense of the RRWP in exchange for occasional use of some of the Colorado River water to which Metropolitan is entitled.

While still in the programmatic evaluation stages, the costs for the projects are being shared by the drinking water and wastewater agencies largely along the lines of their traditional roles. Wastewater agencies contribute an investment commensurate with their benefits (e.g., facilitated compliance with wastewater discharge requirements) as well as provide expertise and real estate for location of treatment facilities. The water supply partners pay for the upgrade to higher levels of recycled water and the distribution system. According to Operation NEXT Program Manager Rafael Villegas (2021),

> In terms of cost sharing, LADWP will actually be responsible for financing 100 percent of the program. It was a pretty easy call: Operation NEXT is a water supply program, so under the City Charter, it is purview of LADWP. LASAN is responsible for treating to discharge limits—for which they do a great job—so anything above and beyond discharge limits is water supply.

While costs and allocations will evolve over time, the collective interest and political leadership at the entities has not made the cost allocation a source of friction or delay to date for any of the programs.

"Economy of Scope" is as Broad as You Can Envision

The scale of the LA suite of projects is breathtaking due to the sheer volume of water being handled and the large land area that the multiple facilities and lengthy pipelines will encompass. Metropolitan and LACSD's joint RRWP program even crosses state lines over hundreds of miles to include other Colorado River users in upstream states, potentially easing scarcity for them while building resilience at home. But the scale of the programs should not obscure that they share with other case studies the virtue of expanding the value of the solution by increasing the complexity of the problem.

Taking on large-scale projects like these always entails risk, as inevitably agencies are required to stretch beyond their traditional responsibilities. When Monterey One Water accepted agricultural wastewater from the City of Salinas to augment their recycled water supply—taking runoff from the fields and water used to clean bagged salad greens to help bridge the divide between agricultural and urban water users—they no longer defined their mission as limited to treating municipal wastewater. Similarly, when Hampton Roads' assumed responsibility for issues historically dealt with by separate agencies (wastewater discharge, stormwater requirements, groundwater pumping rules), they saw the advantage of addressing disparate problems with a single, comprehensive, regional solution.

What inspires leaders to take on this difficult task often boils down to a sense of responsibility for the community as a whole. In this case, the negotiations WRD successfully concluded to make their groundwater basin available for large-scale storage was far more difficult and complex than related here. But as WRD's Robb Whitaker (2021) recounted, he was motivated to accept that challenge simply because of the tremendous benefits it would unlock:

> At the beginning of the negotiations, I told our Board of Directors – 'This is it. This single effort will be the key to creating a locally sustainable water supply for our region—for the 4 million residents of 43 cities in southern Los Angeles County.' That kept me motivated from the start of the groundwater storage discussions in 1999 through the final resolution of those efforts in 2014, through 15 years filled with much acrimony with occasional flashes of goodwill. Gladly, for our region, goodwill finally won out.

Overall, the projects currently on the drawing board in Southern California underscore the lessons of successful water reuse collaborations around the country, many of which have been catalyzed by a single agency willing to extend itself for the benefit of the community at large. WRD's role as a regional entity (like HRSD's position in Eastern Virginia) allowed it to play a pivotal part in facilitating Southern California water reuse when they convinced others using the groundwater basin to provide up to 450,000 acre feet of storage to LA, LACSD, Metropolitan and others in addition to themselves. A remarkable example of vision and persistence, to Whitaker it was a simple decision:

> For me, it was a simple supply and demand issue. Our region still had substantial amounts of recycled water being released to the ocean without being reused. Our region also had substantial amounts of underground storage capacity in our two groundwater basins. Utilizing these unused resources together by advanced treatment of the recycled water and injection of that water into the empty storage space in our groundwater basins would create a new and locally sustainable groundwater supply. Together, the amount of unused recycled water and the amount of unused groundwater storage space was more than enough to provide for the entire water demand in southern Los Angeles County, completely eliminating our region's demand for imported water." (Whitaker, 2021)

Management

The interagency agreements for both projects, which will ultimately define the operational and managerial roles of the various partner agencies, are still at a relatively early stage of development. Of special importance will be their ability to identify all the key parties involved in their operation. Operation NEXT must work closely with WRD, while the RRWP must align their flows with other groundwater basin managers, especially the Main San Gabriel Basin Watermaster and Metropolitan's member agencies. Also, the agreements should address the potential for connecting and further integrating these systems (City of LA and Metropolitan/LACSD) in the future.

The ultimate success of the City of LA's reuse program rests on its ability to coordinate with WRD operations. As noted by Operation NEXT's Rafael Villegas (2021):

> The program doesn't work without groundwater storage. It will be difficult to manage the block flow coming out of Hyperion; we need a way to modulate flows so they match the demand. WRD will play a crucial role in this regard. They manage two large groundwater basins close to Hyperion, so these basins will essentially represent the first phase of the program. We hope to phase Operation NEXT in such a way where we can start producing water when the pipeline has reached predetermined offramps, or buckets.

While the scope and scale of the RRWP and the Operation NEXT and Hyperion 2035 programs are enormous in their own right, the agencies involved have all considered the possibility of connecting them into a "virtual water grid" covering all of Southern California in the future (Figure 20). Should that come to pass, it will be in large part due to the successful collaborations pioneered in earlier reuse programs which are today being developed into the relationships that underpin these mammoth projects.

Leadership

At heart, every successful recycling project is a story of leadership, involving individuals with vision who could see beyond their organizational boundaries and narrow missions, historic achievements, current needs, and comfort. In Southern California, the projects build on an already impressive history of recycling success to reach for the stars and rely on both individual and community leadership.

In the City of LA, the Hyperion Water Reclamation Plant's evolution became the centerpiece of a significant relationship between the City and the environmental community that led to several environmental initiatives and laid the foundation for the drive to recycle 100 percent of the City's wastewater. Mayor Garcetti's water directive was the culmination of decades of engagement; Metropolitan and LACSD's transitions were less visible but their leaders were equally driven by the needs of the community.

Sometimes "leadership" is just doing the right thing because you can.

The preceding case studies provide multiple instances of individuals and agencies stepping beyond their narrow notions of self-interest or "job responsibilities" for the greater good. In many cases there is a logical or significant benefit that accrues to them from that action in an institutional sense. In others, they just thought it was the "right thing to do" (e.g., HRSD providing nutrient credits to the neighboring communities). In the present case, as noted, LACSD was under no political or regulatory pressure to join Metropolitan in undertaking regional reuse. Showing the same initiative they demonstrated when they pioneered water reuse the 1960's, they determined that enhancing community resilience was "the right thing to do." As Robb Whitaker (2021) put it,

> Los Angeles County Sanitation District is truly the pioneer of indirect potable reuse in our region. The Whittier Narrows Water Reclamation Plant was the first recycled water facility built for the purpose of treating recycled water for groundwater recharge through surface percolation.

Sometimes "leadership" is seeing around the bend—and the next bend

A key feature of the leadership demonstrated by these Southern California agencies is their willingness to look at the long-term needs of their communities. In Los Angeles, Mayor Garcetti decided that incremental steps would not provide Los Angeles with a water-secure future. His 2014 "Water Directive" to reduce dependence upon imported water would require LA residents to vastly expand their already impressive conservation, recycling, and stormwater capture programs at tremendous cost. His direction galvanized LA water managers to focus on recovering Hyperion's massive volume, which could meet 35 percent of the City's total water supply needs. As Richard Harasick (2021), former head of LADWP's water system, put it:

> Recycling at this scale is necessary because it matches the scale of the challenge. Quite simply, our current sources of water are not sustainable in the long run. And like Mulholland over 100 years ago, we needed to look for what that next source would be that would allow Los Angeles to thrive—a source to match the scale of Los Angeles itself.

Metropolitan's decision to step into the direct recycling arena, while not attributable to any one person, is an enormous shift for a wholesale agency traditionally focused on imported water. And, to bring the story full circle, all of these projects build upon the pioneering vision of the Orange County agencies, whose historic collaboration has led the way for the rest of the country for the past fifty years.

Referenced Agreements

Memorandum of Understanding Between the Los Angeles Department of Water and Power and the Los Angeles Department of Public Works Bureau of Sanitation Regarding the Development of Recycled Water from the Hyperion Water Reclamation Plant (2019)

https://cityclerk.lacity.org/CouncilAgenda/AttachmentViewer.ashx?AttachmentID=111172&ItemID=110236

Regional Recycled Water Program Agreement between Metropolitan and LACSD (2015) and First Amendment (2020) https://www.mwdh2o.com/media/18199/lacsd_loi_amendment.pdf

Agency Contacts

- Traci Minamide, Chief Operating Officer, LASAN, traci.minamide@lacity.org
- Paul Liu, Manager, Water Recycling Policy, Groundwater Rights, and Resource Management Section, Water Resources Division, LADWP, paul.liu@ladwp.com
- R. Bruce Chalmers, Regional Recycled Water Engineering Services Group Program Manager, Metropolitan, RChalmers@mwdh2o.com
- Martha Tremblay, Department Head, Technical Services, LACSD, MTremblay@lacsd.org
- Robert Whitaker, General Manager (ret'd.), WRD, robb.whitaker@gmail.com

LESSONS LEARNED, QUESTIONS AND EXERCISES

In addition to a variety of advice from reuse practitioners around the country, this section offers questions that will help orient agencies interested in working together to implement water reuse projects, as well as some exercises to help focus on issues critical to successful collaboration.

Lessons Learned

The following is a summary by topic area of the key "lessons learned" identified in the framework and the case studies in this report:

Governance

1. Water utilities were created to solve problems in a specific time and place, but their problems evolve faster than their governance structures. *(Framework)*

2. Water, wastewater, and stormwater agencies work together best when they each recognize how their goals intersect and how water reuse supports their missions. *(Framework)*

3. Legal structures, from agreements to joint authorities, can be used to formalize agency partnerships. *(Framework)*

4. Acknowledge how the stated missions, constituencies, and governance and funding structures varies between partner agencies. Knowing something of an agency's history---when and why it was created, milestone events—can help potential partners better understand the point of view of prospective partners. *(Case Studies)*

5. Identify how your agency's mission intersects with other water, wastewater, and stormwater water authorities in the Recitals section ("Whereas…") of agreements. "Growing the problem" may lead to more complex governance structures but can do more for the community all agencies serve. *(Case Studies)*

6. A variety of legal instruments from simple bilateral agreements to the formation of joint power authorities can all be used to document, formalize, and ultimately institutionalize agency partnerships. There's not one best way to organize multi-agency collaboratives. Transparency and early agreements on accountability to each other can enhance collaboration. *(Case Studies)*

Regulations

1. Successful projects engage with regulators early on—during the development of regulations so the adopted rules are consistent with their practices, and during the development of their projects to see that they comply with regulations. *(Framework)*

2. Early and ongoing communication between water agencies and regulators is both possible and advisable and leads to easier project design and delivery. *(Case Studies)*

3. Do a thorough survey of the complete regulatory landscape early in the process as it can help design projects that can meet multiple objectives with less transaction cost later. *(Case Studies)*

4. Strategic regulation can enable projects; investment in helping to develop regulations can enable strategic regulation. *(Case Studies)*

Economics

1. Clearly articulate all the important benefits to be enjoyed by your communities, the environment, regional businesses, and your utilities. *(Framework)*

a. *Describe, Quantify, and Monetize.* Describe, quantify and (to the extent reasonably credible and feasible) monetize the benefits important to your communities and utilities.

b. *Include TBL Benefits.* Triple bottom line (TBL) benefits often include significant avoided costs for utilities (and your customers), increased regional water supply reliability, environmental support, and quality of life enhancements

c. *Communicate*. Communicate broadly, consistently, and effectively all the important benefits your reuse project will provide your communities and utilities.

d. *Anticipate Critics.* Be prepared to address what may appear as a high unit cost per volume of reuse water produced or sold. Compare reuse costs to other new water supply enhancement options (not to what it cost in the *past* to provide water) – reuse often is cost-effective compared to other potential future supply options

e. *Provide Subsidies.* For nonpotable reuse, recognize that sales revenues are unlikely to fully recover costs (e.g., pricing reuse at less than your current potable rate, to build demand for the reuse water). Anticipate the need for a cross subsidy for nonpotable reuse (e.g., from potable customers).

f. *Remember the Benefits.* Keep the array of reuse benefits in mind – the benefits may well justify what appears as a relatively high cost.

2. Consider a "beneficiary pays" approach for allocating reuse costs across utilities, and across utility customers. *(Case Studies)*

   a. *Align Benefits and Payments.* Align who benefits (and by how much) with who pays. For example, potable system customers typically benefit from nonpotable reuse programs offsetting potable demands, so a cross subsidy borne by potable customers is often justified.

   b. *See Things from the Ratepayers' Perspective.* Recognize that collaborating utilities often serve the same set of customers – "different pocket, same pants."

   c. *Explore Grants.* Explore how collaborative approaches may expand opportunities for grants and advantageous financing.

