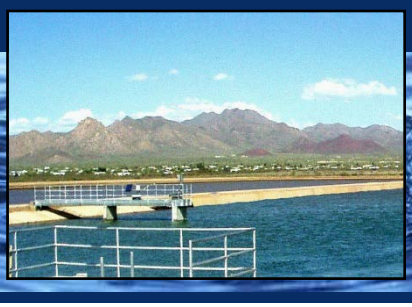
CITY OF TUCSON FOUNDED 1775

TUCSON WATER

RECYCLED WATER MASTER PLAN



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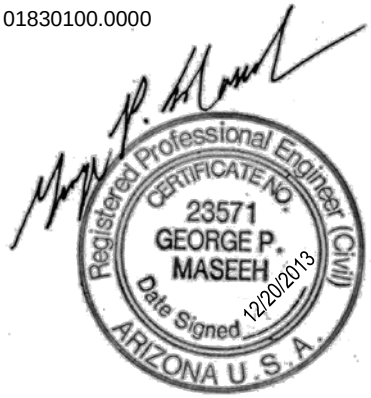

EXPIRES 09/30/2015

Executive Summary

December 2013

MALCOLM PIRNIE | ARCADIS

The Water Division of ARCADIS

EXECUTIVE SUMMARY

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The overall purpose of the *Recycled Water Master Plan* is to provide an integrated recycled water program that maximizes the benefits of the City's recycled water resource. This document provides information to City of Tucson decision makers, Tucson Water customers, and other stakeholders on the planned use of the City's recycled water both in its Reclaimed Water System (RWS) and through other means.

In addition, the *Recycled Water Master Plan* provides a framework for next steps and continued activities that will help ensure the timely implementation of the necessary recycled water projects and programs. These in turn will help achieve Tucson Water's objectives, ensure the long-term sustainability of the Utility's water resources, and enable it to keep its commitment to **"Water Reliability"** for its customers.

Tucson Water's Water Reliability Program includes investments and commitments to ensure our customers have a reliable water supply and system today and in the future. The Program encompasses five areas: water supply, water quality, water customers, water operations and systems, and water conservation and efficiency.

WaterReliability

Introduction

Prior to importation of Colorado River water through the Central Arizona Project (CAP) and establishment of the Clearwater blended water program, Tucson Water had supplied groundwater to meet all potable water demands. The Arizona Groundwater Management Act of 1980 requires that groundwater usage be replaced with renewable water supplies such that "safe yield" of aquifers in portions of the State designated as Active Management Areas (AMAs), including the Tucson AMA, is achieved by 2025. In response, Tucson Water started producing and distributing reclaimed water to large turf customers in 1984 (current reclaimed water system is shown on Figure ES-1) and started importing CAP surface water in 1992 to 1994 (CAP Canal to Tucson is shown on Figure ES-2), and again after the Clearwater Program began operation in 2001. Currently, CAP water, groundwater, and reclaimed water comprise Tucson's water supplies, with groundwater still being utilized to meet peak water demands, to provide backup for emergencies and shortages on the CAP system, and to serve as a finite bridge supply until additional renewable supplies are acquired for the future.

Through the Clearwater Program, Tucson Water received its full CAP allocation for the first time in 2012. However, CAP supplies are nearly fully-allocated and the potential for additional allocations in the future are not promising. Over its three-decade history, the Reclaimed Water System (RWS) has grown to serve irrigation water to many of the golf courses, schools, and parks in metropolitan Tucson and is not anticipated to add significant additional demand in the future. This means that Tucson Water's recycled water supply that is not used in the RWS will continue to be discharged into the Santa Cruz River near the downgradient end of the Tucson Basin, where much of the resource leaves the basin without benefit to the community.

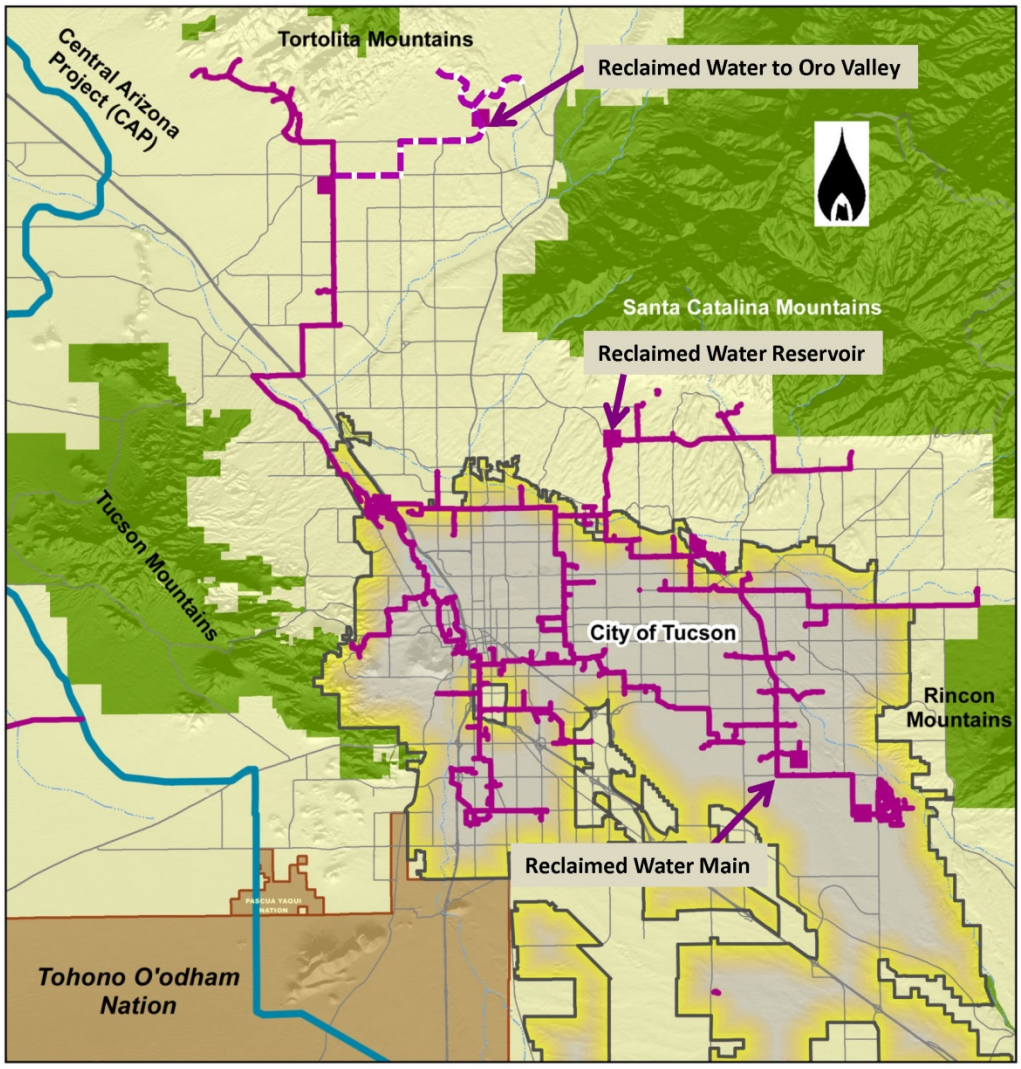

Figure ES-1. The Reclaimed Water System (RWS)

Recognizing that future impacts of sustained drought and climate change will result in shortages to the City's CAP allocation, it is necessary to fully utilize local renewable supplies to provide a reliable and sustainable supply portfolio to meet future demands. Recycled water is the only remaining additional local, renewable water resource available to Tucson. Unused treated wastewater is a valuable resource that can be used to establish additional renewable water supplies that will supplement existing supplies to meet future water demands in the Tucson Water service area.

