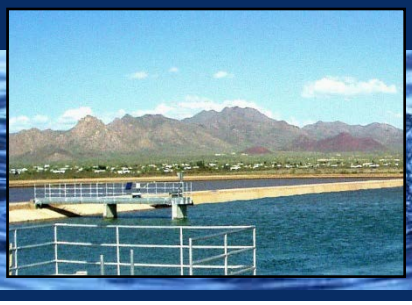
CITY OF TUCSON

TUCSON WATER

RECYCLED WATER MASTER PLAN



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Volume II: Appendices

December 2013

MALCOLM PIRNIE | ARCADIS

The Water Division of ARCADIS

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LIST OF ACRONYMS

AACE	Association for the Advancement of Cost Engineering
ADD	Acquisition, Development, and Delivery
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AF	acre-feet
AFY	acre-feet per year
AMAs	Active Management Areas
AWBA	Arizona Water Banking Authority
AWS	Assured Water Supply
AZPDES	Arizona Pollutant Discharge Elimination System
BAC	Biologically Activated Carbon
C2E	Conserve to Enhance
CAP	Central Arizona Project
CAVSARP	Central Avra Valley Recharge and Recovery Project
CAWCD	Central Arizona Water Conservation District
CCL3	Contaminant Candidate List 3
CEP	Conservation Effluent Pool
CIP	capital improvement program
CWA	Clean Water Act
CWAC	Citizens' Water Advisory Committee
EDCs	endocrine-disrupting compounds
EDR	Electrodialysis Reversal
ENRCCI	Engineering News Record Construction Cost Indices
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FWID	Flowing Wells Irrigation District
GAC	Granular Activated Carbon
GFRs	grandfathered groundwater rights
GMA	Groundwater Management Act
IGA	Intergovernmental Agreement
IPR	indirect potable reuse
IX	Ion Exchange
LEED	Leadership in Energy and Environmental Design
LRV	log reduction value
LT2	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level

MDWID	Metropolitan Domestic Water Improvement District
MF	Microfiltration
MG	million gallons
mg/L	milligram per liter
MGD	million gallons per day
NF	Nanofiltration
ng/L	nanogram per liter
NTU	Nephelometric Turbidity Units
NWRI	National Water Research Institute
O&M	operations and maintenance
O3	Ozone
OCWD	Orange County Water District
PCRWRD	Pima County Regional Wastewater Reclamation Department
PMRRP	Pima Mine Road Recharge Project
PPCPs	pharmaceuticals and personal care products
RO	Reverse Osmosis
ROMP	Regional Optimization Master Plan
RWS	Reclaimed Water System
RWTP	Reclaimed Water Treatment Plant
SAT	soil aquifer treatment
SAVSARP	Southern Avra Valley Storage and Recovery Project
SAWRSA	Southern Arizona Water Rights Settlement Act
SDWA	Safe Drinking Water Act
SE	Southeast
SHARP	Southeast Houghton Area Recharge Project
TDS	total dissolved solids
TOC	total organic carbon
US&R	underground storage and recovery
UV-AOP	Ultraviolet/Hydrogen Peroxide Advanced Oxidation Process
WISP	Water and Wastewater Infrastructure, Supply and Planning Study
WRDC	Water Resources Development Commission
WRF	Wastewater Reclamation Facility

APPENDIX A

REVIEW OF WATER REUSE PROGRAMS

Recycled Water Master Plan

Appendix A:
Review of Water Reuse Programs

December 2013

The Water Division of ARCADIS

Imagine the result

NOTES TO READER:

Appendix A, entitled *"Review of Water Reuse Programs,"* presents a review of several existing and successful recycled water programs. Some of the reviews were based on site visits and program staff interviews conducted in April 2011. Literature reviews were also conducted of other programs that were not visited shortly thereafter in 2011. The information summarized in the Appendix for the programs reviewed was current at the time of the site visits and interviews, and/or when the literature reviews were conducted. To facilitate completion of the Recycled Water Master Plan report, the Appendix was not updated with more current information. The results of the program reviews did, however, accomplish its objective of identifying key success factors and "lessons learned" in implementing successful recycled water programs employing indirect potable reuse of municipal wastewater.

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1 Executive Summary

The Recycled Water Master Plan team conducted a review of significant reuse programs in the U.S. and other countries, selected programs for the team to personally visit and to conduct interviews with key program staff, and reviewed literature for other programs that are relevant to Tucson's recycled water future. The review was completed to obtain detailed firsthand knowledge transfer of facilities and operations, technical and public outreach advice, and to initiate cross-utility relationships that can be leveraged throughout Tucson Water's planning efforts and program implementation.