Management

1. When assigning responsibilities for collaborative reuse projects, consider availability of resources and agency expertise in addition to jurisdictional boundaries. *(Framework)*
2. Joint reuse projects provide utility operators and opportunity to develop new skills. *(Framework)*
3. Accurate, verifiable information builds confidence between partner agencies. Ensure that project data (including costs) are collected in a mutually agreeable manner. *(Framework)*
4. Building and running a recycled water utility involves many different tasks, and some agencies are more suited to some than others. Figure out what the critical jobs are, and who's best suited to them, to save money and add efficiency in the long run. *(Case Studies)*
5. Develop a mutually acceptable process for gathering and reporting project information (including costs and revenues) to ensure transparency and build trust. *(Case Studies)*
6. Joint pilot projects help staff from different organizations learn to work together and set the stage for further collaboration managing full-scale facilities. *(Case Studies)*

Leadership

1. Climate change and population growth contribute to a future of "permanent whitewater" requiring collaborative strategies that build resilience. *(Framework)*
2. Managers who can identify future challenges and understand the "economy of scope" lead people out of their silos by showing how reuse supports their multiple missions. *(Framework)*
3. When planning for a resilient future, there can be no fixed presumptions, other than change will be constant. *(Case Studies)*
4. The most successful water reuse projects demonstrate support for leadership at the individual and organizational level. *(Case Studies)*
5. When utilities and agencies set goals together, they increase the likelihood of successful implementation by embracing shared accountability and responsibility for the process. *(Case Studies)*
6. In order for a vision to be embraced by multiple stakeholders, the leader or champion, must be able to convey the benefits and potential of the vision in such a way that others are compelled to adopt and follow. *(Case Studies)*

Questions and Exercises

The following questions and exercises are designed to help agency managers and other interested parties clarify their common interests, identify potential challenges, and find solutions to support successful multi-agency collaborations.

Governance

1. When were your agencies created, and for what purpose(s)? How do these purposes overlap, and how do they diverge?
2. What challenges do you now face that were not anticipated in your original charters?
3. What common issues have you faced in the past, and how did you work together to resolve them? On what issues have you taken opposing positions, and why?
4. What types of legal structures (agreements, contracts, JPAs) have you executed between your agencies in the past, and which ones have been most successful? Which ones are still current? Which ones are easier to implement in your jurisdiction?

Regulations

1. Call your regulators to discuss your project—don't just seek clarification, enlist their support in helping advance your community goals.
2. Identify all the regulations that are applicable to your project. What are you confused about? What are you concerned about? Don't suffer in silence or defer to consultants who benefit from discord or complexity—ask questions of regulators directly.
3. Consider how to expand or adjust your project to make it meet multiple community goals based upon a collection of regulatory requirements.
4. Identify all the stakeholders in the regulatory process. They can help you succeed through the process or slow your process down. Be sure to include:
   - Local officials
   - Neighbors

- Agency attorneys
- Consultants
- Environmental or other community activists
- The regulators, or other agencies who may not directly regulate you but who could lend credibility to the project.

5. Have you looked "upstream" in the regulatory process and considered possible revisions or adjustments/applications of the regulations to facilitate the project? New regulations that would give you certainty and state backing for recycled water use?
6. Have you called your regulators yet?

Economics

1. Articulate benefits. You are pursuing your reuse project for several good reasons, so clearly articulate all the important benefits to be enjoyed by your communities, the environment, regional businesses, and your utilities, including environmental and social benefits.
2. What were the main objectives for developing your reuse program, and what important benefits has it (will it) provide the communities/customers you serve?
3. How did your collaborative reuse program/project address "who pays, how much, for what" issues across the engaged utilities and your respective ratepayers?
4. What financial and economic advantages did your collaborative approach for reuse provide, such as by reducing/avoiding costs, generating benefits for your customers/ communities, and/or securing grants/better financing?

Management

1. Ask each participating agency to list their priority management and operational concerns. At a minimum, consider the issues discussed in the Management and Operations section of the Analytical Framework related to water production, supply, and reliability (listed in Table 5). Compare lists and identify key concerns. Discuss which agencies are most able to respond to the issues in question and develop a response plan accordingly.
2. Reviewing a list of the operational and maintenance responsibilities associated with the project, which tasks are currently performed by each agency? Which tasks require additional training or certification?
3. With respect to the quantity and quality of recycled water delivered by the project, what criteria (e.g., peak flow, TDS, etc.) are critical to the project's success? What instrumentation and controls are required to ensure that they stay within the optimum range?

Leadership

1. How is leadership development currently supported within your agency? Where are the opportunities to enhance individual and organizational capacity?
2. When do you meet with your peers in other agencies on an informal basis? Has this contributed to building trust among the partners? Do you foster such collaboration outside your organization at different levels of your organization?
3. What can you do differently by looking at your community's needs as a whole through collaboration with other agencies? Can you be a community leader as an organization through partnering with others?

4. Are you really sincere about working across organizational divides? Put aside the time to understand your partners' culture and needs to create a relationship that will help your community thrive and avoid misunderstanding.

AREAS FOR FURTHER RESEARCH

During the course of developing a framework for evaluating interagency cooperation and assembling the detailed case studies presented in this report we discovered a number of additional questions related to how utilities can work more effectively together. These questions included the following:

- How do interagency issues differ with the type of reuse (e.g., onsite or stormwater reuse)?
- Are different collaborative strategies appropriate when developing agreements between agencies of different sizes?
- Are there regulatory streamlining programs that are more effective in facilitating the implementation of reuse projects?
- What types of funding mechanisms are most amenable to multi-agency projects?
- Are different strategies and styles of interagency collaboration more successful in different regions of the country?
- How do organizations led by a charismatic leader continue to implement their projects when the individual is no longer involved?

To answer these questions, building on the understanding developed to date, we identified the following research topics that will add to our capacity to create multi-agency water reuse programs:

1. A review of **successful multi-agency stormwater capture and reuse projects** will provide insight into how this important resource can be developed further in the future.
2. A study of the full range of **direct and indirect community benefits** provided by different types of reuse projects to demonstrate the ability of agencies to justify funding of multi-agency programs.
3. An evaluation of **projects with various funding sources** to determine whether different financing methods may facilitate interagency collaboration.
4. Analysis of **agreements between agencies of different sizes** will shed further light on how large regional utilities can work effectively with more locally focused utilities.
5. Additional **case studies from other parts of the country** may add to our appreciation of the regional nature of water reuse and help clarify which issues may be more critical depending on the different motivations for using recycled water.
6. **A study of unsuccessful collaborations** may also reveal certain “fatal flaws” to be avoided in developing partnerships. How were these issues handled differently by successful programs? What agreements were used to help support their continued cooperation?

REFERENCES

9VAC25-410-10, 2020. Virginia Administrative Code TItle 9. Environment Agency 25. State Water Control Board Chapter 410 Occoquan Policy, Richmond: State of Virginia.

ANCR, 2020. *Community Reslience Benchmarks,* s.l.: Alliance for National & Community Resilience (ANCR).

Arizona Administrative Code, 2021. Title 18, Ch. 9 Arizona Administrative Code Article 7. Use of Recycled Water. Phoenix AZ: State of Arizona.

ASU, 2021. *Workforce and Demographics.* [Online]
Available at: https://mapazdashboard.arizona.edu/workforce-demographics/population-profile
[Accessed 22 April 2021].

AWK, 2020. *Annual Report,* Camden, NJ: American Water Works Company, Inc..

AWWA, 2017. Manual of Water Supply Practice M1--Principles of Water Rates, Fees, and Charges. Denver CO: American Water Works Association (AWWA).

AWWA, 2019. *Water Reuse Cost Allocation and Pricing Survey,* Denver: American Water Works Association (AWWA).

Bailey, R., 2021. *Personal Communication* [Interview] (20 July 2021).

Barrows, H. & Luther, I., 1893. Chapter XXIV The Pacific Improvement Company. In: *Memorial and Biographical History of the Coast Counties of Central California.* Chicago: Lewis Publishing, p. 446.

Benvenisti, E., 2005. The Legal Framework of Joint Management Institutions for Transboundary Wter Resource: Ancient Practices Informing Contemporary Regional Cooperation. In: P. M. Schmitz, ed. *Water and Sustainable Development.* Frankfurt Am Main: Peter Lang, pp. 21-59.

Beutler, L., 2008. Water Agency Roles and Responsibilities from 2005 California Water Plan, Sacramento: California State University (CSU).

Bielefeldt, A. R., Summers, R. S. & Relph, T., 2012. TEC Project Report: National inventory of regional collaboration mong water and wastewater utilities, s.l.: s.n.

Blomquist, W., 1992. *Dividing the Waters: Governing Groundwater in Southern California.* San Francisco: Center for Self-Governance Press.

Blomquist, W. & Schlager, E., 1999. Watershed Management from the Ground Up: Political Science and the Explanation of Regional Governance Arrangements. Atlanta, American Political Science Association.

Blue Ribbon Committee, 2011. *Report of the Blue Ribbon Committee,* s.l.: Metropolitan Water District of Southern Califonia (MWD).

BOR, 2021. Draft Annual Operating Plan for Coloardo River Reservoirs, 2022, s.l.: US Department of Interior.

Bott, C. B., 2014. Advances in Point Source Nutrient Removal Technologies: Doing more with less…, Oakland: BACWA.

Boxall, B., 2019. L.A.'s ambitious goal: Recycle all of the city’s sewage into drinkable water. *LA Times*, 22 February.

Brown and Caldwell, 2017. *Bay Area Regional Reliability Drought Contingency Plan,* Walnut Creek (CA): Bay Area Regional Reliability Program (BARR).

Browning, R. M., 2006. Our Family Album: A History of the Trinity River Wastewater Treatment Plants. s.l., Water Environment Foundation, p. p. 3118. .

Brown, P. R. & Trussell, R. S., 2018. Moral dimensions of resilience in integrated urban systems: surprised by the expected.. *H2Open Journal,* 1 December, 1(2), pp. 169-178.

Brownstein, R., 2021. The Unbearable Summer. *The Atlantic*, 26 August.

Brulliard, K. & Partlow, J., 2021. First-ever water shortage declared on the Colorado River, triggering water cuts for some states in the West. *Washington Post*, 16 August.

Buche, B., 2021. *Personal Communication* [Interview] (7 July 2021).

Burn, S., Maheepala, S. & Sharma, A., 2012. Utilising integrated urban water management to assess the viability of decentralised water solutions.. *Water Science and Technology,* pp. 113-121.

Businesswire, 2020. MWD, SNWA Collaborate to Explore Development of Recycled Water Project: Supply augmentation project could improve Colorado River sustainability. *Businesswire*, 9 December.

Cantor, A., Sherman, L., Milman, A. & Kiparsky, M., 2021. Regulators and utility managers agree about barriers and opportunities for innovation in the municipal wastewater sector. *Environmental Research Communications,* 3(3).

Cantu, C., 2015. People, Resources, and Policy in Integrated Water Resource Management. In: *Sustainable Water: Challenges and Solutions from California.* Berkeley: University of California Press, pp. 201-219.

Cantu, C., 2015. People, Resources, and Policy in Integrated Water Resource Management. In: *Sustainable Water: Challenges and Solutions from California.* Berkeley: University of California Press, pp. 201-219.

Carpenter, G. et al., 2008. Water Reuse Rates and Charges: 2000 and 2007 Survey Results (Prepared by Water Reuse Committee), Denver, CO: AWWA.

CCWD, 2017. Water Management Plan: Report to USBR on CCWD's Water Conservation Program and Activities, Concord, CA: Contra Costa Water District .

Chalmers, R. B., Trembay, M. & Soni, R., 2020. A New Water Source for Southern California: the Regional Recycled Water Program. *Journal AWWA,* 112(12).

Chesapeake Bay Program, 2021. *Early History and Formation of the Chesapeake Bay Program.* [Online] Available at: https://www.chesapeakebay.net/who/bay_program_history [Accessed 11 July 2021].

Chesnutt, T., 2021. The economics of sustainable industrial water use, reuse, and the value of water.. In: C. K. Davis & E. Rosenblum, eds. *Sustainable Industrial Water Use: Perspectives, Incentives, and Tools.* London: IWA Publishing, pp. 199-205.

City of Dallas, 2007. The Path to 2060: The Lake Palestine Connection. Dallas(TX): s.n.

City of Dallas, 2008. The Path to 2060: Dallas' Water Plan Update Reuse Partnership with North Texas Municipal Water District, Dallas, TX: Dallas Water Utilities.

City of Dallas, 2020a. *Dallas Water Utilities Fact Sheet.* [Online] Available at: https://dallascityhall.com/departments/waterutilities/DCH%20Documents/pdf/DWU-

FactSheet.pdf
[Accessed 13 September 2021].

City of Dallas, 2020b. *Annual Budget: Fiscal Year 2020-21.* [Online]
Available at: https://dallascityhall.com/departments/budget/financialtransparency/AnnualBudget/2021-00-Adopted-Budget.pdf
[Accessed 13 September 2021].

City of LA, 2020. 2020-2021 City of Los Angeles Annual Budget, Los Angeles: s.n.

City of Tucson and County of Pima, 1979. *Intergovernmental Agreement.* Tucson: Pima County.

City of Tucson and County of Pima, 2000. Supplemental Intergovernmental Agreement Related to Effluent. Tucson: Pima County.

Clayton, F., 2021. *The Southwest Offers Blueprints for the Future of Wastewater Reuse.* [Online]
Available at: https://truthout.org/articles/the-southwest-offers-blueprints-for-the-future-of-wastewater-reuse/
[Accessed 25 April 2021].

Clingenpeel, G., 2020. *Personal Communication* [Interview] (25 May 2020).

Cohen, A. & Davidson, S., 2011. The Watershed Approach: Challenges, Antecedents, and the Transition from Technical Tool to Governance Unit. *Water Alternatives,* 4(1), pp. 1-14.

Collins, H. & Tremblay, M., 2018. Regional Recycled Water Program: Developing a new source of water for Southern California. Los Angeles(CA): s.n.

Cook, T. D. & Buetler, C. S., 1978. *Soil survey of Monterey County, California,* Washington DC: Soil Conservation Service.

Cooley, H., Shimabaku, M., Wilkinson, R. & Bradford, M., 2018. *Moving Toward a Multi-Benefit Approach for Water Management,* Oakland: Pacific Institute.

COV 62.1 Ch. 26 , 2019. *Potomac Aquifer Recharge Monitoring.* Richmond(VA): Code of Virginia.