Figure ES-2. The Central Arizona Project (CAP)

Community Investments in Water Resources

The metropolitan Tucson community has already made large investments and will continue to make investments to bring CAP water into the community and to manage wastewater (Figure ES-3 and Table ES-1). The Clearwater Program currently supplies the majority of Tucson's water supply, allowing for reduction of groundwater pumping in the Central Wellfield, and will continue to do so in the future. Full implementation of additional infrastructure supporting reliability of the Clearwater facilities is a primary initiative within Tucson Water's capital improvement program (CIP) planning horizon. When complete, a total of approximately $314 million will have been invested in the Clearwater Program to reliably deliver and make use of Tucson's allocation of CAP water, and $39 million will continue to be spent annually to purchase the CAP allocation and to operate and maintain the Clearwater infrastructure.

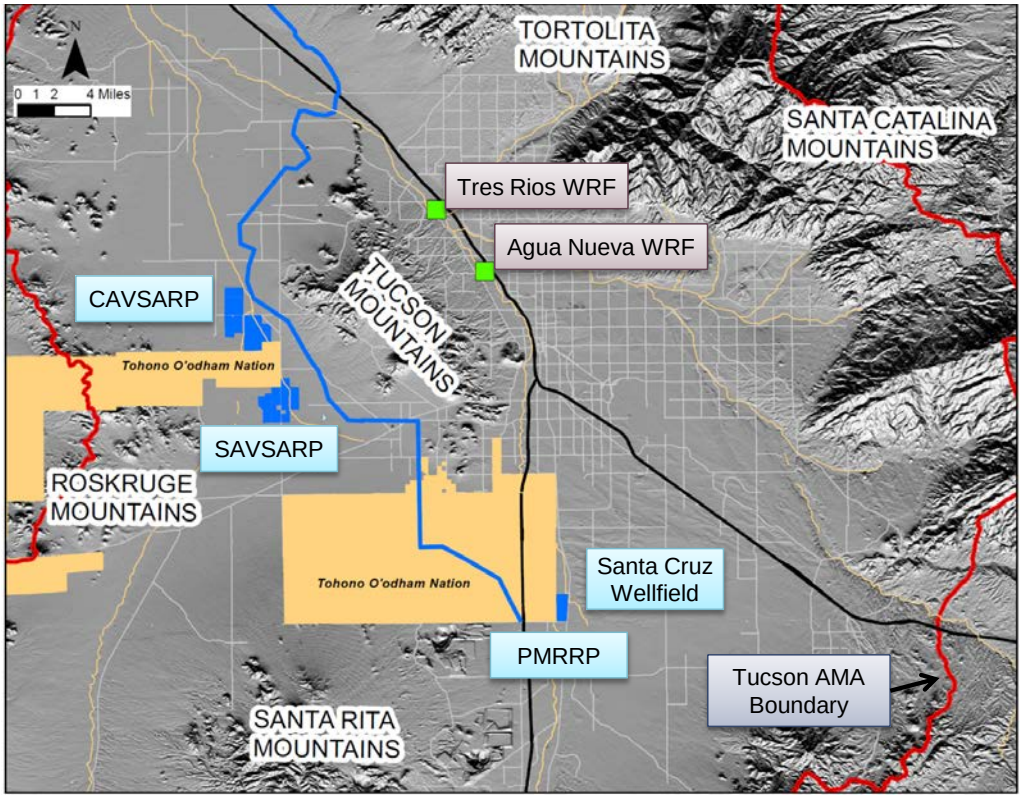

Figure ES-3. Clearwater Program Facilities

Table ES-1. Community Investments in Water Resources

Facility/Program	Capital Investments Already Made	Planned Capital Investments	Current Annual Investments
Purchase CAP allocation (144,191 AFY)	--	--	$20,800,000
Clearwater Program (Tucson Water)			
CAVSARP	$80,600,000	--	$8,300,000
SAVSARP	$47,900,000	$17,000,000	$8,600,000
PMRRP	$5,500,000	--	$200,000
Santa Cruz Wellfield	--	$6,700,000	$700,000
Reliability, Resiliency, and Redundancy Projects	--	$156,000,000	--
Subtotal Clearwater	**$134,000,000**	**$179,700,000**	**$38,600,000**
ROMP (Pima County)	$288,100,000	$372,000,000	$15,000,000
Totals	**$422,100,000**	**$551,700,000**	**$51,100,000**

The potable water used for domestic and industrial purposes is discharged to the Pima County Regional Water Reclamation Department (PCRWRD) wastewater treatment

facilities. These Pima County facilities are the source for Tucson Water's recycled water supplies. The community has made a significant investment in implementing PCRWRD'S Regional Optimization Master Plan (ROMP) to replace aged treatment infrastructure, meet new environmental regulations; and, ultimately, to improve recycled water quality. The ROMP program includes upgrading and expanding the Tres Rios Wastewater Reclamation Facility (WRF), which was formerly known as the Ina Road WRF, building a new Agua Nueva WRF to replace the existing Roger Road WRF, and installing pumps and pipelines to transfer wastewater between the two plants. When complete, approximately $660 million will have been invested in ROMP, and $15 million per year will continue to be spent to treat and manage the recycled water.

Despite all of these major community investments, only a little over 50 percent of Tucson Water's recycled water is being reused or stored for future use. A new recycled water program would maximize the value of these investments by converting a valuable resource that is currently being lost from the basin into a new renewable supply to support metropolitan Tucson's water sustainability.

Preparing for Tucson's Water Future

To plan for a reliable water future, Tucson Water has produced three comprehensive, integrated long-range plans over the last 25 years: the *Tucson Water Resources Plan 1990-2100, Water Plan: 2000-2050,* and the *2008 Update to Water Plan: 2000-2050.* The *2012 Update to Water Plan: 2000-2050* is also currently being prepared and is scheduled to be complete by the end of 2013 (Figure ES-4).

Figure ES-4. Tucson Water's Long Range Water Planning Documents

Each one of these plans recognized the importance of recycled water for both non-potable use in the RWS and for possible future potable use, thus setting the stage for the development of a *Recycled Water Master Plan*.

During the development of the 2009 City of Tucson/Pima County *Water & Wastewater Infrastructure, Supply & Planning Study,* the need for a comprehensive, long-range recycled water plan was again recognized and was included in the *2011-2015 Action Plan for Water Sustainability* (Figure ES-5).