The review of reuse programs resulted in the following key findings and conclusions:

- Statistically valid research early in the process is critical to success. Focus groups can help refine messages, key community influences and leaders, and other details of approach and timing.
- Orange County Water District and West Basin Water are water wholesalers and so have a considerably different set of communication issues than Tucson Water with its customers being direct users, although there are approaches used by these wholesalers that, in part, would be applicable to Tucson Water outreach.
- Major budget commitments have been made to water reuse public involvement and education by all these water providers.
- There is inconsistency in nomenclature regarding recycled water with some utilities referring to potable recycled water as 'reclaimed.'
- Educate and win over civic, community, business, and government leadership first. Get them to sign support cards if possible.
- There is inconsistency between the utilities regarding the extent to which they encourage or accept public input and comment during the planning process.
- Distributing "support statement" cards to everyone who hears the water reuse story and asking them to be signed and returned to the utilities is an excellent way for the utility to demonstrate a broad and deep level of community support for the reuse project.

- Beware of politics and the project becoming a political issue. This has been devastating to water reuse efforts in San Diego and other communities. Avoid election cycles when conducting critical public outreach and participation efforts.
- A systematic speakers' bureau is still the most effective way to communicate with stakeholder groups, although face-to-face, one-on-one communication with leadership should take place prior to the implementation of a full-scale speakers' bureau.
- Engage third party advocates (public health, environmental, business) to the greatest degree possible. They will bring an additional and strong level of credibility to the project.
- Work to maintain high levels of trust and credibility in the implementing utility, including ensuring customers understand the utility is the "source of water quality" as opposed to the water resource itself.
- Pilot or demonstration scale treatment facilities provide the opportunity to implement a treatment approach on a small scale and generate site-specific information to evaluate operability, cost, and performance.
- At pilot, demonstration, or full scale treatment facilities, include interactive interfaces and public displays for all ages related to recycled water.
- The treatment approach for pilot or full scale treatment facilities was largely based on Orange County Water District's Groundwater Replenishment System, which includes microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide. The treatment approach emphasizes redundant barriers for pathogens and "diverse" barriers for trace organic chemicals.

2 Identification of Programs for Review

The following sections highlight the objectives for review and the identification of programs.

2.1 Objectives for Review

Planning efforts for potential new beneficial uses of the City of Tucson's wastewater effluent entitlements are likely to result in large investments in new infrastructure. For aquifer augmentation and indirect potable reuse, this may also include application of advanced technologies for water quality control and by-product management (brine, residuals). In addition, past experience demonstrates that programs of this scale and nature have associated risks, beyond those of other types of water resources programs, which require significant community outreach and support for successful outcomes.

Information exists in the literature describing reuse applications, including indirect potable reuse, at utilities in the U.S. and other countries. While the literature provides useful summary information on technologies evaluated and used, and public relations programs developed for both successful and unsuccessful efforts, they do not provide the depth of information and understanding that can be obtained through direct, focused interaction with responsible utility representatives and on-site inspection of facilities and infrastructure.

It is prudent, therefore, to commit to due diligence early in the Recycled Water Master Plan effort to obtain detailed firsthand information through carefully selected site visits and interviews with key representatives of relevant reuse programs. This effort includes obtaining knowledge transfer and advice, firsthand facility and infrastructure inspections, and initiation of cross-utility relationships that can be leveraged throughout Tucson Water's planning efforts and program implementation.

Specific technical and public outreach objectives of the site visits and interviews include the following:

- Obtain a time-line, associated technical and public outreach activities/phases, and financial commitment information for each program's development. Solicit opinions of where improvements could have been made.
- Learn why and how a utility has achieved success. What specific activities worked or didn't work? Find out what drawbacks occurred and how they were overcome.

- Conversely, learn why and how a utility did not achieve success. What were the activities (or lack of activities) that contributed most to non-achievement?
- Find out what organizational model for decision-making was used and whether the same approach would be used again.
- Find out what types of people were identified as champions and advisors for the program. Would the same be chosen? At what point were they brought into the program, and how exactly did they participate?
- Understand how and when the public interacted with the utility on the program. What were the biggest challenges and costs in this arena? What was the nature and extent of utility/customer interface at the program's outset, and how did it develop/change over the course of the program?
- Obtain advice/recommendations for implementing the Tucson Water program.
- Observe the extent and nature of key facilities, and review public display areas and ongoing public touring/outreach practices.

2.2 Identification of Programs for Review

Programs were identified for site visits and interviews based on collective challenges, successes, setbacks, and demonstrated industry best practices that would be applicable to Tucson Water's current recycled water effort. Other programs were identified for a literature review based on similar program characteristics, such as inland site location. Table 2-1 provides a comprehensive list of water reuse projects that are currently in operation world-wide and water reuse projects that are currently in development.