CPUC, 2014. *Decision 14-08-058. CPUC Rulemaking 10-11-014 (August 29, 2014),* Sacramento, CA: California Public Utiltiies Commission.

CPUC, 2018. PROPOSED DECISION OF ALJS HAGA, HOUCK, AND WEATHERFORD APPROVING A MODIFIED MONTEREY PENINSULA WATER SUPPLY PROJECT, ADOPTING SETTLEMENT AGREEMENTS, ISSUING CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY AND CERTIFYING COMBINED ENVIRONMENTAL REPORT, Sacramento, CA: CPUS.

Cristiano, T. & Henderson, J., 2009. Evaluating Pricing Levels and Structures to Support Reclaimed Water Systems (Project 05-01), Denver, CO: WateReuse Research Foundation.

CUWA, 2016. *Potable Reuse Operator Certification White Paper,* Walnut Creek: California Urban Water Agencies.

CWFCG, 2017. *California Interagency Mobilization Guide 2017.* [Online]
Available at: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd540996.pdf
[Accessed 15 December 2020].

Daley, D. M., 2008. Interdisciplinary Problems and Agency Boundaries: Exploring Effective Cross-Agency Collaboration. *Journal of Public Administration Research and Theory,* 19(3), pp. 477-493.

De Souza, S., Medellin-Azuara, , J., Lund, J. & Howitt, R., 2011. *Beneficiary Pays Analysis of Water Recycling Projects,* California State Water Resources Control Board,: A report prepared for the California State Water Resources Control Board, Economic Analysis Task Force for Water Recycling in California.

Degen, M., Bunce, R., Henifin, T. & Powel, D., 2021. *VDH Environmental Technical Services Manager* [Interview] (16 February 2021).

Dentoni, D., Bitzer, V. & Schouten, G., 2018. Harnessing Wicked Problems in Multi-stakeholder Partnerships. *Journal of Business Ethics,* Volume 150, p. 333–356.

DERWA, 2021. *San Ramon Valley Recycled Water Project2.* [Online]
Available at: http://www.srvrwp.org/
[Accessed 23 April 2021].

Diringer, S. et al., 2019. Moving Toward a Multi-Benefit Approach to Water Management, Oakland: Pacific Institute.

DSRSD and EBMUD, 1995. *DERWA-DSRSD-EBMUD Recycled Water Authority (1995).* Oakland(California): Alameda County LAFCO.

Duffy, 2016. Consoidated FInal EIR for the Pure Water Monterey Groudnwater Replenishment Project, Monterey, CA: Monterey One Water.

Duffy, 2021. Environmental Analysis of the 2021 Changes to the Expanded Pure Water Monterey Groundwater Replenishment Project, Monterey, CA: M1W.

Dussert, B. W. & Van Stone, G. R., 2000. The BIological Activated Carbon Process for Water Purification. *Water & Wastes Digest,* Issue December 28, 2000.

DWR, 2014. *2014 California Water Action Plan,* Sacramento, CA: CA Department of Water Resources.

DWU, 2020. *2020-2021 Annual Budget,* Dallas, TX: Dallas Water Utilities.

Ehisen, R., 2015. Felicia Marcus navigates drought's rough water. *Capitol Weekly*, 25 June.

EPA, 1974. Final Environmental Impact Statement for Construction of Wastewater Facilities, City of Houston, Texas, Almeda - Sims Regional Treatment Plant, Dallas, TX: EPA Region VI.

EPA, 2004. *Guidelines for Water Reuse,* Washington, DC: EPA.

EPA, 2004. Interagency Agreement Required forent Required for Water Reuse: Monterey County Water Recycling Project, Monterey, California. In: B. &. Veatch, ed. *Guidelines for Water Reuse.* Washington, DC: EPA.

EPA, 2012. 2012 Guidelines for Water Reuse, Washington, DC: EPA.

EPA, 2015. *Chesapeake Bay TMDL Fact Sheet.* [Online]
Available at: https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-tmdl-fact-sheet
[Accessed 11 July 2021].

EPA, 2016a. Clusters: Overcoming Barriers to Water Innovation in the U.S. (Statement of Innovation Cluster Leaders), s.l.: s.n.

EPA, 2016b. *Saving Water in Texas.* [Online]
Available at: https://www.epa.gov/sites/default/files/2017-02/documents/ws-ourwater-texas-state-fact-sheet.pdf

EPA, 2020. National Water Reuse Action Plan: Collaborative Implementation, Washington, DC: s.n.

ESA, 2009. California American Water Company Coastal Water Project-Draft Environmental Impact Report, Sacramento, CA: California Public Utilities Commission.

EVGMAC, 2017. Report to the Virginia Department of Environmental Quality and Virginia General Assembly, Richmond, VA: Eastern Virginia Groundwater Management Advisory Committee.

FEMA, 2017. National Incident Management System Guideline for Mutual Aid, Washington DC: FEMA.

Ferrante, R. C., 2021. *Personal Communication* [Interview] 2021.

Franco-Torres, M., Rogers, B. C. & Harder, R., 2020. Articulating the new urban water paradigm. *Critical Reviews in Environmental Science and Technology.*

Freeman, J. & Rossi, J., 2012. Agency Coordination in Shared Regulatory Space. *Harvard Law Review,* March, 125(5), pp. 1134-1211.

Gallet, D., 2019. A Utility Scale One Water Approach: Clean Water Services, Oregon, Denver: Water Research Foundation (WRF).

GAO, 2005. Results Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies, Washington DC: GAO.

Garcettti, E., 2019. *LA's Green New Deal: Sustainable City pLAn,* Los Angeles: City of LA.

Geisseler, D. & Horwath, W. R., 2016. *Lettuce Production in California,* Davis, CA: UC Davis.

Gile, B. C., Sciuto, P. A., Ashoori, N. & Luthy, R. G., 2020. Integrated Water Management at the Peri-Urban Interface: A Case Study of Monterey, California. *Water,* 12(3585), p. 26.

Gleick, P. H., 2000. The Changing Water Paradigm: A Look at Twenty-first Century Water Resources Development. *Water International,* 25(1), pp. 127-138.

Grafton, R. Q., Garrick , D., Manero, A. & Do, T. N., 2019. The Water Governance Reform Framework: Overview and Applications to Australia, Mexico, Tanzania, USA and Vietnam. *Water,* 11(1), p. 137;.

Graves, P., 2019. *Fiscal Notes/A Texas Two-fer:The North Texas Integrated Pipeline Project.* [Online] Available at: https://comptroller.texas.gov/economy/fiscal-notes/2019/apr/pipeline.php [Accessed 2 September 2021].

Green, D., 2007. *Managing Water: Avoiding Crisis in California.* 1st ed. Berkeley: University of California Press.

Haddad, B. M., 2002. Monterey County Water Recycling Project: Institutional Study. *Journal of Water Resourced Planning and Management,* Volume July/August, pp. 280-287.

Hagekhalil, A. & Wiersema, I., 2016. Los Angeles. In: C. Lossouarn, ed. *Water, Megacities and Global Change: Portraits of 15 Emblematic Cities of the World.* France: UNESCO/ARCEAU IdF.

Hampson, L., 2010. *Carmel River Historical Timeline,* Monterey, CA: Monterey Peninsula Water Management District.

Hanson, L., Faeth, P., Glass, C. & Ramamoorthy, M., 2017. Drivers, Hindrances, Planning, and Benefits Quantification: Economic Pathways and Partners for Water Reuse and Stormwater Harvesting, Alexandria, VA: Water Research Foundation.

Harasick, R., 2021. *Personal Communication* [Interview] (10 September 2021).

Harris-Lovett, S., Baker, K., Luthy, R. & Sedlak, D., 2019. ADVANCING WATER REUSE IN THE SAN FRANCISCO BAY AREA: Integrating Water Reuse into a Regional Approach to Water Management, Stanford, CA: Bay Area One Water Network (Bay Area OWN).

Harsh, J. F., 1980. *Ground-Water Hydrology of James City County, Virginia,* Richmond, VA: US Geological Survey.

Hazen and Sawyer, 2021. *Full-Scale Implementation of Groundbreaking SWIFT Program.* [Online] Available at: https://www.hazenandsawyer.com/work/projects/full-scale-implementation-of-groundbreaking-swift-program/

Henderson, J. & Raucher, R. S., 2019. *Water Utility Partnerships: Resource Guide and Toolbox (WRF-4750),* Denver: Water Research Foundation.

Henifin, E., 2020. *Personal Communication* [Interview] (20 April 2020).

Henifin, E., Degen, M., Powell, D. & Bunce, R., 2021. *Lions, Gazelles, and Hippos: Lessons in Cooperation from the Waterhole* [Interview] (24 February 2021).

Henley, A. T., 1957. The Evolution of Forms of Water Users Organizations in California. *California Law Review,* 45(5), pp. 665-675.

Howe, C., 2019. Pittsburgh Region: A Regional Scale Analysis of a One Water Approach, Denver: Water Research Foundation.

HRSD, 2008. *Nutrient Credit Trading Policy,* Hampton Roads, VA: Hampton Roads Sanitation District.

HRSD, 2014a. Memorandum of Understanding for the development, financing, and implementation of the RWWMP. Hampton Roads(VA): HRSD.

HRSD, 2014b. MOA with Chesapeake, Hampton, Newport News, Norfolk et al., Hampton Roads, VA: HRSD.

HRSD, 2019. *Hampton Roads Sanitation District-About Us,.* [Online]
Available at: ttps://www.hrsd.com/about-us
[Accessed 28 May 2019].

HRSD, 2020a. Annual Budget, Fiscal Year 2020-2021, Hampton Roads, VA: HRSD.

HRSD, 2020b. Hampton Roads Water Quality Agreement for Chesapeake Bay Restoration--Fort Monroe Authority Agreement (Item 7). *HRSD Commission Meeting Minutes (10/27/20)*, 27 October.

HRSD, 2021a. *Swift Industry Outreach: SWIFT Master Schedule.* [Online]
Available at: https://www.hrsd.com/sites/default/files/assets/Documents/pdfs/SWIFT/200630_HRSD-SWIFTProgramSummarySchedule.pdf

HRSD, 2021b. *SWIFT Master Schedule.* Hampton Roads(VA): HRSD.

Huxley, A., 2002. Hyperion to a Satyr. In: *Complete Essays of Aldous Huxley, Volume V 1939-1956, .* s.l.:Ivan R. Dee, pp. 325-338 .

JCSA, 2021. *FY 2022 Adopted Budget,* James City County, VA: James City Service Authority.

Jones & Stokes, 1993. *ENVIRONMENTAL IMPACT STATEMENT SALINAS VALLEY SEAWATER INTRUSION PROGRAM,* Sacramento, CA: US Department of Intereior, USBR Mid-Pacific Region.

Kmiec, J., 2021. *History of Tucson Water's Reclaimed Water System.* Tucson, Tucson Water, Interim Director.

Kudlas, S., 2021. *VDEQ Planning and Water Director* [Interview] (20 May 2021).

LA County, 2021. *Safe Clean Water for LA County.* [Online]
Available at: https://safecleanwaterla.org/about
[Accessed 8 October 2021].

LA San, 2021a. *Watershed Protection: Measure O: Projects.* [Online]
Available at: https://www.lacitysan.org/san/faces/home/portal/s-lsh-wwd/s-lsh-wwd-wp/s-lsh-wwd-wp-po/s-lsh-wwd-wp-po-p?_adf.ctrl-state=16oo86biv7_5&_afrLoop=4301591387720133#!
[Accessed 13 September 2021].

LA San, 2021b. *Water Reclamation Plants.* [Online]
Available at: https://www.lacitysan.org/san/faces/home/portal/s-lsh-wwd/s-lsh-wwd-cw/s-lsh-wwd-cw-p?_adf.ctrl-state=a1kreyc53_5&_afrLoop=2667118158821643#!

LACSD, 2021a. *2020 Annual Report,* Whittier, CA: LACSD.

LADPW, 2020. *Sun Valley Watershed-Enhancing the community and enriching lives: Elmer Avenue Neighborhood Retrofit.* [Online]
Available at: https://pw.lacounty.gov/wmd/svw/elmeravenue
[Accessed 29 December 2020].

LADWP, 2021a. *Operation NEXT.* [Online]
Available at: https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-water/a-w-sourcesofsupply/a-w-sos-operationnext?_adf.ctrl-state=xxws2g08z_4&_afrLoop=164603709354980

LADWP, 2021b. *Water: Facts and Figures.* [Online]
Available at: https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-water/a-w-factandfigures?_adf.ctrl-state=nqlmdqx5q_21&_afrLoop=412799971840220
[Accessed 14 September 2021].

Lang, J. T. & Kane, C., 2017 . A New Approach to Water for Hampton Roads Cities. *VIRGINIA LAWYER-ENVIRONMENTAL LAW SECTION,* April.Volume 65.

Lillis, T., 2015. HRSD's First 75 Years: Ensuring Future Generations Inherit Clean Waterways. Hampton Roads, VA: HRSD.

Lustgarten, A., 2021. Climate Change is Killing the Colorado. *New York Times*, 27 ,August .

LWV, 2007. *STUDY ON PRIVATE V. PUBLIC OWNERSHIP OF WATER SYSTEMS,* Monterey, CA: League of Women Voters of the Monterey Peninsula.

M1W, 2021. *History.* [Online]
Available at: https://www.montereyonewater.org/185/History
[Accessed 22 August 2021].

Mackey, E., 2019*. New Voluntary AWT Operator Certification-The AWTO Certification Program.* [Online]
Available at: https://watereuse.org/wp-content/uploads/2019/09/A1.4-Mackey_07.29.2019-Arizona-Water-Reuse.pdf
[Accessed 16 April 2021].