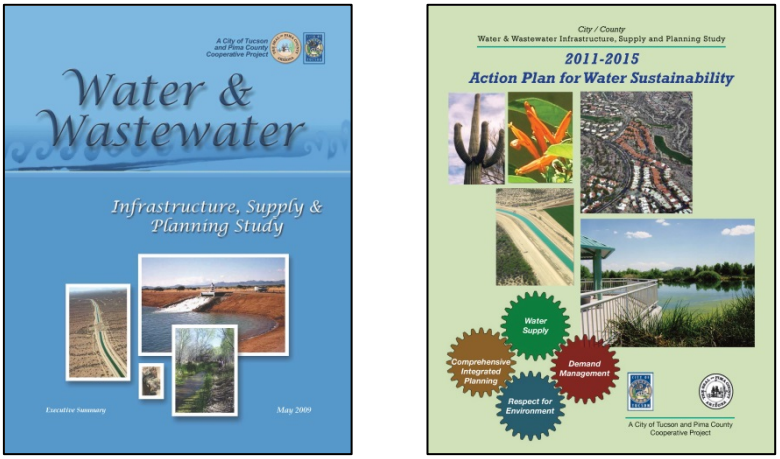

Figure ES-5. City/County Joint Long-Range Water & Wastewater Planning

Maintaining a Designation of Assured Water Supply (AWS) is vitally important for demonstrating availability of long-term, reliable water resources to support current and future water customers for communities in Arizona. Tucson Water is currently conducting an update to its long-range water planning efforts to prepare for application to extend the current Designation which expires in 2015. The *2012 Water Plan Update* projects that current CAP allocations will be sufficient for Tucson Water's "obligated service area" through approximately 2040, based on conservative assumptions of per-capita water use and occurrence of shortage on the CAP system (Figure ES-6). After 2040, the *Water Plan Update* indicates that the CAP allocations can be supplemented with a combination of Tucson Water's renewable and finite water supplies. Renewable supplies include recycled water and Central Arizona Groundwater Replenishment District (CAGRD) replenishment water. Finite supplies include Arizona Water Bank credits, long-term storage credits, and incidental recharge.

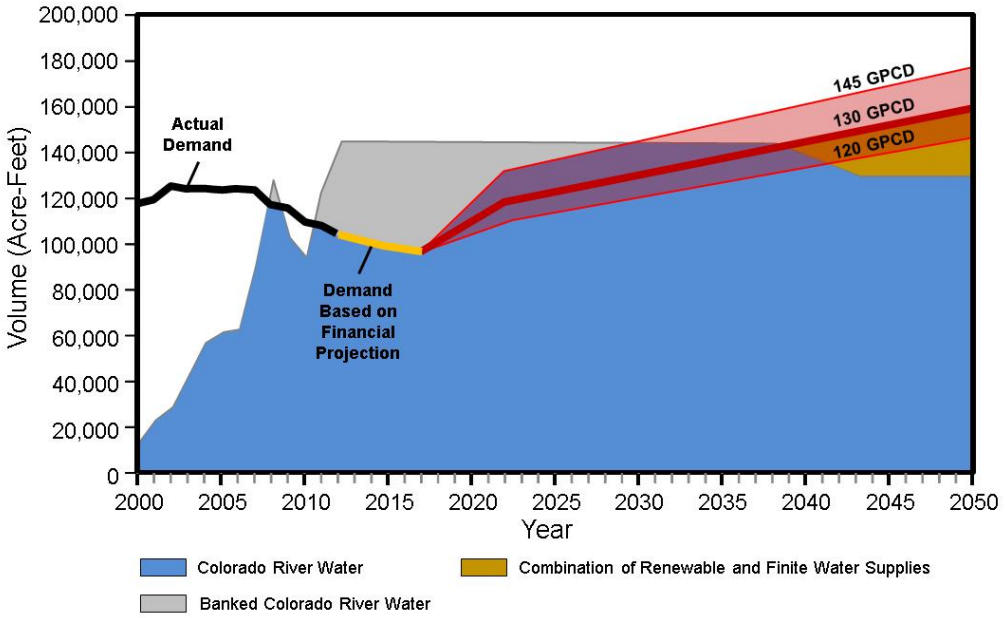

Figure ES-6. Projected Water Demand and Supply for Tucson Water's Obligated Service Area

Because the use of renewable supplies is more reliable and sustainable than finite supplies, it is prudent for Tucson Water to begin establishing additional renewable supplies so that it will be available for use well before potential supply shortfalls become imminent.

The *2012 Water Plan Update* concludes that Tucson Water should continue full use of its CAP allocations and complete capital programs to increase its reliability, redundancy and resiliency; continue efficiency and conservation efforts that will increase long-term reliability; and, begin outreach and demonstration of advanced treatment for recycled water.

Because there is not an immediate urgency, Tucson Water has time to carefully plan new recycled water programs. However, since planning, design, permitting, and construction for infrastructure will require significant lead time and establishment of funding, phased planning and implementation efforts should progress consistently to avert the need for urgent responses in the future.

Recycled Water Master Plan Goals

The goals and objectives of the *Recycled Water Master Plan* are consistent with the broader resource planning goals of Tucson Water's long-range water planning efforts:

Meet Projected Reclaimed Water Demand. The Utility's reclaimed water demand has grown since the mid-1980s, when it was first utilized. Current population projections within the Tucson Water service area indicates that reclaimed water demand will increase in the foreseeable future, albeit at a slower rate.

Utilize the Balance of the City's Recycled Water to Reinforce Vulnerable Supplies and Ensure Supply Reliability. In order for the community to be sustainable into the longer term future, Tucson Water will need to maximize its use of the projected unused portion of its recycled water. This will help strengthen currently available supplies that will be vulnerable to shortage in the future.

Continue to Meet Potable and Recycled Water Quality Targets. In addition to complying with federal, state, and local regulations, Tucson Water must also be responsive to the water quality expectations and preferences of its customers.

Manage Costs and Rate Impacts. Projects and programs to maximize the use of Tucson Water's available recycled water must be cost-effective.

Augment the City's Assured Water Supply Designation. The Assured Water Supply Program regulated and administered by the Arizona Department of Water Resources limits the amount of groundwater that utilities can legally withdraw. Expanded use of recycled water will provide Tucson Water with the ability to further reduce its reliance on groundwater for municipal supply.

For 20 years, NWRI – a science-based 501c3 non-profit located in Fountain Valley, California – has sponsored projects and programs to improve water quality, protect public health and the environment, and create safe, new sources of water.

The *Recycled Water Master Plan* assesses the potential to improve the RWS and expand to add new customers, and evaluates how Tucson Water's unutilized recycled water supplies can be used to maximize benefits to the community.

An important element of the planning process was interaction with an Independent Advisory Panel of experts in the water reuse industry. The Independent Advisory Panel for this effort was formed and administered by the National Water Research Institute (NWRI). NWRI specializes in working with researchers across the country, such as laboratories at universities and water agencies. The Panel evaluated topics related to public health and safety, public outreach and advocacy, groundwater, advanced treatment technologies, and other topics related to recycled water reuse.

The customer outreach activities started as part of the planning process will be continued and expanded as Tucson Water implements the recycled water program

Another important element of the planning process was to begin formulating plans for outreach to Tucson Water customers. The planning process included activities to begin identifying customer outreach messages by visiting successful indirect potable reuse programs and by reviewing best practices developed by these and other successful programs. The work found that public/customer education for a recycled water program should begin early in the process and continue throughout its planning and development. Outreach should seek to engage City and Utility leadership and staff and, eventually, create community-wide support for the program.