Four utilities were selected for site visits and onsite program interviews:

- Orange County Water District
- West Basin Municipal Water District
- Los Angeles Department of Water and Power
- City of San Diego Public Utilities Department

Additional utilities and programs were selected for a literature review and include:

- Scottsdale Water Resources Department
- El Paso Water Utilities
- Singapore Public Utilities Board

Summaries of the site visits and onsite program interviews are presented in Section 3, while information on the additional programs is included in Section 4.

Table 2-1. Water Reuse Projects

Projects in Operation	Years Operating	Production Rate (afy)	Treatment Processes							Purpose				Notes
			AS	TF	LC	MF	RO	UV	GAC	SR	IR	IPR	DPR	
Whittier Narrows / Montebello Forebay Project	43	44,000	•	•						•		•		
South Lake Tahoe Water Reclamation Project	40	7,500	•	•	•				•			•		
Windhoek, Namibia (Africa) Reuse Project	35	5,000	•	•	•				•				•	
Water Factory 21	30	4,000	•	•	•		•	•	•		•	•		No longer operates
Upper Occoquan, VA Reclamation Project	25	27,000	•	•	•				•			•		
El Paso, TX, Fred Hervey Water Reclamation Project	20	7,500	•	•	•			O	•		•	•		
West Basin Recycling Project (Phase 1)	15	6,000	•	•	•		•				•	•		
West Basin Recycling Project (Phase 2)	12	3,360	•			•	•				•	•		
West Basin Mobil Boiler Feed Plant	13	3,600	•	•			•	•						Industrial
West Basin Carson Regional Water Recycling Plant	10	5,600	•	•			•	•						Industrial
West Basin Recycling Phase 3 - Chevron Boiler Feed	8	5,100	•		•	•								Industrial
West Basin Recycling Project (Phase 4)	4	4,000	•			•	•	•			•	•		
West Basin Recycling Project (Phase 2)	12	3,360	•			•	•				•	•		
Terminal Island Treatment Plant (Phase 1)	8	5,600	•	•		•	•				•	•		
Water Replenishment District of So. Cal., Alamitos Barrier Project	7	3,500	•			•	•	•			•	•		
Gwinnett County, GA, North Advanced Water Reclamation Facility	10	22,400	•	•	•	•		O						
Scottsdale, Arizona, Water Campus (Phase 1, 2 and 3)	11	13,435	•	•		•	•				•	•		
Tempe, Arizona, Water Reclamation Facility	6	9,000	•	•		•					•			MBR
Mesa, Arizona, Northwest Reclamation Facility	21		•	•							•			Media Filters
Anthem, Arizona, Water Campus	11	5,000	•	•		•		•			•			MBR
Chandler, Arizona, Ocotillo WRF	12	7,000	•	•							•			Media Filters
Chandler, Arizona, Industrial Process Water Reclamation Facility	14	3,000				•	•				•	•		MF-RO and NF
Avondale, Arizona, Charles M. Wolf Plant	1	17,000	•							•				Nitrification / denitrification
Glendale, Arizona, Arrowhead Ranch Water Reclamation Facility	25	5,000	•	•				•			•			
Glendale, Arizona, West Area Water Reclamation Facility	10	12,900	•	•				•		•	•			
Carlsbad, CA, Water Reclamation Plant	5	500	•	•		•	•							Irrigation
Brisbane, Qld, Australia, Bundamba Phase 1A (20 MLD)	3.3	6,000	•			•	•	•				•		
Sulaibiya Water Reclamation Facility, Kuwait	6	112,000	•			•	•	•			•	•		Irrigation and Industrial
Singapore NEWater Project (Bedok WRP)	7.8	6,700	•			•	•	•				•		
Singapore NEWater Project (Kranji WRP)	7.8	10,000	•			•	•	•				•		
Singapore NEWater Project (Seletar WRP)	6.8	5,900	•			•	•	•				•		
Singapore NEWater Project (Ulu Pandan WRP)	3.5	35,828	•			•	•	•				•		
Orange County Groundwater Replenishment System	3	72,000	•			•	•	•		•	•	•		
Brisbane, Qld, Australia, Bundamba Phase 1B (30 MLD)	2	9,400	•			•	•	•				•		
Brisbane, Qld, Australia, Gibson Island WRF (50 MLD)	2	14,700	•			•	•	•				•		
Brisbane, Qld, Australia, Luggage Point WRF (70 MLD)	2	20,000	•			•	•	•				•		

Table 2-1. Water Reuse Projects (continued)