Macon, A., 2021. What the New Census Numbers Tell Us About Dallas-Fort Worth's Growth.. *D Magazine*, 12 August.

Malcolm Pirnie/Arcadis, 2013. *Reclaimed Water Master Plan.* Tucson: s.n.

Marcus, F. et al., 2020. It Takes a Team: Helping Megacities Build Water Security in the Face of Socio-Economic and Climate Change Challenge. Paris, UNESCO, p. Online: https://en.unesco.org/sites/default/files/marcus.pdf.

Markus, M., 2021. *Email communication.* s.l.:s.n.

Martz, R. J., McCarthy, W. J. & Morris, J. . C., 2017. The Consent Order as Mandated Collaboration: The Case of Hampton Roads Sanitation District. *Public Works Management & Policy,* 23, 2(2), pp. 168-185.

Mayer, P., 2017. Water Conservation Keeps Rates Low in Tucson Arizona: Demand Reduction over 30 Years Have Dramatically Reduced Capital Costs in the City of Tucson, s.l.: Alliance for Water Efficiency.

McCullough, M., 2021. Monterey County Water Recycling Projects (MCWRP) & Salinas River Diversion Facility (SRDF) Water Production (Acre Feet). Monterey(CA): MCWRA.

McCullough, M., 2021. *Personal Communication* [Interview] (12 February 2021).

MCWRA, 1992. AN ORDINANCE OF THE MONTEREY COUNTY WATER RESOURCES AGENCY CONFIRMING APPROVAL OF THE WASTEWATER RECLAMATION SYSTEM FOR THE BENEFIT OF ZONES 2A AND 2B, AND APPROVING ASSESSMENTS TO BE LEVIED IN ZONES 2A AND 2B FOR SUCH PROJECT. Monterey(CA): s.n.

MCWRA, 1998. Summary Report: 1996 Ground Water Extraction Data and Agricultural and Urban Best Management Practices, Monterey, CA: Monterey County Water Resources Agency (MCWRA).

MCWRA, 2020. *Recommended Budget Fiscal Year Ending June 30th 2021,* Monterey, CA: Monterey County Water Resources Agency.

Meridian Institute, 2018. Mainstreaming Potable Reuse in the United States: Strategies for Levelling the Playing Field, s.l.: s.n.

Metropolitan, 2019. *Regional Recycled Water Program Conceptual Planning Studies Report (Report No. 1618),* Los Angeles: The Metropolitan Water District of Southern California.

Metropolitan, 2021a. *Expanding Local Resources.* [Online]
Available at: https://www.mwdh2o.com/planning-for-tomorrow/building-local-supplies/regional-recycled-water-program/
[Accessed 2 September 2021].

Metropolitan, 2021b. *How We Get Our Water.* [Online]
Available at: https://www.mwdh2o.com/your-water/how-we-get-our-water/
[Accessed 2 September 2021].

Meyer, C., 2017. Wastewater: The untapped resource. *UN World Water Development Report*.

Miller, K., Costa, K. & Cooper, D., 2012. *How to Upgrade and Maintain Our Nation's Wastewater and Drinking Water Infrastructure,* Washington, DC: Center for American Progress (CAP).

Minamide, T., 2021. *Personal communication* [Interview] (25 August 2021).

Monterey County Civil Grand Jury, 2015. A Glass Half Full? The Monterey Peninsula Water Management District and the Marina Coast Water District, Monterey, CA: Superior Court of California for Monterey County.

Monterey Farm Bureau, 2021. *Facts, Figures & FAQs.* [Online]
[Accessed 10 August 2021].

Mouakkad, S., 2021. *Operation NEXT – LA's New Water Supply Program.* [Online]
Available at: https://www.cwea.org/news/operation-next-las-new-water-supply-program/
[Accessed 8 October 2021].

MPWMD, 2011. Frequently Asked Questions and Aswers about the CDO Issued by the SWRCB, Monterey: MPWMD.

MPWMD, 2016. *Water Purchase Agreement for Pure Water Monterey Project.* Monterey(CA): Monterey Peninsula Water Management District.

MPWMD, 2019. OVERVIEW OF SEASIDE BASIN ADJUDICATION: Report to the Water Supply Planning Committee (9/10/19), Monterey: Monterey Peninsula Water Management District.

MPWMD, 2020. *Fiscal Year 2019-2020 Budget,* Monterey, CA: MPWMD.

Mukheibir, P., Howe, C. & Ashbolt, N. J., 2015. *Institutional Issues for Integrated "One Water" Management,* Alexandria, VA: Water Environment Research Foundation.

MWD/LACSD, 2020. *First Amendment to Regional Recycled Water Program Agreement.* s.l.:Metropolitan Water District of Southern California and Los Angeles County Sanitation Districts.

MWD, 2015. Potential Regional Recycled Water Supply Program: Historical Review and 2015 Update, Working Draft, Los Angeles: MWD.

MWH, 2021. *Trinity River Authority Central Regional Wastewater System Project.* [Online]
Available at: https://mwhconstructors.com/projects/trinity-river-authority-central-regional-wastewater-system-project/
[Accessed 1 September 2021].

Myatt, K., 2020. A silent killer, the heat wave of 1980 remains among the nation's deadliest weather events: Thousands may have died in the heat wave 40 years ago.. *Washington Post*, 11 July.

NACWA, 2013. *The Water Resources Utility of the Future...A Blueprint for Action,* Washington, DC: National Association of Clean Water Agencies (NACWA) in assocition with Water Environment Research Foundation (WERF) and Water Environment Federation (WEF).

NACWA, 2020. *Roster of Public Wastewater Agencies.* [Online]
Available at: https://www.nacwa.org/about-us/member-agencies-affiliates/public-agency

Nading , T. et al., 2018. *A 'SWIFT' Approach to Managed Aquifer Recharge.* [Online]
Available at: https://www.wateronline.com/doc/a-swift-approach-to-managed-aquifer-recharge-0001
[Accessed 21 February 2021].

NIDIS/NOAA, 2019. *News and Events: Colorado River Drought Continegency Planning.* [Online]
Available at: https://www.drought.gov/news/colorado-river-drought-contingency-planning
[Accessed 12 September 2021].

North Texas Commission, 2019. *2020 Profile: North Texas,* s.l.: s.n.

NRC, 2012. Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater., Washington DC: The National Academies Press..

NTMWD, 2016. Presentation to Water Committee Meeting. s.l.:s.n.

NTMWD, 2019. *2019-2024 Strategic Plan.* [Online]
Available at: https://www.ntmwd.com/wp-content/uploads/2019/11/2019-24-NTMWD-Strategic-Plan-Placemat-2.pdf
[Accessed 13 September 2021].

NTMWD, 2021a. *East Fork Water Reuse Project.* [Online]
Available at: https://www.ntmwd.com/east-fork-water-reuse-project/

NTMWD, 2021b. *FY21 Approved Budget and Rates Fact Sheet..* [Online]
Available at: https://www.ntmwd.com/documents/fy21-approved-budget-and-rates-fact-sheet/

Nylen, N. G., 2019. *Case Study #10--Sustainable Water Initiative for Tomorrow (SWIFT).* Berkeley, CA, UC Berkeley Center for Law, Energy and Environment (CLEE).

OCWD, 2014. *A History of the Orange County Water District (OCWD).* 2nd ed. Fountain Valley(CA): Orange County Water District.

OCWD, 2021. *Facilities: Final Expansion.* [Online]
Available at: https://www.ocwd.com/gwrs/final-expansion/
[Accessed 12 September 2021].

Oregon State University College of Forestry, 2016. *Recreation Use Values Database.,* s.l.: Oregon State University.

Owen, W., 2020. *Personal communication* [Interview] (25 August 2020).

Paulsen, C., Broley, W. & Stephens, L., 2017. *Blueprint for One Water,* Denver: Water Research Foundation (WRF).

PCAD, 2021. *Pacific Improvement Company, Hotel DelMonte #1, Monterey CA.* [Online]
Available at: http://pcad.lib.washington.edu/building/16859/
[Accessed 19 August 2021].

Pima County, 2016. *2016 Wastewater Facility Plan.* s.l.:Pima County.

Powell, D., 2021. *Private Communication* [Interview] (9 February 2021).

Qualls, D., 2021. Lions, Gazelles, and Hippos: Lessons in Cooperation from the Waterhole [Interview] (23 February 2021).

Qualls, D., 2021. *Personal Communication* [Interview] (31 August 2021).

Quick, K. S. & Feldman, M. S., 2014. Boundaries as Junctures: Collaborative Boundary Work for Building Efficient Resilience. *Journal of Public Administration Research and Theory,* July.pp. 673-695.

Raucher, R. S. et al., 2013. *The Value of Water Supply Reliability in the Residential Sector,* Alexandria, VA: WateReuse Research Foundation.

Raucher, R. S. et al., 2006. *Regional Solutions to Water Supply Problems.* Second (2008) ed. Denver: AWWA Research Foundation.

Raucher, R. S. et al., 2008. *Regional Solutions to Water Supply Provision,* Denver: AWWA Research Foundation.

Raucher, R. S. et al., 2006. An Economic Framework for Evaluating the Benefits and Costs of Water Reuse (Project 03-06), Denver, CO: AWWA.

Raucher, R. S., Henderson, J., Atwater, R. & Rosenblum, E., 2019. *Challenges and Successful Strategies for Pricing Reuse Water (Project 4662),* Denver CO: Water Research Foundation.

Raucher, R. S. et al., 2015. *The Value of Water Supply Reliability in the CII Sector,* Alexandria, VA: WateReuse Research Foundation.

Rawn, A. M., 1965. *Narrative-C.S.D..* [Online]
Available at: https://www.lacsd.org/civicax/filebank/blobdload.aspx?BlobID=23931
[Accessed 3 September 2021].

Rees, J. A., 2002. *Risk and Integrated Water Management,* Stockholm: Global Water Partnership.

Reibenspiess, V., Drechsler, K., Eckhardt, A. & Wagner, S., 2018. Enabling Innovation Champions in Organizations - Results of a Systematic Literature Analysis.. s.l., s.n., pp. 4161-4170.

Richardson, S., 2019. *Wetlands: Water's Original Filter.* s.l., Texas Water Resources Institute.

Rogers, P. & Hall, A. W., 2003. *Effective Water Governance,* Stockholm: Global Water Partnership Technical Committee (TEC).

Rosenblum, E., 1998. Keynote Address, CWEA Annual Conference. Oakland, CA, CWEA.

Rosenblum, E., 1999. Selection and Implementation of Nonpotable Water Recycling in Silicon Valley (San Jose area) California,. *Water Science and Technology,* 40(4), pp. 51-58.

Rosenblum, E., 2016. *Putting the Pieces Together: Interagency Agreements for Integrated Water Use.* [Online]
Available at: https://watereuse.org/wp-content/uploads/2015/01/Interagency-Agreements-Integrated-Water-Use.pdf
[Accessed 11 March 2021].

Rosenblum, E., 2017. Institutional Issues and Agreements Required to Reuse Municipally Treated Effluent, Walnut Creek, CA: Carollo Engineers.

Rosenblum, E., 2021. Incentivizing sustainability: How utiltiies can support industrial water conservation and reuse. In: C. K. Davis & E. Rosenblum, eds. *Sustainable Industrial Water Use: Perspectives, Incentives, and Tools.* London: IWA Publishing, pp. 261-269.

Rosenblum, E. & Anderson, J., 2009. The Water Reclamation Matrix. In: M. Beck & A. Speers, eds. *Proceedings: 2nd IWA Leading-Edge on Sustainability in Water-Limited Environments (Sydney, Australia, 2005)..* London: International Water Association, pp. 216-224.

Rosenblum, E. et al., 2021. Planning for Water Recycling and Reuse. In: B. Moore, ed. *Industrial Water Reclamation and Reuse to Minimize Liquid Discharge.* Alexandria, VA: Water Environment Federation, pp. 17-72.

Ryan, M. & Breschini, G. S., 2021. *An Overview of Monterey County Agriculture.* [Online]
Available at: http://mchsmuseum.com/agoverview.html
[Accessed 9 August 2021].

Safford, L., 2021. Tucson Audubon Society Sweetwater Activity. s.l.:s.n.

SAWPA, 2020. *About Santa Ana Watershed Project Authority - SAWPA.* [Online]
Available at: https://sawpa.org/about-us/
[Accessed 28 December 2020].

SBRA, 2020. *San Francisco Bay Restoration Regulatory Integration Team (BRRIT).* [Online]
Available at: http://sfbayrestore.org/san-francisco-bay-restoration-regulatory-integration-team-brrit
[Accessed 28 December 2020].

Sciuto, P., 2021. *Personal Communication* [Interview] (18 October 2021).

Scott, R. J. & Boyd, R., 2020. Determined to succeed: Can goal commitment sustain interagency collaboration. *Public Policy and Administration*, 1 April, pp. 1-31.

Scully, B., 2021. *Personal communication* [Interview] 2021.

Sedlak, D., 2014. Water 4.0: The Past, Presnt, and Future of the Wprld's Most Vital Resource. 1st ed. New Haven: Yale University Press.

Sehring, J., 2005. 'Do not fix the pipes, fix the institutions that fix the pipes.' Water Governance as a crucial factor for sustainable and equitable water management. In: P. M. Schmitz, ed. *Water and Sustainable Development.* Frankfurt am Main: Peter Lang, pp. 101-116.

SFWMD, 2020. *Land Management (Stewardship).* [Online]
Available at: https://www.sfwmd.gov/our-work/land-management
[Accessed 24 December 2020].

Sharpsteen, B., 2010. Dirty Water: One Man's Fight to Clean Up One of the World's Most Pollluted Bays,. Berekeley(CA): University of California Press.