Reclaimed Water System

The RWS is currently near full capacity with over 900 customers, including 23 golf courses, 60 schools, 49 parks, and hundreds of residential customers. The RWS has effectively done the job that was originally intended, the conversion from potable or groundwater resources used for non-potable purposes into a system that is now fully renewable for those needs. The RWS has allowed Tucson Water to retain non-renewable groundwater resources for future use or to allow those groundwater credits to be stored indefinitely. Recycled water use in the RWS will continue to be an important component of Tucson Water's Designation of AWS to demonstrate water supply reliability. For these reasons, Tucson Water is committed to continuing reliable reclaimed water service into the future. Recommendations for the RWS are presented on Table ES-2 and Figure ES-7.

It is recommended that improvements be made to the RWS to address existing system deficiencies and provide better service for existing and future Tucson Water customers, which include existing Pima County and Oro Valley Water Utility demands. The recommendations include the following:

- The **North Loop Improvements** are the highest priority improvements. The northwest area represents the highest volume of reclaimed water deliveries and provides the largest source of reclaimed water revenues. This loop would also improve service to Oro Valley and would prepare the system for future service to MDWID.
- The **Dove Mountain Area Improvements** are the second priority improvements. The primary improvement is a new storage 6 MG reservoir which will improve service in the entire northwest area. The improvements will address storage deficiencies and would improve the ability to meet contractual agreements with golf courses during peak demand periods.
- The **Northeast Loop Improvements** are the third priority improvements and would supplement booster pumping and storage at the La Paloma reservoir, and address deficiencies in nearby pipelines. The improvements, which include a new 7.3 MG reservoir, will improve reliability and the ability to meet contractual agreements with golf courses in the La Paloma area during peak demand periods.

Additional recommendations to serve future Tucson Water reclaimed water demands (including existing Pima County and Oro Valley demands) include various booster pumping expansions and upgrades.

Unutilized Recycled Water Supplies

The City of Tucson has legal rights to wastewater generated within its service area. These "effluent entitlements" are based on agreements with the federal government, Pima County, and various other local governmental entities. There are also agreements in place whereby Tucson Water can deliver reclaimed water allotted to other entitlement holders to various reuse sites through the RWS.

Conservation Effluent Pool - A Dedicated Water Supply for the Environment

As part of its commitment to enhancing the local environment, Tucson Water has undertaken an initiative, which figures prominently in determining its effluent entitlements. The City has collaborated with Pima County to allocate up to 10,000 acre-feet (AF) of effluent per year to create or enhance riparian (water-influenced) ecosystems through an agreement entitled the Conservation Effluent Pool (CEP).

Contributors to the CEP are Tucson Water, Pima County and all other water providers that have an effluent entitlement. Applications for CEP resources may be submitted by local entities that can develop restoration projects that only need supplemental water for a short establishment period (three to five years) so more projects can be completed over time. If there are no projects requesting CEP resources, then the CEP pool reverts back to the individual contributors.

Recent Effluent Entitlements

In 2012, approximately 61,400 AF of recycled water was produced by the Pima County metropolitan wastewater reclamation facilities (Table ES-3). Since none of the CEP was utilized in 2012, its allotted volume reverted back to the contributing entities. The City's entitlement was approximately 25,100 AF. In 2010, Tucson Water reused approximately 9,400 AF to meet the needs of its RWS customers and 4,000 AF was banked as long-term storage credits. A significant portion of the City's entitlement (11,700 AF) left its service area as surface flow after it was discharged to the Santa Cruz River channel without further physical or economic benefit to the City.

Projections of Effluent Entitlements

The *Recycled Water Master Pla*n developed a range of projections for Tucson Water's effluent entitlements:

- A "High" range based on the most recent "official" regional wastewater flow projections and assuming that the CEP allotment was not being utilized.
- A "Low" range based on 90 percent of the regional wastewater flow projections and assuming that the CEP allotment was being utilized by non-Tucson Water users.

Table ES-2. Recommended RWS Improvements and Cost Opinions

Project No.	Improvement	Projected Capital Costs ($1,000) [1,2,3]			
		Near-Term	Mid-Term	Long-Term	Total
IMPROVEMENTS TO ADDRESS EXISTING SYSTEM DEFICIENCIES (not in current CIP)					
North Loop Improvements (Priority 1)					
P-1	Pipe - 24-inch diameter, 57,500 LF	$20,400			$20,400
BPS-1	Booster Station - 14 MGD @ 270 ft	$2,900			$2,900
Subtotal		$23,200			$23,200
Dove Mountain Area Improvements (Priority 2)					
	Pipe				
P-2	8-inch diameter, 2,300 LF	$400			$400
P-3	12-inch diameter, 5,500 LF	$1,100			$1,100
P-4	16-inch diameter, 2,100 LF	$600			$600
T-1	Storage - 6 MG	$8,300			$8,300
Subtotal		$10,200			$10,200
Northeast Loop Improvements (Priority 3)					
	Pipe				
P-5	16-inch diameter, 10,600 LF	$1,500	$1,200		$2,700
P-6	24-inch diameter, 18,800 LF	$3,700	$3,000		$6,700
BPS-2	Booster Station - 5 MGD @ 340 ft	$1,700	$1,400		$3,100
T-2	Storage - 7.3 MG	$5,600	$4,600		$10,200
Subtotal		$12,300	$10,100		$22,400
Subtotals Existing System Deficiencies		**$45,700**	**$10,100**		**$55,800**
IMPROVEMENTS TO SERVE FUTURE TUCSON WATER DEMANDS (unless noted, not in current CIP)					
BPS-3	Tucson Reclaimed Water Plant Booster Station [4] 8 MGD @ 440 ft		$2,700		$2,700
BPS-4	Houghton Road Booster Station 1.5 MGD @ 220 ft			$900	$900
BPS-5	Thornydale Booster Station [5] 4.4 MGD @ 270 ft	$2,600			$2,600
BPS-6	Thornydale Booster Station [5] 5.4 MGD @ 270 ft			$3,200	$3,200
Subtotals Future Tucson Water Demands		**$2,600**	**$2,700**	**$4,100**	**$9,400**
GRAND TOTALS		**$48,300**	**$12,800**	**$4,100**	**$65,200**

[1] *January 2012 (ENR CCI = 9176)*
[2] *Cost opinions include engineering & administration at 25% and project contingencies at 30%*
[3] *Fiscal Year ending June 30 of the year indicated*
[4] *Project included in Tucson Water's proposed 10-year CIP*
[5] *Thornydale Booster Station upgrades necessary to serve future Oro Valley reclaimed water demands. Recommended system improvement added at request of Tucson Water staff for planning purposes (Oro Valley will be responsible for the recommended improvements).*

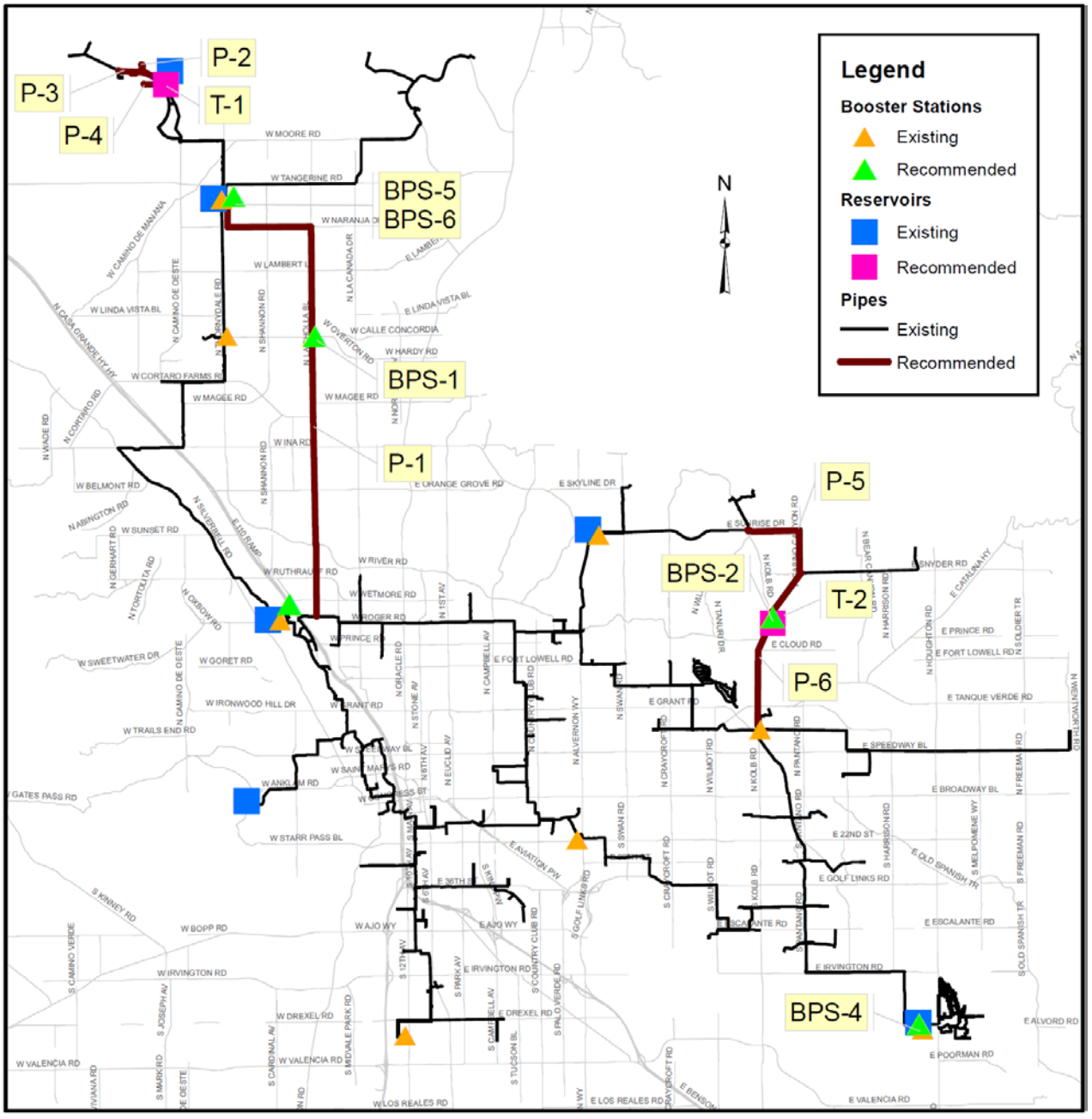

Figure ES-7. Recommended RWS Improvements

Table ES-3. Effluent Entitlements in Calendar Year 2012

Entities with Effluent Entitlements in 2012	Volume (AF)	Percent of Total
Secretary of Interior/SAWRSA	28,200	46%
City of Tucson/Tucson Water	**25,092**	**41%**
Pima County	3,319	5%
Metropolitan Domestic Water Improvement District	2,172	4%
Town of Oro Valley	1,928	3%
Flowing Wells Irrigation District	639	1%
Spanish Trail	43	>1%
Total	**61,393**	**100%**

The projections indicate that the City's annual effluent entitlement from the metropolitan area wastewater reclamation facilities could increase to as much as 46,000 AF by 2030 depending on actual wastewater flows and actual utilization of the CEP allotment (Figure ES-8).

The amount of Tucson Water's effluent entitlements (now "recycled water" after water reclamation treatment) available to be removed from river discharge and utilized for other purposes will depend on demands within the RWS and other existing non-potable uses. The projections indicate that the City's unutilized recycled water supply from the metropolitan area facilities could increase to as much as 29,000 AF by 2030 depending on actual wastewater flows and actual utilization of the CEP allotment.

Variations in Availability of Unutilized Recycled Water

The amount of unutilized recycled water will vary throughout the year due to the wide variation in RWS irrigation demands (the primary reclaimed water use) and other non-potable uses. Almost all of the recycled water is unutilized during the winter period when irrigation demands are low, and almost all of it is utilized during the summer high irrigation demand periods. This high variation in unutilized recycled water supplies figures prominently in sizing of new recycled water program facilities and infrastructure.

It is projected that in 2020, the maximum recycled water availability could vary from 19 to 32 MGD during the low reclaimed water demand period, to 0 to 8 MGD during the high demand period (Figure ES-9). In 2030, the maximum recycled water availability is projected to vary from 26 to 41 MGD during the low demand period, to 1 to 14 MGD during the high demand period (Figure ES-10).

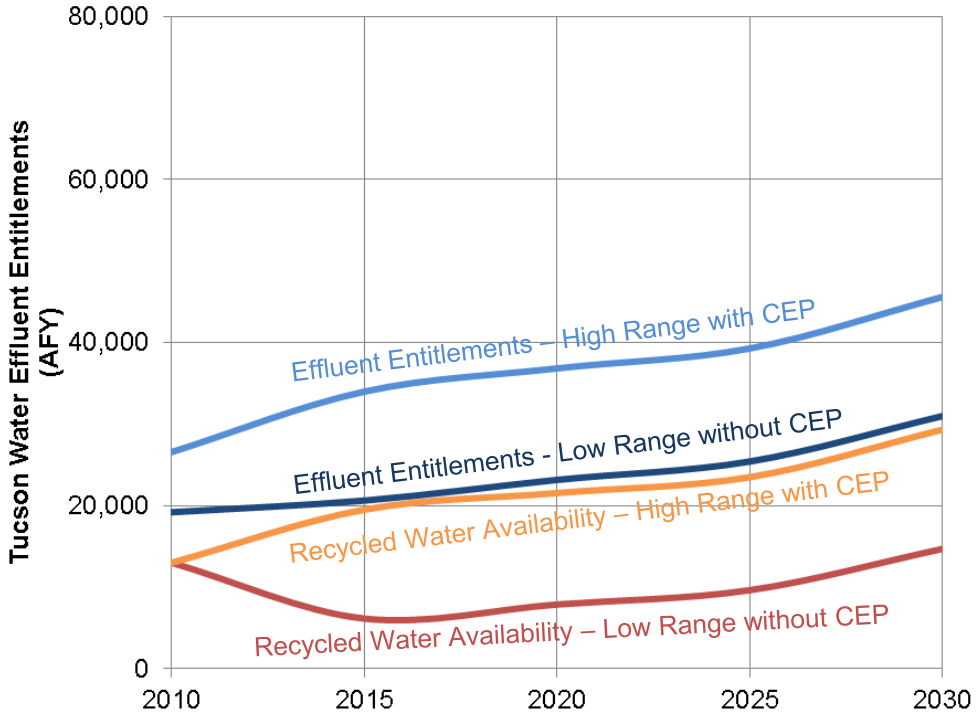

Figure ES-8. **Effluent Entitlements and Recycled Water Available For Other Programs from Metropolitan Area Reclamation Facilities**