Sheikh, B., 1986. Monterey Reclaimed Water for Agriculture Study (MRWSA), Monterey, CA: MRWPCA.

Sheikh, B., 2017. Use of Recycled Water in Jordan's Commercial & Industrial Sectors, Washington, DC: USAID.

Sheikh, B., Rosenblum, E., York, D. & Hartling, E., 2004. Institutional Requirements in California and Florida for Implementation of Water Recycling/Reclamation Projects. Phoenix, Arizona, WateReuse Association.

Simpson, T. R., 1946. *Salinas Basin Investigation Summary Report,* Sacramento, CA: California Department of Public Works, Division of Water Resources.

Sklar, A., 2008. Brown Acres: An Intimate History of the Los Angeles Sewers. s.l.:Angel City Press.

Slatyer, T., 2019. Getting on Track with SDG6-A Role for Multilateral Processes. Bengaluru, INDIA, Water Policy Group.

Smith, C., 2021. California Invests in Recycled Water as Droughts Take a Toll,. *Governing*, 4 August.

Spaulding, P. P., 2017. City of Marina Letter Responding to Draft Environmental Impact Report/Environmental Impact Statement Monterey Peninsula Water Supply Project, Marina, CA: s.n.

State of California, 1996. *CHAPTER 118. Monterey Peninsula Water District Law.* St. Paul(MN): WEST PUBUSHING CO..

State of Virginia, 2021. Potomac Aquifer Recharge Monitoring (Title 62.1 Chapter 26). Richmond(VA): s.n.

Stoldt, D., Sciuto, P. & Frus, B., 2021. *Lions, Gazelles, and Hippos: Lessons in Cooperation from the Waterhole* [Interview] (24 February 2021).

SWRCB, 1975. *Water Quality Control Plan: Central Coast Basin,* Sacramento, CA: State Water Resources Control Board:.

SWRCB, 1995. OrderNo. WR 95-10 on Four Complaints Filed Against the California American Water Company, Carmel River, Monterey, California, Sacramento, CA: California Environmental Protection Agency.

SWRCB, 2016. Water Reclamation Requirements for Recycled Water Use (WQ 2016-0068-DDW). Sacramento: California State Water Resources Control Board.

SWRCB, 2021. DPR Framework 2nd edition Addendum – Early Draft of Anticipated Criteria for Direct Potable Reuse, Sacramento: California State Water Resources Control Board.

Tannian, M., 2017. *Interagency Collaboration in Law Envordcement.* [Online] Available at: https://www.powerdms.com/blog/interagency-collaboration-law-enforcement [Accessed 2021].

Tett, G., 2016. The Silo Effect: The Peril of Expertise and the Promise of Breaking Down Barriers. New York: Simon & Schuster.

Texan by Nature, 2018. *2018 Conservation Wrangler: Constructed Wetlands,.* [Online] Available at: url: https://texanbynature.org/projects/constructed-wetlands/, corporate author: Texas by Nature).

Texan By Nature, 2020. *Cleaning Water Nature's Way.* [Online] Available at: https://texanbynature.org/wp-content/uploads/2018/06/TRWD-George-W.-Shannon-Wetlands-Overview.pdf.

Texas Conservation Alliance, 2020. *The Facts: Water Recycling.* [Online] Available at: https://www.tcatexas.org/post/water-recycling

Thakhathi, A., 2018. Champions of Change and Organizational Development: A Return to Schön and Typology for Future Research and Practice" In Research in Organizational Change and Development. *Research in Organizational Change and Development,* Volume 26, pp. 265-306.

Tharp, R. N., 1976. Handbook of Texas-Trinity River Authority. [Online].

Tollman, P. et al., 2017. *Getting Smart About Change Management.* [Online] Available at: https://www.bcg.com/publications/2017/change-management-getting-smart-about-change-man [Accessed 27 December 2020].

TRA, 2011. An Agreement Among the Cities of Dallas and Fort Worth, NTMWD and TRA Continuing the Upper Trinity Basin Water Qualtiy Compact. Arlington, TX: Trinity River Authority.

TRA, 2016. *2016 Trinity River Basin Master Plan,* Arlington: Trinity River Authority.

TRA, 2021a. BASIN PLANNING: Planning and Environmental Management, s.l.: s.n.

TRA, 2021b. *Our Mission and Vision.* [Online] Available at: https://www.trinityra.org/our_mission_and_vision.php

TRA, 2021c. *Annual Budget for 2022--Submittal for Review.* [Online] Available at: https://tragis.maps.arcgis.com/apps/MapJournal/index.html?appid=fb63978fd5774e42839c05b0e474f557# [Accessed 13 September 2021].

TRA, 2021d. *2021 Trinity River Basin Master Plan,* Arlington, TX: Trinity River Authority of Texas.

TRA, 2021e. *Recreation.* [Online] Available at: https://www.trinityra.org/recreation/index.php [Accessed 1 September 2021].

TRA, 2021e. *Timeline.* [Online] Available at:

https://storymaps.arcgis.com/stories/b54978ec20424c9d939f7db1251f99e4?play=true&speed=slow [Accessed October 11 2021f].

TRWD, 2014. Tarrant Regional Water District Integrated Water Supply Plan, s.l.: Tarrant Regional Water District.

TRWD, 2019. *North Texas' Largest Water Providers Join Forces.* [Online] Available at: https://www.trwd.com/press-release-water-is-awesome/ [Accessed 10 October 2021].

TRWD, 2020. *New Pipeline Already Proving to be a Cost Savings.* [Online] Available at: https://www.trwd.com/new-pipeline-already-proving-to-be-a-cost-savings/

TRWD, 2021a. *Fiscal Year 2022 Proposed Revenue, General & Contingency Funds Operating Budgets.* [Online] Available at: https://www.trwd.com/wp-content/uploads/2021/07/Budget-Book-FY22-7.16.21-with-watermark.pdf [Accessed 13 September 2021].

TRWD, 2021b. *Wetlands.* [Online] Available at: https://www.trwd.com/resource/wetlands

TSALC, 2021. *Major Droughts in Modern Texas.* [Online] Available at: https://www.tsl.texas.gov/lobbyexhibits/water-droughts

TWDB, 2021a. *River Basins.* [Online] Available at: https://www.twdb.texas.gov/surfacewater/rivers/river_basins/index.asp

TWDB, 2021b. *Trinity River Basin.* [Online] Available at: https://www.twdb.texas.gov/surfacewater/rivers/river_basins/trinity/index.asp [Accessed 13 September 2021].

TWDB, 2021c. *2022 State Water Plan,* s.l.: s.n.

UC Davis Cooperative Extension, 2021. *Salinas-Monterey Area Agriculture.* [Online] Available at: https://vric.ucdavis.edu/virtual_tour/salinas.htm [Accessed 9 August 2021].

Ulibarri, N., Cain, B. E. & Ajami, N., 2017. A Framework for Building Efficient Environmental Permitting Processes. *Sustainability,* 9(180).

Umble, A., 2021. The role of the consultant in supporting sustainable industrial water use. In: C. K. Davis & E. Rosenblum, eds. *Sustainable Industrial Water Use: Perspectives, Incentives and Tools.* London: IWA Publishing, pp. 105-113.

University of Michigan Center for Sustainable Systems, 2020. *US Water Supply and Distribution Factsheet.* [Online] Available at: http://css.umich.edu/factsheets/us-water-supply-and-distribution-factsheet

Upadyhay, D., 2020. *Personal Communication* [Interview] (14 April 2020).

US et al. v HRSD Consent Decree (4th Amd.) (2017).

US Water Alliance, 2021a. *One Water Hub.* [Online] Available at: http://uswateralliance.org/one-water [Accessed 5 October 2021].

US Water Alliance, 2021b. *US Water Prize 2021.* [Online]
Available at: http://www.uswateralliance.org/one-water/us-water-prize-2021
[Accessed 29 August 2021].

USBR, 2015. *Environmental Assessment Western Dublin Recycled Water Project (15-11-MP),* Washington, DC: Bureau of Reclamation, US Department of the Interior.

USEPA, 1974. Final Environmental Impact Statement for Construction of Wastewater Facilities, City of Houston, Texas, Almeda - Sims Regional Treatment Plant, Dallas, TX: USEPA Region VI.

USEPA, 2016b. *Saving Water in Texas.* [Online]
Available at: https://www.epa.gov/sites/default/files/2017-02/documents/ws-ourwater-texas-state-fact-sheet.pdf

USGS, 2021. *USGS.* [Online]
Available at: https://groundwaterwatch.usgs.gov/AWLSites.asp?mt=g&S=371749076441801&ncd=awl
[Accessed 4 August 2021].

UTRWD, 2019. *Annual Operating and Capital Budgets.* [Online]
Available at:
https://downloads.ctfassets.net/v8jpyszhn40x/5vGep4tPZ6mloF3grlAqXo/b2cb2e904721ede7c4914a581da9c152/UTRWD_FY_2021_GFOA_Budget.pdf

UTRWD, 2021. *Our Water Reclamation Services.* [Online]
Available at: https://www.utrwd.com/what-we-do/water-reclamation

VA DHRM, 2018. State Employee Workforce, Compensaion, Health Benefits,HR Systems, Richmond: State of Virginia.

VAC, 2017. 9VAC25-820-70. Regulation for Total Nitrogen and Total Phosphorus Discharges and Nutrient Trading, s.l.: Virginia Administrative Code.

Villegas, R., 2021. *Personal Communication* [Interview] (30 August 2021).

Virginia Tech, 2021. *Who We Are.* [Online]
Available at: https://owml.cee.vt.edu/mission/who-we-are.html

VisitDallas, 2021. *Dallas Stats and Fun Facts.* [Online]
[Accessed 11 October 2021].

Warrick, D., 2017. What leaders need to know about organizational culture. *Business Horizons,* 60(3), pp. 395-404.

WateReuse, 2020a. Investing in Water Reuse for Climate Change, Adaptation, and Economic Resiliency, Alexandria, VA: WateReuse Association.

WateReuse, 2020b. *Water Reuse 101,* Alexandria, VA: WateReuse Association.

WateReuse, 2021. *State Policy and Regulations.* [Online]
Available at: https://watereuse.org/advocacy/state-policy-and-regulations/
[Accessed 10 September 2021].

Watson, R., Fane, S. & Mitchell, C., 2016. The Critical Role of Impact Distribution for Local Recycled Water Systems. *International Journal of Water Governance,* 4(1), pp. 1-18.

WBMWD, 2021. *Facilities.* [Online]
Available at: https://www.westbasin.org/water-supplies/recycled-water/facilities/

WERF Exploratory Team, 2011. *Sustainable Integrated Water Management,* Alexandria, VA: Water Environment Research Foundation.

Wheedbee, E., Hopkins, E. D. & Burr, J. G., 1925. Trinity River Sanitary Survey, 1924-1925 in Glass and To, "The Trinity River Past, Present, and (most importantly) Future" (2019). s.l.:Texas State Department of Health; Texas Association of Clean Water Agencies.

Whitaker, R., 2021. *Personal Communication* [Interview] (7 June 2021).

Winter, L., 2016. Expanding the Role of Reclaimed Water. *Headwaters Magazine*, 1 December.

Wolf, J. A., 2010. Transcending paradox: Movement as a means for sustaining high performance. In: *Research in organizational change and development.* Bingley, UK: Emerald Group Publishing, pp. 77-107.

WRD, 2021a. *About WRD: Mission and History.* [Online]
Available at: https://www.wrd.org/about/mission-and-history

WRD, 2021b. *WIN 4 All.* [Online]
Available at: https://www.wrd.org/content/win-4-all
[Accessed 13 September 2021].

WRD, 2021c. *Special BAC Presentation on WRDs Budgeting Process.* Lakewood, CA: Water Replenishment District of Southern California.

ANNOTATED BIBLIOGRAPHY

The Challenge of Interagency Collaboration

Dentoni, D. V., Schouten, J., & Bitzer, G. (2018). Harnessing Wicked Problems in Multi-stakeholder Partnerships. *Journal of Business Ethics*, 150, 333-356. Retrieved from https://doi.org/10.1007/s10551-018-3858-6

This is a comprehensive overview of "wicked problems" including definition, attributes, and applications. The case study focus of the paper is on multi-stakeholder public-private partnerships in the regulation of the palm oil industry—the Roundtable on Sustainable Palm Oil, but it is nevertheless applicable to the water industry. The authors hold that the key to developing appropriate responses to wicked problems (there are no "solutions" *per se*) lies in embracing ("harnessing" in their words) the nature of their wickedness. From the text:

> The key implication of these dimensions of wicked problems is that no stakeholder can effectively respond to wicked problems independently from other stakeholders—individual action against wicked problems has limited or no effectiveness action of others… "Harnessing wickedness," i.e., the approach of taking into account and responding to the different dimensions of wicked problems, thus **requires a governance process that enables networked action, stimulate collective processes and deal with complex dynamics** to achieve small wins." p.338. (Emphasis added.)

Diringer, S., Thebo, A., Cooley, H., Shimabuku, M., Wilkinson, R., & Bradford, M. (2019). *Moving Toward a Multi-Benefit Approach to Water Management.* Oakland: Pacific Institute. https://pacinst.org/wp-content/uploads/2019/04/moving-toward-multi-benefit-approach.pdf

Researchers set out "to develop, build consensus around, and promote the uptake of a framework to embed the multiple benefits of water projects into decision-making processes." Key elements of this framework address the challenge of 1) identifying a broad range of costs and benefits related to water: energy, risk reduction, environmental and social impacts; 2) characterizing these benefits with "benefit-specific methods"; and 3) incorporating benefits and costs into the decision-making process. The ultimate goal is to broaden consensus around water management solutions that address multiple issues.