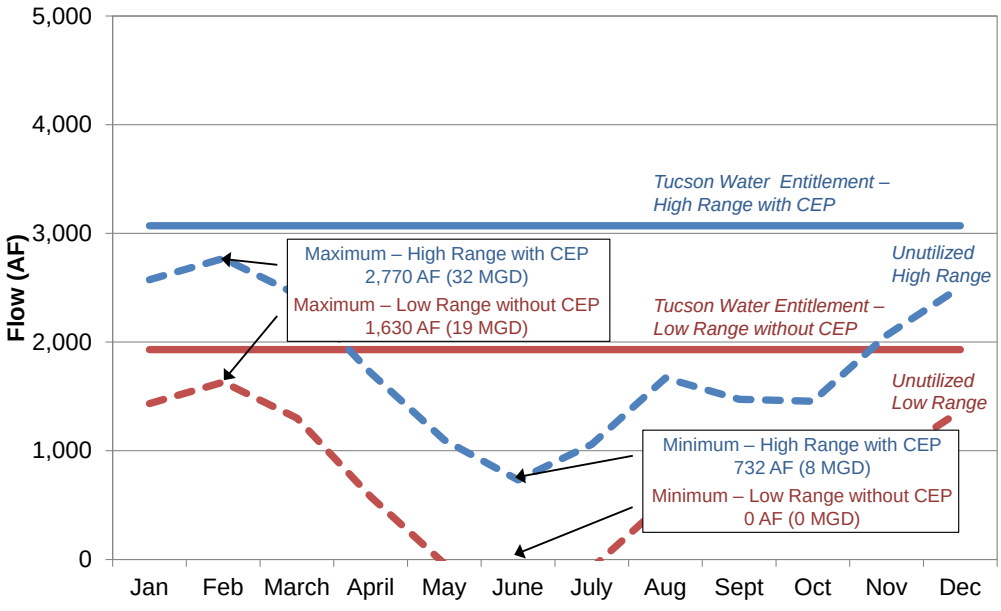

Figure ES-9. **2020 Projection of Seasonal Distribution of Recycled Water Resources from Metropolitan Area Reclamation Facilities**

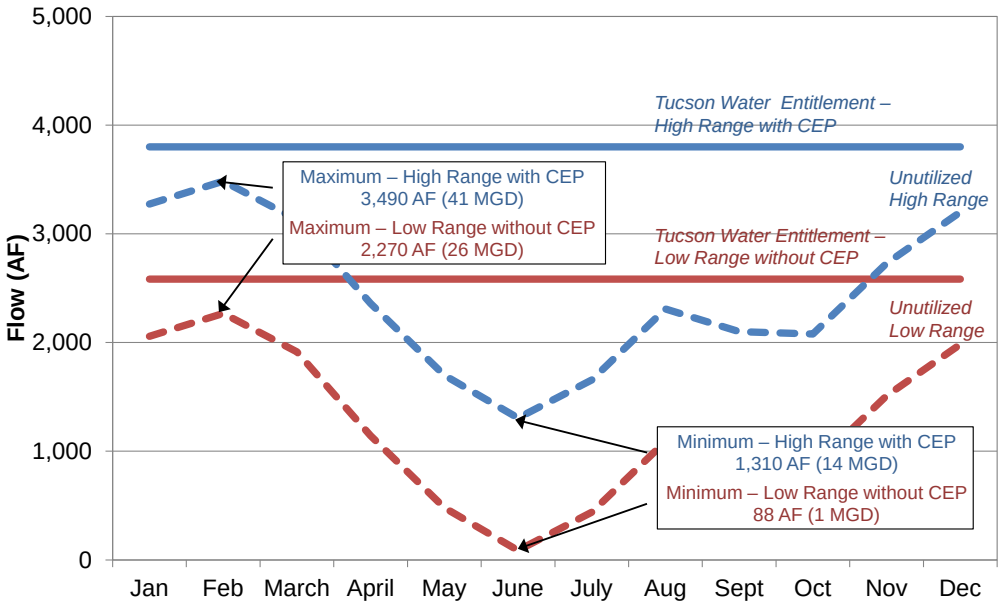

Figure ES-10. 2030 Projection of Seasonal Distribution of Recycled Water Resources from Metropolitan Area Reclamation Facilities

New Recycled Water Programs

Since limited additional demands are anticipated for the RWS, new recycled water programs will be required to put Tucson Water's unutilized recycled water resource to beneficial use. The unutilized recycled water could be used to replenish groundwater and, after additional advanced treatment, to supplement potable water supplies, a practice termed "indirect potable reuse (IPR)." This practice is now being utilized successfully by many communities in the arid southwest to supplement scarce water supplies.

Need for New Recycled Water Programs

There are several very compelling reasons for Tucson Water to establish a program to make use of the community's significant unutilized recycled water supplies:

- The impacts of sustained drought and climate change in the Southwest will result in shortages to the City's CAP allocation, and will increase the cost to purchase and deliver the water to Tucson.
- The existence of other renewable water resources that Tucson Water could access is highly uncertain at this time, including the availability, eventual costs, and legal challenges to bring other new water supplies into the area.

- Tucson Water currently has significant unutilized recycled water supplies which will increase as new customers are connected in the future.
- Recycled water is the only remaining new local, renewable water resource. It can be used to establish additional renewable water supplies and help to decrease reliance on CAP supplies and increase the reliability and sustainability of the community's water supplies.
- Tucson Water customers have made large investments and are still making investments to bring CAP water into the community and to manage its wastewater. A new recycled water program will leverage these investments and maximize utilization of the valuable recycled water resource that is currently discharged to the riverbed and leaves the basin without further benefit to Tucson Water customers.
- Recycled water programs involving IPR in the arid Southwest are being widely recognized as feasible and valuable in increasing the reliability of community water supplies.

Potential Benefits of New Recycled Water Programs

New recycled water programs through indirect potable reuse would enhance Tucson Water's renewable water resources portfolio and support the utility's Water Reliability efforts by providing the following community benefits:

- **Increase the reliability of Tucson Water's future water supplies.** The imported CAP water supplies are susceptible to drought, which is anticipated to become more problematic due to climate change. Recycled water is a renewable water supply that is not significantly affected by drought and its increased use will strengthen the resistance of the community's water supply to drought and water emergencies.
- **Increase the sustainability of local groundwater resources.** Groundwater replenishment with recycled water will further protect the basin from subsidence and resulting reductions in water storage capacities.
- **Support economic development.** A reliable water supply will attract more industry and businesses to the community which will increase the revenue and tax base, and ultimately contribute to community enhancements and sustain a high standard of living.
- **Increase local control and management of water resources.** The community will become less dependent on the decisions and actions of other agencies and entities that may have different objectives for the State's renewable water resources.
- **Avoid the costs and environmental impacts of importing additional water supplies.** New water supplies will be costly and may be located at great distances from the community and require significant pumping energy to deliver the water.