Henderson, J., & Raucher, R. S. (2019). Water Utility Partnerships: Resource Guide and Toolbox (WRF-4750). Denver: Water Research Foundation.

This report includes a tool to "help practitioners assess the needs of the utility and explore the types of partnerships that may be beneficial." The authors suggest that local agencies can cooperate together as an alternative to forming a single large agency to implement a broader regional solution, and that developing recycled water might even forestall the need for trans-basin solutions. They begin with a working definition of water/wastewater partnerships:

> A utility partnership is a collaboration between utilities (or similar organizations with water management responsibilities) located in proximity to one another, for the purpose of addressing challenges or taking advantage of opportunities.

That raises the question, "*Why should utilities partner?*" One plausible reason is to recycle water, which usually requires the cooperation of both water and wastewater utilities. The special character of partnerships between water and wastewater agencies is explored further in the section, "**Differences between Drinking Water and Clean Water Partnershi**ps." There the authors observe that, despite the fact that agency consolidation has reduced the number of clean water utilities below that of water agencies, "there may be fewer opportunities for partnerships. Nonetheless, **important benefits from future additional partnerships exist**."

Another partnership approach is for drinking water and wastewater systems to combine or work more closely together. An integrated water and wastewater approach can capture efficiencies and help meet community goals. For instance, the Louisville Water Company and Louisville MSD entered into a **Comprehensive Interlocal**

Agreement in 2014 to save money and provide better services. Under the agreement, employees provide services to either organization under a work order, but they remain either Louisville Water or Louisville MSD employees. The two utilities so far have joined their information technology, fleet services, and purchasing teams and are evaluating how to share human resources, customer service, and energy functions. The ultimate vision is for the utilities to operate as an integrated "One Water" utility of the future (Louisville Water 2018).

Henley, A. T., 1957. The Evolution of Forms of Water Users Organizations in California. California Law Review, 45(5), pp. 665-675. https://lawcat.berkeley.edu/record/1109557

Fragmentation of the water industry has deep historic roots. Writing about special water districts in California when they were a new phenomenon, Henley (1957) observes that the formation of flood control and water conservation districts "all follow naturally from pressures of need created and felt by an expanding and demanding citizenry." He traces California water utilities from 19th century reclamation districts whose purpose was "to reduce land from a natural to a useable state" to the irrigation districts whose development "was of infinitely greater value to California than the discovery of gold" and the 20th century municipal water districts established as the state became more urban. Looking back, he observes that "the history of water management organization laws provides a rough parallel of the evolution of California from a true frontier through a period of agricultural dominance…to one in which the influence of the needs of suburbs and industries is clearly felt." In conclusion, he presciently observes:

> It seems probable that **a great deal of the water management work which we can perceive in the future will be done by two or more districts or other public agencies, working together.** As public necessities in this field…grow in magnitude it will become more and more advantageous for existing bodies to unite their resources, both financial and political, in the interest of a mutually beneficial plan. (Emphasis added.)

Paulsen, C., Broley, W. & Stephens, L., 2017. *Blueprint for One Water,* Denver: Water Research Foundation (WRF).

A "One Water" paradigm allows agencies to pool resources to address water challenges holistically. "A One Water approach considers the water cycle as an integrated system, recognizing the interconnectedness of surface water and groundwater supply, stormwater, wastewater, and energy." (p.2) The One Water approach involves connecting the various utilities each responsible for a segment of "the urban water cycle" by "identifying potential partners with similar interests can help you accomplish goals that cannot be achieved alone. Partners may include separate departments within your own agency, regional departments, and agencies responsible for water supply reliability, wastewater treatment, and/or stormwater management—or even other city departments such as planning, parks, or transportation (p. 16). Individual utilities can work together to implement a One Water strategy in five (5) stages (p.9):

- **Setting the Foundation**: Define you One Water scope; identify and convene partners; assess needs and opportunities
- **Establishing Direction**: Craft vision and objectives
- **Developing the Framework**: Establish lasting leadership and institutional structure; create framework of plan; conduct adaptive planning; develop financing strategies
- **Implementation:** Implement the Framework
- **Engaging Stakeholders:** Public & Special Interest Groups; Regulators; Elected Officials

Raucher, R. S., Cromwell, J., Henderson, J., Wagner, C., Rubin, S., Goldstein, J., Kirsch, B. (2008). Regional Solutions to Water Supply Provision. Denver: AWWA Research Foundation. (Raucher, et al., 2008)

This WRF-funded study of regionalization of water agencies characterizes how water agencies relate to each other in order to pursue joint supply projects. It is applicable to water-wastewater interactions as well. A key finding of this research and related case studies is the importance of identifying and clearly articulating what the anticipated benefits of cooperative multi-utility agreements will be (e.g., long-term savings to customers; more reliable and resilient water supply for meeting community demands) to set the stage for more challenging aspects of the deliberations (e.g., addressing concerns over potential loss of local autonomy).

Raucher, R., J. Henderson, R. Atwater, E. Rosenblum, R. Watson, J. Chong. 2019. Challenges and Successful Strategies for Pricing Reuse Water. Water Research Foundation, Project 4662. Denver, CO.

This report provides practical information to assist utility practitioners, and other water sector professionals, as they grapple with the challenges of setting prices, generating revenues, and recovering costs from the provision of reuse water. A significant challenge utilities face in pricing reuse water is developing a suitable balance between (1) creating and sustaining a market for NPR water—by offering attractive, competitive pricing and other incentivizing terms; and (2) concurrently generating sufficient revenue to cover their costs of acquiring or producing reuse water and delivering the recycled water to their customers.

A key distinction is made between traditional COS-based cost recovery (which is rarely feasible for reuse) and a more suitable alternative of applying a "beneficiary pays" approach that provides sound justification for cross subsidies (e.g., from potable and/or wastewater system customers) to help cover reuse costs. Additional issues examined include (1) the use of contracts and various types of contract clauses to help establish and sustain a viable reuse program, (2) using a Triple Bottom Line framework to identify beneficiaries and estimate reuse program benefits, and (3) how institutional arrangements between wastewater and water supply agencies need to be able to accommodate changing circumstances as regional needs and values evolve over time. Several case studies are provided as well.

Sedlak, D. (2014). Water 4.0: The Past, Present, and Future of the World's Most Vital Resource (1st ed.). New Haven: Yale University Press.

Sedlak (2014) takes an even more panoramic view of holistic water management. Beginning in antiquity with Iraqi *qanats* and Roman aqueducts (Water 1.0), he follows the arc of water management through the advent of drinking water disinfection (2.0) and wastewater treatment (3.0), and predicts a future of integrated centralized and distributed water infrastructure (Water 4.0). At this stage, "*there will **no longer be separate divisions within cities or utilities dedicated exclusively to water supply, sewage treatment, or urban drainage**. Instead, we will manage water holistically and will integrate the natural environment into water conveyance and treatment systems.*" (Emphasis added.)

Sehring, J., 2005. 'Do not fix the pipes, fix the institutions that fix the pipes.' Water Governance as a crucial factor for sustainable and equitable water management. In: P. M. Schmitz, ed. *Water and Sustainable Development.* Frankfurt am Main: Peter Lang, pp. 101-116.

Sehring (2005) maintains that water institutions reflect the society in which they operate, which explains the evolution of water management over the past 150 years. During the heroic age of water engineering (in the late 19th and 20th centuries), agencies built dams and pipelines to support the growth of cities ("the paradigm of industrial modernity"). In the 1960s, rising envirnomental awareness and technological improvements allowed agencies to decouple water supply from progress, conserving water and reserving a share for the environment ("the ecological paradigm"). This was succeeded in the 1980s by a demand-oriented approach and a trend to value water as an economic good ("the economic paradigm"), with a focus on market-based water allocation strategies. Holding that "The current water crisis is mainly a crisis of water governance," Sehring proposes that **further advances in water governance will also remain linked to the larger legal, political, social and environmental context in which these water systems operate**. (Emphasis added.)

WERF Exploratory Team, 2011. SUSTAINABLE INTEGRATED WATER MANAGEMENT, Alexandria, VA: Water Environment Research Foundation.

Institutional challenges limit the ability of organizations to collaborate with each other on projects of mutual benefit. The Water Environment Research Council's Exploratory Team (2011) concluded that management of various water resources by different agencies at the federal, state, regional, and local levels make managing water in a holistic manner "virtually impossible." Among the steps required to facilitate integrated water planning they highlighted *"**Development of governance and institutional structures** necessary to affect a global paradigm shift towards sustainable water management, including watershed scale planning and management."* (Emphasis added.)

Governance Issues

Blomquist, W. (1992). Dividing the Waters: Governing Groundwater in Southern California. San Francisco: Center for Self-Governance Press.

Blomquist, W., & Schlager, E. (1999). Watershed Management from the Ground Up: Political Science and the Explanation of Regional Governance Arrangements. Atlanta: American Political Science Association.

Blomquist, William, Edella Schlager, and Tanya Heikkila Common Waters, Diverging Streams: Linking Institutions to Water Management in Arizona, California, and Colorado. Washington, DC: Resources for the Future (2004)

Blomquist, W., Heikkila, T., & Schlager, E. (2004). Common Waters, Diverging Streams: Linking Institutions to Water Management in Arizona, California, and Colorado. Washington, DC:: Resources for the Future.

Schlager, E. & Blomquist, W., 2008. Multiple Goals, Communities, and Organizations: A Watershed Political Economy. In: Embracing Watershed Politics. Boulder: University of Colorado Press, pp. 123-150

These five sources authored by William Blomquist and his colleagues offer an innovative approach to integrated water management that does not rely on the enlightened judgment of a single basin-wide authority. Based on their study of water management strategies, policies, and practices in the southwestern United States, they demonstrate how comprehensive watershed management goals can be achieved through a variety of different institutional structures, including a “federalist” approach which embraces local decision-making. This approach provides a useful background for the multi-agency collaboration discussed in this report.

The 1999 address provides a reasoned critique of watershed management as a governance tool. It provides a thorough and detailed analysis of the evolution of alternative governance strategies to manage the San Gabriel River Watershed and the Santa Ana River Watershed in southern California, and the South Platte and Arkansas River Watersheds in Colorado. The authors propose that the formation of these important governance strategies allows for “watershed management without a watershed manager” and points to a collaborative process that creates an effective self-governing structure without the need of a single overarching agency.

Based on their analysis of several water agencies in the western US, the authors make a case for a decentralized approach to watershed management. While many argue that coordination of the many issues that impact a given watershed require the oversight of a single authority, they show how authority distributed among multiple agencies with overlapping constitencies can result in robust management of complex issues. This approach, they claim, has the advantage of building on past institutional infrastructure, adding, that we cannot simply abandon the institutions of the past, created by enterprising pioneers who “frequently had to invent new concepts and propose new rules that no one previously had used…that have performed effectively over several decades with many efficiently enhancing properties.” (Blomquist, 1992). (Emphasis added.)

The authors further elaborated this concept in their book, “Embracing Watershed Politics” (Schlager, E. and W. Blomquist, Embracing Watershed Politics, University of Colorado Press, 2008) which offers federalism as “an approach for structuring complementary, cooperative, competitive, and conflicting relations among citizens, organizations, and governments at interstate watershed scales (p.152).

GAO, 2005. Results Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies, Washington DC: GAO. https://www.gao.gov/products/gao-06-15

In support of its overall goal of promoting government efficiency, in 2005 the GAO published a report which identified a number of strategies and practices that agencies can implement to collaborate more effectively. GAO studies three collaborative agency efforts: the Healthy People 2010 initiative (HHS-NIH, FDA, CDC, and DOE); Wildland Fire Management (USDA-Forest Service and DOI-BIA, BLM, FWS and NPS); and health sharing between DOD and the VA. The report identified eight (8) key strategies to promote interagency collaboration:

- define and articulate a common outcome;
- establish mutually reinforcing or joint strategies;

- identify and address needs by leveraging resources;
- agree on roles and responsibilities;
- establish compatible policies, procedures, and other means to operate across agency boundaries;
- develop mechanisms to monitor, evaluate, and report on results;
- reinforce agency accountability for collaborative efforts through agency plans and reports; and
- reinforce individual accountability for collaborative efforts through performance management systems.

This report was followed in 2012 by a sequel ("Managing for Results: Key Considerations for Implementing Interagency Collaboration," Washington: GAO, 2012 https://www.gao.gov/products/gao-12-1022) which broadened the scope of the inquiry to include a number of other collaborative efforts, including response to climate change and inter-service cooperation among branches of the armed forces. The report confirmed the findings of the earlier study and added a number of issues to be considered when collaborating, including:

- outcomes and accountability;
- bridging organizational cultures;
- clarity of roles and responsibilities;
- leadership;
- participants;
- resources; and
- written guidance and agreements.

The experts enlisted by the authors provided many insights to the collaboration process, notably "that in a collaborative process, the participants may not have the same overall interests—in fact they may have conflicting interests. However, by establishing a goal based on what the group shares in common, rather than on where there is disagreement among missions or philosophies, a collaborative group can shape its own vision and define its own purpose."

Grafton , R. Q., Garrick , D., Manero, A. & Do, T. N., 2019. The Water Governance Reform Framework: Overview and Applications to Australia, Mexico, Tanzania, USA and Vietnam. *Water,* 11(1), p. 137

After reviewing other institutional frameworks for integrated water management, the authors determined that to facilitate water management reform a new framework was needed. Their "Water Governance Reform Framework" is more specific than the general tenets of Integrated Water Management, but less prescriptive than either international Organization for Economic Cooperation and Development's 12-point framework, or the Asian Development Bank's 10-point River Basin Planning framework. The table below shows how the frameworks compare thematically:

Water Governance Reform Framework (WGRF)	OECD	River Basin Planning
well-defined and publicly available reform objectives (1)	Clear roles and responsibilities (1) Policy coherence (3)	Develop a comprehensive understanding of the entire system (1) Develop relevant and consistent thematic plans (6) Select the planning approach and methods to suit basin needs (10)
transparency in decision-making and public access to available data (2)	Data and information (5) Integrity and transparency (9) Stakeholder engagement (10)	Engage stakeholders (8)

water valuation of uses and non-uses to assess trade-offs and winners and losers (3)	Trade-offs across users (11)	
compensation for the marginalized or mitigation for persons who are disadvantaged by reform (4)	Financing (6)	
reform oversight and "champions" (5)	Regulatory frameworks (7)	
capacity to deliver; and (6)	Appropriate scales within basin systems (2) Capacity (4)	Plan and act, even without full knowledge (2) Prioritize issues and adopt a phased and iterative approach (3) Address issues at the appropriate scale (7) Focus on implementation (9)
resilient decision-making (7)	Innovation (8)	Enable adaptation (4) Accept basin planning is an inherently iterative and chaotic process (5)

Following their introduction of the framework, the authors retroactively apply it to successful efforts to modify water management institutions in five (5) countries. Of note, their framework focuses more than others on the need to compensate those negatively impacted by reform efforts and emphasizes a robust valuation of water beyond its market price.

Rogers, P. & Hall, A. W., 2003. *Effective Water Governance,* Stockholm: Global Water Partnership Technical Committee (TEC). https://gwp.org/globalassets/global/toolbox/publications/background-papers/07-effective-water-governance-2003-english.pdf

Produced by the Global Water Partnership, an organization that claims nearly 4000 partner associations throughout the world, this white paper provides a high-level view of water governance in theory and practice. The authors define "governance" broadly to include both the legal structures that regulate the operation of water management agencies as well as the "informal" structures which influence their activity. Invoking the conclusion of the 2000 World Water Forum that *"that the water crisis is often a crisis of governance*," they argue that societies should organize and regulate their water system in a manner that facilitates "Integrated Water Resource Management (IWRM)." To this end they suggest that the water utilities and the institutional rules which govern them should be designed to reduce the "transaction costs" of integrated water management. They also provide references to the GWP "IWRM ToolBox" (https://www.gwp.org/en/learn/iwrm-toolbox), an online resource that provides advice to water professionals on institutional arrangements to build capacity.

Reuse and the Regulatory Framework

Blue Ribbon Committee, 2011. Report of the Blue Ribbon Committee, Los Angeles, CA: Metropolitan Water District of Southern Califonia (MWD)

When the directors of the Metropolitan Water District of Southern California (MWD) established their Blue Ribbon Committee (BRC) in January 2010 to "look over the horizon for strategies to meet the region's water-related needs fifty years out, they may not have known it would come back with a recommendation to reuse an additional 100 MGD of treated effluent. But to provide for sustainability for Southern California in the coming decades, a big increase in recycled water and other local sources (vs. imported water) was required (p. xxiv Table S.5. "Comparison of 2011 and 2060 Metropolitan Business Models."). The report provides insight into "The Steps to Get to 2060 Metropolitan Business Model" and how it needs to change to engage wastewater and stormwater agencies as partners (p. xxv Table S.6.) It also makes a clear case for change, listing the characteristics required for MWD to remain relevant to their membership over the coming decades as a "regional integrator" (pp. 48-53).

New partnerships with other agencies that manage water in the region will expand Metropolitan's capacity to implement a more integrated and efficient regional system with its members and take advantage of sources and storage facilities that could reduce regional vulnerabilities to supply disruptions.

Notably, the Blue Ribbon Committee's report also reaffirms that **"neighbors helping neighbors"** is an effective strategy. MWD's success a success was built on cooperation among the cities and agencies that together achieve goals that none could have achieved independently. From that perspective, MWD will not survive if it devolves into an amalgamation of water "haves" and "have-nots."

Cantu, C. 2015. People, Resources, and Policy in Integrated Water Resource Management. Pp. 201-219. Chapter 9 in Lassiter, A. Sustainable Water: Challenges and Solutions from California. University of California Press. (Cantu, 2015)

In this chapter from Lassiter's book on California water management, former general manager for the Santa Ana Watershed Project Authority (SAWPA) Celeste Cantu provides an overview of integrated regional water management (IRWM) principles and progress around the world, with specific applications to SAWPA. She describes the creation of a "One Water, One Watershed" committee (OWOW) with over 4000 members and an 11 member stakeholder committee, including everyone from the Army Corps of Engineers, the Regional Water Quality Control Board and water agencies, to local mayors and planning commissions. She explains how principles adapted from systems scientist Peter Senge form the basis of SAWPA's holistic approach, inspiring the agency to solve their collective watershed issues by "thinking anew" and adopting a watershed health based approach.

With respect to the role of regulation in interagency collaboration, Cantu describes how SAWPA included federal, state, and local regulators at every level in their committee (including the steering committee), creating "a shared vehicle" for understanding the interests, drivers, and concerns of all participants so that by the time an issue gets to the regional board it is well thought-out and resolved. "Every watershed has its own idiosyncratic history, challenges, and opportunities," Cantu claims, adding that "each enjoys past successes and suffers from old misunderstandings." She acknowledges that interpersonal communication skills often make up "the missing piece" (referencing Blomquist and Dinar).

This example of regional collaboration produced many significant achievements. Residents in the lower watershed helped pay for desalters in the upper watershed because they understood the bigger picture water quality and regulatory needs. Wetlands were employed to protect water quality and enhance groundwater recharge because of the multiple benefits they offered to participants including the private sector.

Freeman, J. & Rossi, J., 2012. Agency Coordination in Shared Regulatory Space. *Harvard Law Review,* March, 125(5), pp. 1134-1211.

This article does not describe how water agencies deal with their regulators or divide regulatory responsibilities but focuses instead on the "shared regulatory space," where agency regulatory responsibilities overlap. The authors propose that, as a result of legislative action, there are multiple "overlapping and fragmented" regulatory jurisdictions comprising "a complex thicket" requiring extensive coordination so that they can progress efficiently, effectively, and without surprises. It should be noted that this thicket is as complex for the regulators as for the regulated. (p.1135)

The paper includes a discussion of interagency agreements especially Memoranda of Understanding (MOUs), describing how agencies sign MOUs for a variety of purposes, including:

1. delineating jurisdictional lines;
2. establishing procedures for information;
3. sharing or production of information;
4. agreeing to collaborate in a common mission;

5. coordinating reviews or approvals where more than one agency has authority to act; and (in rarer cases subject to the Administrative Procedure Act 36),
6. agreeing on substantive policy.

The authors note that the content of MOUs varies widely. Though they tend to be short (less than 10 pages), some are quite detailed and may specify goals, assign responsibilities, establish metrics, commit personnel and funding, and establish responsibility for oversight. Some include deadlines for revisiting and updating the agreement, while others are more like framework documents that outline principles and leave more detailed elaboration to subsequent agreements or "implementing arrangements." In order to have successful recycling projects, the impact on the local agencies needs to be managed collectively at the local level.

National Research Council. 2012. Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater. Washington, DC: The National Academies Press. https://doi.org/10.17226/13303. Chapter 10 Social, Legal, and Regulatory Issues and Opportunities, pp. 165-192. (National Research Council, 2012).

This paper provides an excellent summary of a full range of issues pertaining to water reuse and includes an especially complete chapter on the regulatory framework. They not only identify the range of issues that project proponents need to consider, e.g., water rights as well as recycled water standards and waste discharge standards, but they illustrate how different states may have extremely different rules on the same subject matter. While not complete, and there are other types of regulations to be considered for deciding whether a water recycling program is appropriate and for, the paper gives a flavor of the range of regulations to be considered, albeit some outdated. Many regulations, of course, are at the local or state level (with federal guidance when the Clean Water Act is involved or where the state does not have a delegated program), but this summary is a good overview and preliminary checklist.

Nellor, M. H., & Larson, R. (2010). 08-01: Assessment of Approaches to Achieve Nationally Consistent Reclaimed Water Standards. *The Water Research Foundation.* https://watereuse.org/watereuse-research/08-01-assessment-of-approaches-to-achieve-nationally-consistent-reclaimed-water-standards/.

This White Paper assesses five potential alternatives to achieving national consistency in the quality of recycled water produced through reuse. The options were evaluated in terms of their advantages and disadvantages, how they would be implemented, and potential implementation obstacles. Water reuse in the United States is currently governed by individual state regulations and guidelines as there are no national regulations or guidelines in place. As some states lack regulations and there is no uniformity among the state regulations that do exist, concerns have been raised regarding confidence in reuse projects and public acceptance of projects. Project 08-01: Assessment of Approaches to Achieve Nationally Consistent Reclaimed Water Standards originates from the idea that a consistent and accepted treatment and/or monitoring scheme may, if reliably applied, provide enhanced public confidence in water reuse projects.

Economic Issues

Atwater, R., F. Dryden, and V. Grebbien. 1998. Urban Water Recycling Assessment Feasibility Guidebook. California Urban Water Agencies with assistance from the WateReuse Association of California. Bookman-Edmonston Engineering. September.

This report provides guidance and several strategies for how utilities can secure long-term water reuse customers by overcoming the various concerns and obstacles that often arise, including retrofit costs, concerns over system reliability and water quality, and long-term pricing guarantees. In addition, strategies to attract external funding are described.

Note that the BOR feasibility report grant guidance requires the agency submitting a request to identify interagency agreements and legal requirements along with solutions and a timetable:

from the **Preface**:

This Guidebook is to be used by a public water supply or wastewater disposal agency that may be considering developing a water recycling project. The purpose of the Guidebook is to provide an overview of the planning process for evaluating the feasibility of a water recycling project and the critical implementation issues. The Guidebook provides a method for developing answers to the following questions:

- How do you determine if there is a need?
- How much will it cost?
- Who has to be involved?
- What are the regulatory issues and hurdles?
- How to involve the public and other interested parties in the evaluation of the project feasibility?
- What are the next steps to determine feasibility?

The Guidebook addresses all the issues that should be considered, the technical and economic questions that should be addressed, and provides several case studies for comparison purposes. It briefly discussed issues and concerns to include in developing and evaluating a water recycling concept to the point of determining feasibility and potential financing mechanisms. (ER 7/1/20)

AWWA. 2008. *Water Reuse Rates and Charges: 2000 and 2007 Survey Results*. Denver, CO: American Water Works Association, Water Reuse Committee. Prepared by G. Carpenter, G. Grinnell, C. Haney, G. Jacobi, S. Koorn, D. O'Reilly, C. Pierce, C. Riley, A. Rimer, K. Thompson, and D. Vandertulip.

Survey results of water reuse utilities confirm that utilities often need to offer incentives to encourage the use of reclaimed water, especially for nonpotable purposes, because of the higher unit cost of most reclaimed water supplies relative to potable supplies, and the need to anticipate upward pressure on water and wastewater rates due to substitution. Hence, the price charged for reclaimed water is often capped at the potable water price, and more frequently the costs recovered are less than the full cost. This AWWA-sponsored survey of reclaimed water rates in 2000 and in 2007 showed rates for reclaimed water vary greatly from 20% to 100% of the potable water rate, with a median rate of 80%.

AWWA (2017) Manual of Water Supply Practices. M1—Seventh Edition. Principles of Water Rates, Fees, and Charges. Denver, CO: American Water Works Association.

Water and wastewater utilities typically use a cost-of-service (COS) rate setting methodology, based on a utility-specific study that is dependent on system characteristics, to recover the full cost of providing the utility's service. This is the predominant pricing methodology adopted in the U.S. A definitive discussion of the COS methodology for water service can be found in the American Water Works Association's (AWWA's) M1 service manual, *Manual of Water Supply Practices*. The M1 manual details the multi-step cost allocation process that underlies the COS methodology.

Unfortunately, for water reuse (especially NPR), COS-based pricing typically is not feasible, as creating a market for NPR requires incentivized pricing below the competing potable rate, resulting in a fiscal loss (reuse revenues less than costs) for most NPR programs. As described elsewhere, cross subsidies from potable water customers is often justified, however, based on benefits accruing to the potable system (e.g., avoided costs).

AWWA. 2019. *Water Reuse Cost Allocations and Pricing Survey*. Prepared by William B. Zieburtz, Jr., Mihaela Coopersmith, and Andrew Burnham, for the AWWA Technical and Education Council. (Denver: May, 2019)

The authors were engaged by AWWA to develop a survey, conduct interviews, and report on patterns in the cost allocation and pricing for reuse water service in the United States. The objective was to illustrate practices and to draw out lessons and opportunities, based on the practices of a sample of water utilities drawn from across the country. They found that utility efforts at cost allocation and pricing are highly varied and disconnected.

The authors discovered a wide diversity of approaches to pricing and cost recovery for reuse water programs. Their primary conclusion was that a "one size fits all" approach does not apply, and that "a fully informed approach to reuse pricing must focus on utility-specific policies and objectives, not on specific [cost] allocation processes, and be fully responsive to the unique conditions facing each reuse utility. It is not that cost of service principles do not apply, or that revenue adequacy, financial stability, or any other fundamental principle of utility management is irrelevant, it is rather that successful reuse programs are especially sensitive to local conditions, and that these conditions require the use of very different cost allocation and pricing strategies from locale to locale…"

Carpenter, G., G. Grinnell, C. Haney, G. Jacobi, S. Koorn, D. O'Reilly, C. Pierce, C. Riley, A. Rimer, K. Thompson, and D. Vandertulip. 2008. Water Reuse Rates and Charges: 2000 and 2007 Survey Results. Denver, CO: American Water Works Association, Water Reuse Committee.