- **Expand and diversify the water supply portfolio.** Recycled water, as an additional renewable water supply, will increase water supply reliability, reduce the risks of relying on finite supply sources, and increase flexibility for water supply management.
- **Provide the opportunity to start improving the region's groundwater quality through salinity control.** By including membrane treatment processes as part of the advanced water treatment process, a side benefit is that minerals contributing to salinity would be removed from the urban water cycle. It is estimated that advanced water treatment can remove between 4,000 and 7,500 tons per year of salt from the water supply (for 2020 and 2030 recycled flows, respectively).
- **Support environmental stewardship.** Additional use of recycled water resources will support and promote the community's desire for sustainability, increasing efficient use of water, and protecting its water resources.

Advanced Water Treatment

An Independent Advisory Panel established with the assistance of the National Water Research Institute (NWRI) reviewed the work to identify recycled water program alternatives and helped to shortlist advanced treatment process options for detailed evaluations.

To secure support and investment for new recycled water projects, Tucson Water will need to build trust with respect to multiple issues, but especially water quality. This clearly applies to water treatment recommendations and decisions regarding IPR. Although advanced water treatment is not technically necessary to meet safe drinking water standards, it is a prudent approach to reducing public health risks. Advanced water treatment processes can be employed to provide multiple barriers for removal of pathogens and diverse barriers for removal of trace organic contaminants in recycled water projects.

The *Recycled Water Master Plan* identified and prioritized advanced water treatment processes for consideration in new recycled water program alternatives (example process shown in Figure ES-11). Advanced water treatment was considered both before recharge (pre-recharge) and after recovery (post-recovery). Pre-recharge treatment is more costly and energy intensive, as the treatment facilities must be sized to accommodate the significant variations in unutilized recycled water during the year. Post-recovery treatment is efficient for inland IPR applications (where there is no ocean to accept brine from the treatment steps) and provides the opportunity for soil aquifer treatment (SAT) as a natural treatment process for removing many wastewater constituents remaining after treatment at the Pima County water reclamation facilities. SAT also provides natural pre-treatment that replaces processes, such as filtration prior to membrane treatment. Therefore, post-recovery treatment has the potential to be more cost-effective because 1) the aquifer provides storage to buffer the seasonal variations in unutilized recycled water, resulting in smaller treatment facilities that can be operated at uniform flows year-round, and 2) the natural treatment provided by SAT reduces advanced treatment process needs.

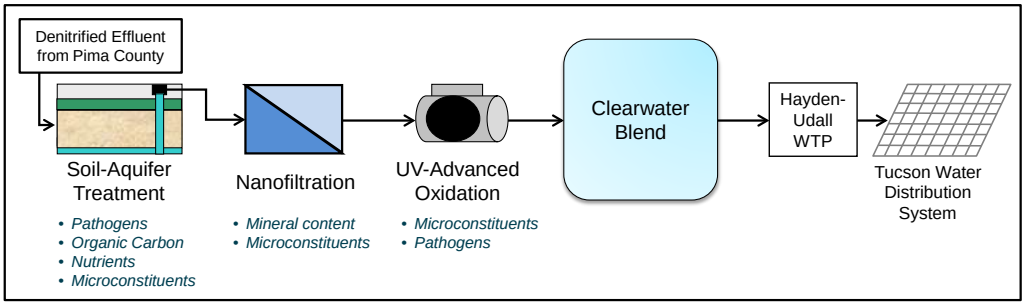

Figure ES-11. Example Advanced Water Treatment Schematic

New Recycled Water Program Alternatives

The *Recycled Water Master Plan* also identified and evaluated new recycled water program alternatives employing IPR. The alternatives evaluated represent the range of program possibilities given the current uncertainties that will influence the development of any new recycled water program. The alternatives included water conveyance, pumping, recharge and recovery, advanced water treatment, and finished water transmission facilities. The advanced water treatment for the alternatives consisted of the highest priority treatment process trains (Table ES-4).

Table ES-4. New Recycled Water Program Alternatives

Alternative	Pre-Recharge Treatment	Natural Treatment & Storage	Post-Recovery Treatment	Concentrate Treatment
North CAVSARP-1	MF + NF + UV-AOP	Recharge	Disinfection	O_3 + BAC + IX + EDR
North CAVSARP-3	-	Recharge/SAT	SAT + NF + UV-AOP + GAC (for H_2O_2 quenching) + Disinfection[1]	EDR
North CAVSARP-4	-	Recharge/SAT	SAT + NF + Disinfection[1]	EDR + GAC

CAVSARP - Central Avra Valley Storage and Recovery Project, SAVSARP - Southern Avra Valley Storage and Recovery Project, SE Tucson - Southeast Tucson, MF - Microfiltration, NF - Nanofiltration, UV-AOP - Ultraviolet/Hydrogen Peroxide Advanced Oxidation Process, O3 - Ozone, BAC - Biologically Activated Carbon, IX - Ion Exchange, EDR - Electrodialysis Reversal, SAT - Soil Aquifer Treatment, GAC - Granular Activated Carbon

The estimated conceptual unit costs for new recycled water program alternatives employing IPR are presented on Table ES-5. The recycled water source for all alternatives is the future Water Reclamation Campus. The recycled water conveyance route from the Water Reclamation Campus to the North CAVSARP location is approximately 25 miles, with a total pumping lift of approximately 100 feet. The recycled

Table ES-5. Estimated Conceptual Costs for New Recycled Water Program Alternatives

Item	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4	
Mainstream Treatment Train	MF + NF + UV-AOP + Recharge		Recharge/SAT + NF + UV-AOP + GAC (for H_2O_2 quenching)		Recharge/SAT + NF	
Flow Basis (Year)	2020	2030	2020	2030	2020	2030
Capital Costs	$329	$406	$203	$266	$198	$258
Annualized Capital Costs[1]	$19.0	$23.5	$11.7	$15.4	$11.5	$15.9
Annual O&M Costs	$6.7	$11.1	$3.4	$6.1	$3.5	$6.4
Total Annual Costs	$25.7	$34.6	$15.1	$21.5	$15.0	$21.3
Annual Water Supply	7 MGD (7840 AFY)	13 MGD (14,560 AFY)	7 MGD (7840 AFY)	13 MGD (14,560 AFY)	7 MGD (7840 AFY)	13 MGD (14,560 AFY)
Unit Cost ($/AF)[2]	**$3,300**	**$2,400**	**$2,000**	**$1,500**	**$2,000**	**$1,500**

[1] *Based on an interest rate of 4% and term of 30 years.*

[2] *Unit cost based on Annual Water Supply.*

water conveyance route for the SE Tucson location is approximately 35 miles long and would require three booster stations with a total pumping lift of 1,200 feet.