Survey results of water reuse utilities confirm that utilities often need to offer incentives to encourage the use of reclaimed water, especially for nonpotable purposes, because of the higher unit cost of most reclaimed water supplies relative to potable supplies, and the need to anticipate upward pressure on water and wastewater rates due to substitution. Hence, the price charged for reclaimed water is often capped at the potable water price, and more frequently the costs recovered are less than the full cost. This AWWA-sponsored survey of reclaimed water rates in 2000 and in 2007 showed rates for reclaimed water vary greatly from 20% to 100% of the potable water rate, with a median rate of 80%.

CPUC. 2014. Decision 14-08-058. CPUC Rulemaking 10-11-014. California Public Utilities Commission. Issued August 29. Pp. 28–32.

An important ruling by the California Public Utilities Commission (which is the economic regulator for investor-owned water utilities in the state) recognizing that traditional COS-based pricing is unsustainable to support many water reuse projects, and that cross subsidies from potable system (and/or wastewater system) customers is justified and allowed.

Cristiano, T., and J. Henderson. 2009. Evaluating Pricing Levels and Structures to Support Reclaimed Water Systems. Denver, CO: WateReuse Research Foundation, Project 05-01.

The authors examine the fiscal challenges associated with pricing reuse water, and they note that one challenge is that reclaimed water is often used as a direct substitute for potable water demand (e.g., irrigation demand is switched from potable water to reclaimed water). Water utility costs are fixed in the short run in that costs do not vary much with usage. As reclaimed water usage is substituted for potable water usage, the amount of potable water consumption is reduced, but the costs of potable water production remain essentially fixed. The substitution of potable water by reclaimed water therefore results in an upward pressure on potable water and wastewater rates

De Souza, S., J. Medellín-Azuara, J. Lund, and R. Howitt. 2011. Beneficiary Pays Analysis of Water Recycling Projects. A report prepared for the State Water Resources Control Board, Economic Analysis Task Force for Water Recycling in California. March 9.

This report addresses challenges and approaches for applying a beneficiary pays approach for reuse cost recovery. Several methods are available to allocate cost under a COS methodology, one of which is the Separable Costs-Remaining Benefits (SCRB) method. The SCRB method is suited to allocating costs across users and purposes for the project in a manner that align with beneficiary pays. Costs are distributed among project purposes by identifying separable costs for each user or participant (the "private" costs that can be directly associated with that user), and then determining joint costs by subtracting separable costs from total project costs. The method then allocates joint costs or joint savings in proportion to each user's share of the remaining public benefits. This report also examines approaches for obtaining external funding support, such as via grants or low interest loans.

Hanson, L., P. Faeth, C. Glass, and M. Ramamoorthy. 2017. Economic Pathways and Partners for Water Reuse and Stormwater Harvesting. Alexandria, VA: Water Environment and Reuse Foundation.

This report describes various strategies that may be beneficial to water reuse utilities for dealing with challenging issues such as seasonal demands or other fluctuations in demand that might otherwise limit sales and revenues, and/or result in unused product water. Strategies for managing/reducing costs, as well as a basis for allocating costs between wastewater and water supply utilities, also are provided.

Raucher, R., K. Darr, J. Henderson, J. Rice, and B. Sheikh. 2006. An Economic Framework for Evaluating the Benefits and Costs of Water Reuse. Denver, CO: WateReuse Research Foundation, Project 03-06.

This report provides a rationale and guidance for applying a Triple Bottom Line (TBL) approach to fully identify, describe, and – to the extent feasible and credible – quantify and monetize all the benefits and costs associated with a water reuse option. A key distinction is made between a financial analysis (focused on *revenues* and costs), and an economic analysis (focused on *benefits* and costs). A step-by-step process is defined and illustrated for assessing benefits and identifying associated beneficiaries. By understanding the full range of benefits, a reuse project can be properly evaluated relative to its anticipated costs. And, by understanding the full range of benefits, the beneficiary pays approach can be more readily developed to generate the fiscal revenues required to pay for reuse programs generating positive net benefits.

Watson, R., Fane, S., & Mitchell, C. (2016). The Critical Role of Impact Distribution for Local Recycled Water Systems. International Journal of Water Governance, 4(1), 1-18.

This report describes how when recycled water systems are delivered at a different scale and/or by a different provider, compared to the centralized potable water system, a different and much broader distribution of impacts will arise than has traditionally occurred. Most significantly, it can place the upfront and ongoing costs on a smaller customer group than larger centralized systems. In contrast, as a cumulative strategy, benefits of local recycled water systems can accrue to the broader community (greening, urban cooling) and potentially to the public utility (avoided costs, enhanced resilience).

Watson, R., P. Mukheibir, and C. Mitchell. 2017. Recycled Water Investment in Sydney—What's Happening and Why. OzWater 17. Sydney, Australia: AWA.

This report describes the various challenges associated with trying to quantify and value many of the important benefits associated with water reuse projects, and the authors suggest approaches to address these challenges. The application to the setting of Sydney, New South Wales (Australia) is provided. Continuing to improve measurement and assessment tools, particularly in the areas of resilience and liveability, will be an important factor in improving the capacity to make efficient recycled water investment decisions. However, the full picture is more complex. Considering the interplay among environmental, social, and regulatory conditions, together with the interaction between recycled water and the centralized potable system, is critical for identifying and measuring impacts more robustly. The proposed approach will assist in both robustly identifying and valuing recycled water investment, and fairly allocating benefits to the full range of beneficiaries.

Management Issues

CUWA, 2016. *Potable Reuse Operator Certification White Paper,* Walnut Creek: California Urban Water Agencies.

The introduction of nonpotable reuse as a common practice changed the focus of operations from regulatory compliance and the preservation of aquatic ecosystems to protection of public health, as recycled water was applied to parks and schoolyards. Treatment of wastewater to potable standards represents an even more significant challenge to the operators of conventional water and wastewater treatment plants, who often gained their experience with different technologies. As this foundational report by the California Urban Water Agencies (CUWA) notes, *"Such systems use complex treatment trains centered on reverse osmosis (RO) and advanced oxidation processes (AOPs) not present in conventional WWTPs and WTPs."* The report served as guidance to the California and Nevada water and wastewater associations in their development of a certification process for Advanced Water Treatment Operators (AWTO) which has become a model for similar certifications through the United States. In addition to the details of certification, the report provides evidence of the fundamental changes confronting water and wastewater agencies as they evolve into organizations dedicated to sustainable resource recovery.

Martz, R. J., McCarthy, W. J. & Morris, J. . C., 2017. The Consent Order as Mandated Collaboration: The Case of Hampton Roads Sanitation District. *Public Works Management & Policy,* 23, 2(2), pp. 168-185.

This article offers a detailed account of Hampton Roads Sanitation District's collaboration with the Tidewater Virginia cities to create the Sustainable Water Initiative for Tomorrow, also profiled in the WRAP Action 2.16 report. The authors' contention that the consent order mandated collaboration seems to understate the importance of HRSD leadership and local water managers commitment to the common good, Nevertheless they offer a rare "play-by-play" account of the negotiation process, including the agencies reluctance to share data and its critical significance in moving the project forward.

Rosenblum, E. (2017). Institutional Issues and Agreements Required to Reuse Municipally Treated Effluent. Walnut Creek, CA: Carollo Engineers.

This slide deck contains a number of tables listing the issues which arise between agencies working together to reuse water in the San Francisco Bay Area. It includes a graphic depicting the highly fragmented status of water management in that region including overlapping jurisdictions of water treatment, wholesale and retail water supply, sewage collection, wastewater treatment, and wastewater discharge agencies. It also includes examples of terms negotiated in cooperative agreements executed between cooperating entities. It was presented to the Northern California chapter of WateReuse in December 2017.

Interpersonal Issues and Leadership

Burn, S., Maheepala, S., & Sharma, A. (2012, 07). Utilising integrated urban water management to assess the viability of decentralised water solutions. Water Science and Technology, 66(1), 113-121. doi:10.2166/wst.2012.071

This paper explores Integrated Urban Water Management (IUWM) and its applications, using the Australian water sector as an example. Though it primarily focuses on a decentralized approach, it applies a collaborative lens and offers a set of activities to identify opportunities for implementation, highlight the individual champion, and reinforce the necessity of engagement with key stakeholders, and underscore the importance of organizational support from complementary utilities and agencies.

Bahri, Brikké, F., & Vairavamoorthy, K. (2016, 08). Managing Change to Implement Integrated Urban Water Management in African Cities. Aquatic Procedia, 6, 3-14. doi:10.1016/j.aqpro.2016.06.002

The paper identifies the critical issues for improving uptake and scaling up of integrated urban water management (IUWM), including strong leadership, the commitment of government and the institutions involved, and a formal approach to capacity building and technical assistance in three African locations. Specifically, it identifies the importance of leadership from government as well as the Public Utilities Commission in scaling urban water management and expanding water reuse. Bahri et al concludes, "Strong leadership and commitment from the national government, city policymakers and elected officials is essential in driving the IUWM process, for coordinating across city departments and for fostering a supportive staff environment."

Bettini, Y., Brown, R. R., & Haan, F. J. (2015). Exploring institutional adaptive capacity in practice: Examining water governance adaptation in Australia. Ecology and Society, 20(1). doi:10.5751/es-07291-200147

Through studying different responses to drought in Australia, this paper highlights three forms of adaptive capacity that appear critical: the ability to learn, decide, and act. "The analytical approach developed provides insight into change dynamics and the agency mechanisms that generate them. The paper proposes a typology of adaptive capacity by characterizing these change dynamics and mechanisms for locked-in, crisis, reorganizing, and stabilizing systems." Additionally, this paper examines leadership and the various forms it must take on in order to successfully navigate change and opportunities to adapt in rapidly shifting environments.

Daley, D. M. (2008, 10). Interdisciplinary Problems and Agency Boundaries: Exploring Effective Cross-Agency Collaboration. Journal of Public Administration Research and Theory, 19(3), 477-493. doi:10.1093/jopart/mun020

This research explores what conditions are needed to promote interagency collaboration across two state departments. The author uses departments in the state of Wisconsin for her research and concludes that trust and leadership is essential for long-term collaboration and that, not surprisingly, long-term collaboration relies on partners trusting each other. Daley's study also reports that state department personnel indicated that support from top leadership in forming and sustaining collaborative relationships across departments was important.

Meyer, C. (2017, 03). UN World Water Development Report 2017: "Wastewater: The untapped resource". doi:10.29104/wins.d.0002.2018

This 2017 report gives an extensive overview of the opportunities and challenges to develop water reuse and recycling projects. Most importantly, wastewater is framed as a resource with potential to enhance local water capacity, security, and resilience.

Thakhathi, Andani, "Champions of Change and Organizational Development: A Return to Schön and Typology for Future Research and Practice" In Research in Organizational Change and Development. Published online: 30 Jul 2018; 265-306. https://doi.org/10.1108/S0897-301620180000026007

This study explores organizational development and seeks to understand the drivers of champions of change. The author undergoes a rigorous review of the typology of champions since the 1960s and distills the fragmented literature into ten meta-champions, which reflect the primary ways in which people are compelled to drive change.

Figure 23. The Meta-champions of Change and Organizational Development (OD) Typology (Thakhathi, 2018)

Reibenspiess, V., Drechsler, K., Eckhardt, A., & Wagner, H. (2018). Enabling Innovation Champions in Organizations - Results of a Systematic Literature Analysis. Proceedings of the 51st Hawaii International Conference on System Sciences. doi:10.24251/hicss.2018.523

"Based on a systematic literature analysis, this paper takes stock of the current landscape of research on innovation champions from an individual and organizational perspective: 149 journals and conference proceedings were examined on the topic of innovation champions. 85 articles were identified as relevant and systematically categorized according to two perspectives by synthesizing enablers of innovation champions on the individual (e.g., skills) and organizational level (e.g., knowledge management). While our analysis illuminates a high variety of enablers that influence innovation champions, the descriptive findings show a stronger focus of innovation champion studies on individual level enablers."

Tollman, P., Keenan, P., Mingardon, S., Dosik, D., Rizvi, S., & Hurder, S. (2020, December 02). Getting Smart About Change Management. Retrieved December 27, 2020, from https://www.bcg.com/publications/2017/change-management-getting-smart-about-change-management

This piece delves into four "fatal errors" through which innovation via change programs may come to an abrupt halt within an organization. Notably, Fatal Error 2 is Underengaging the Extended Leadership Team. Essentially, innovations may fail because only the senior leadership team (thought leaders) understands the who, when, and why; those who may be in charge of implementing a change or innovation are often not adequately brought into the process and thus, do not feel brought into the change or may even feel disincentivized to enact the change because they have not been engaged with the greater vision.

Warrick, D. (2017, 05). What leaders need to know about organizational culture. Business Horizons, 60(3), 395-404. doi:10.1016/j.bushor.2017.01.011

Organizational culture is linked to leadership development and the sustaining of an organization during times of change and transition. Warrick asserts that, "Although many factors influence culture, organizational cultures primarily reflect their leaders." This research provides a comprehensive description of conditions that are needed to build a high performing, organizational cultures.

Wolf, J. A. (2010). Transcending paradox: Movement as a means for sustaining high performance. In R. W. Woodman, W. A. Pasmore, & A. B. Shani (Eds.), Research in organizational change and development (Vol. 18, pp. 77_107). Bingley, UK: Emerald Group Publishing Limited.

With the rapidly changing times, we now regularly operate and plan in a state of "permanent whitewater." The author drives home the need to shift and adapt ones thinking and approach to be able to understand and distill information as it is presented in order to make action-based decisions. The author hypothesizes that this is necessary to sustain high performance and relevant, meaningful, organizational impact.