New recycled water programs will come at a significant cost, due primarily to the need to move large volumes of water over long distances. Other Arizona cities, as well as other large cities in the arid Southwest, are conducting long range planning to assure water supply reliability. Because much of the existing water supplies have been allocated, many projects being contemplated involve moving water supplies over long distances and utilizing waters with impaired quality (brackish water, seawater, recycled water, etc.). A comparison of the estimated costs of recently implemented and proposed Southwest water supply projects indicates that the potential costs for a Tucson Water new recycled water program is generally comparable with other Southwest water supply projects, particularly at higher new water supplies provided (Figure ES-12).

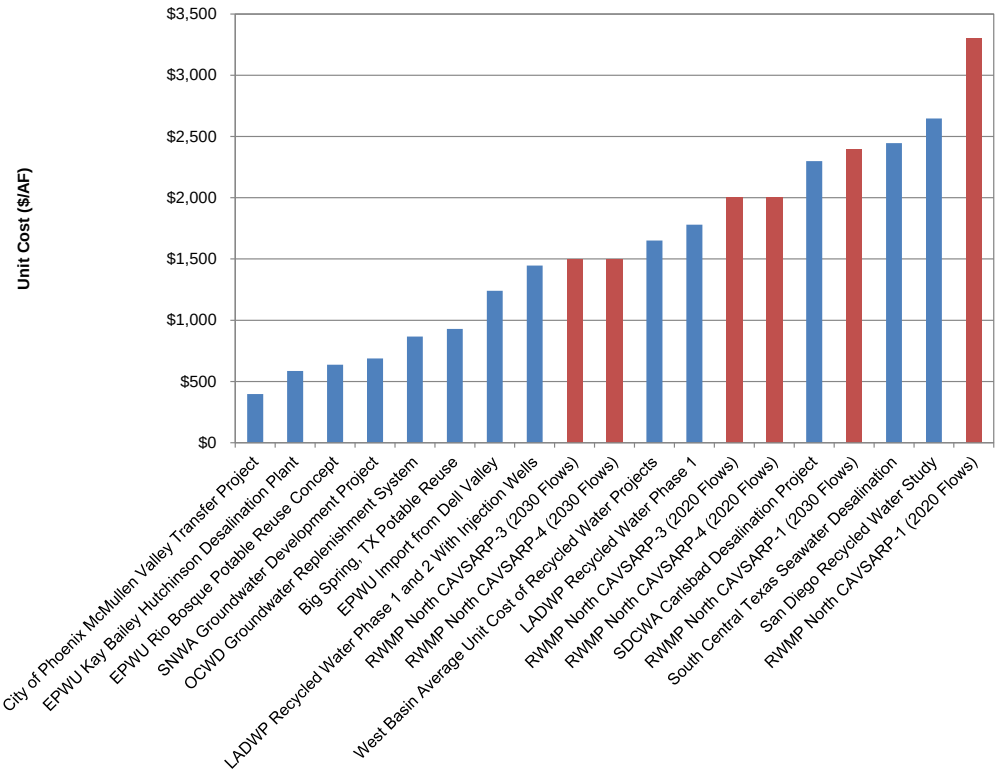

Figure ES-12. Comparison of Southwest Water Supply Projects

Recommendations for New Recycled Water Programs

Because of the impelling business case, it is recommended that Tucson Water continue with an implementation program to put its future unutilized recycled water supplies to beneficial use. Recycled water is a local renewable water supply that can be used to increase the reliability of the City's water supplies. A new recycled water program will maximize utilization of the valuable recycled water resource that the community has invested heavily in and that currently leaves the basin without further physical or economic benefit to Tucson Water customers. Finally, a new recycled water program will provide a range of other benefits to the community, including increasing the sustainability of local groundwater resources, supporting economic development, providing an opportunity to begin salinity management for local groundwater resources, and supporting the community's desire for sustainability and protection of water resources.

It is recommended that Tucson Water prepare a phased multi-year implementation plan that identifies near- and long-term activities and capital improvement program requirements to support sustained progress toward realization of this renewable water supply. The implementation plan should be structured around addressing the following key uncertainties that have been identified in this *Recycled Water Master Plan*:

- **Conveyance Pipeline to Avra Valley:** Additional investigations should be conducted to acquire the necessary rights-of-way in advance of additional development that may occur along the alignment. The investigations should include a study to identify the most feasible pipe alignment, refine cost estimates, identify potential additional regional contributors, and identify any reclaimed water source issues (physical and institutional) that can be addressed to reduce costs.

- **Facility Planning at North CAVSARP Site:** Additional investigations should be conducted to refine the North CAVSARP site concepts and to develop a preliminary site design that identifies and locates all recharge, treatment, recovery and conveyance facilities.

- **Hydrogeologic Investigations**: Investigations should be conducted of the North CAVSARP site to refine the recharge and recovery concepts, define the water retention times in the ground before recovery, assess the ability to segregate the recycled water recharge and recovery operations from the CAVSARP operations, and provide information for permitting.

- **Role of SHARP in Future Recycled Water Programs:** Additional work should be conducted to clearly define the role of SHARP in a new recycled water program. This work should include determination of the ability to reliably deliver recycled water to the SHARP site, the site's potential for a demonstration project, groundwater quality impacts, and the ability to manage recharged water at the site for demonstration testing, recharge and recovery for the RWS, and/or for long-term underground storage.

- **Cost and Effectiveness of Advanced Treatment and Concentrate Management:** The preferred treatment and concentration management processes should be investigated and refined through additional research, bench- and pilot-scale testing, and demonstration efforts. A literature review should be conducted to monitor evolving trends in recycled water treatment and concentrate management and to assist in the design of bench- and pilot-scale testing and demonstration project opportunities. All testing and demonstration efforts should be carefully planned to provide information for implementation, including refinement of facility layouts, treatment evaluations, impact of blending advanced treated water with other Clearwater blend water, sustainability analysis, and cost estimates. The program should also develop sufficient information for permitting of the program facilities and operations. Opportunities for collaboration with key entities such as the University of Arizona and Pima County in these investigations should be explored.

- **Public Outreach:** Public outreach efforts should be developed to engage local and regional stakeholders. The efforts should leverage lessons learned from similar programs that have been particularly successful, engage experts in the recycled water industry (including those that have planned and implemented outreach programs for similar projects), and provide public information on best management

practices developed for groundwater replenishment and IPR. The program should also leverage an advanced treatment demonstration program to educate the public through activities such as site tours, expert presentations, and treated water tasting.

- **Financial Plan for Implementation:** The estimated costs for a new recycled water program are significant. A financial plan should be developed for the program that considers a range of funding alternatives, impacts to water rates, and sensitivities to different implementation horizons.

Due to increasing water demands, continued droughts, and dwindling water supplies, the drinking water and water reuse industry is now moving towards direct potable reuse (DPR), which involves introduction of recycled water directly into potable water treatment facilities without an intermediate natural or engineered buffer, such as an aquifer or reservoir. Although DPR may become a valid consideration at some point in the future, this Recycled Water Master Plan focuses on IPR since the momentum for such projects in the Southwest is well established. Tucson Water should, however, monitor developments in the DPR regulatory and technological advances, and should continue to revisit the goals and objectives of the program, given the advances, during further implementation of a new recycled water program