Projects in Development	Years Operating	Production Rate (afy)	Treatment Processes							Purpose				Notes
			AS	TF	LC	MF	RO	UV	GAC	SR	IR	IPR	DPR	
West Basin Recycling Project Expansion (Phase 5)	-	7,500	•			•	•	•			•	•		
Miami-Dade WASD, South District Water Reclamation Facility	-	24,000	•	•		•	•	•			•	•		
Miami-Dade WASD, Central Water Reclamation Facility	-	3,000	•			•	•							Irrigation
Miami-Dade WASD, North Water Reclamation Facility	-	8,000	•	•		•								Irrigation
Los Angeles Harbor / Dominguez Gap Project	-	7,000	•			•	•				•	•		
East Bay Municipal Utilities District, CA, RARE Project	-	4,000	•			•	•							
Oxnard, CA GREAT Project	-	3,000	•			•	•				•			
Santa Clara Valley Water District, CA	-	5,600	•			•	•				•	•		
Terminal Island Treatment Plant Phase 2	-	5,600	•	•		•	•				•	•		
Fallbrook Recycling Project	-	-	•	•		•				•		•		

LEGEND - Treatment Processes

AS - Activated Sludge Secondary Treatment

TF - Tertiary Filtration

LC - Lime Clarification

MF - Microfiltration

RO - Reverse Osmosis

UV - Ultraviolet Disinfection

GAC- Activated Carbon

O - Ozonation

LEGEND - Purpose

SR - Spreading Recharge

IR - Injection Recharge

IPR - Indirect Potable Reuse

DPR- Direct Potable Reuse

3 Summary of Programs Visited

The Recycled Water Master Plan team conducted reuse program site visits and interviews with key utility staff from April 6 through April 8, 2011. The program interviews were conducted by a team comprised of Jeff Biggs, Fernando Molina, and Wally Wilson of Tucson Water, Christine Cotton and George Maseeh of Malcolm Pirnie, the Water Division of ARCADIS (Pirnie/ARCADIS), and Rick Kaneen of Kaneen Advertising and Public Relations. This section provides a summary description of each program and a summary table of specific information compiled during the site visits and interviews.

3.1 Orange County Water District

The Orange County Water District (OCWD) wholesales water to 19 cities and three water districts in northern and central Orange County. OCWD has been using highly treated recycled water for a seawater intrusion barrier since the 1970s with Water Factory 21, a facility that was recently replaced by OCWD's Groundwater Replenishment System (GWRS). The current treatment system utilizes membrane filtration, reverse osmosis, and ultraviolet light with hydrogen peroxide. The plant capacity is 70 million gallons per day (MGD) and OCWD has immediate plans to expand to 100 MGD. Highly purified recycled water is currently used for the seawater intrusion barrier and surface spreading for indirect potable reuse (IPR).

OCWD provided a detailed tour of the treatment facility and interactive public displays. The OCWD tour concluded with the opportunity to taste the highly-purified recycled water. OCWD expressed interest in providing guidance and support to Tucson Water as the effluent planning efforts continue.

Specific advice for Tucson Water regarding public outreach strategies for IPR included obtaining written endorsements from public officials and important members of the community, which can be posted online and included in presentations to the public. Furthermore, OCWD suggested that unsuccessful IPR projects generally did not place sufficient emphasis and resources toward public education and outreach, and indicated that political understanding and acceptance are critical to success. OCWD's GWRS efforts have served as a model of success for modern IPR program implementation, and the system continues to receive utility and media attention worldwide.

Table 3-1 provides additional information gathered during the site visit and interviews with OCWD staff.

3.2 West Basin Municipal Water District

The West Basin Municipal Water District (WBMWD) wholesales potable and recycled water to 17 cities, a range of private companies and the West Coast Basin Seawater Barrier Project in southwest Los Angeles County. WBMWD produces five qualities of recycled water, including highly purified recycled water for a seawater intrusion barrier and IPR utilizing a post-tertiary treatment process of membrane filtration, reverse osmosis, and ultraviolet light with hydrogen peroxide. Groundwater replenishment for the seawater intrusion barrier has been in operation for 30 years. WBMWD currently purchases secondary effluent from the City of Los Angeles at its Hyperion Wastewater Treatment Plant for $7/acre-ft to produce the five qualities of recycled water.

As a water wholesaler, WBMWD does not perform direct public outreach with residential and commercial customers, but considerable efforts for on-going interviews, education, and information exchange are conducted with elected officials and community opinion leaders in the municipalities and districts that purchase water from WBMWD. In addition, the treatment facility has interactive public displays for adults and children, and plant tours conclude with an opportunity to taste the highly-purified recycled water.

WBMWD is also performing a seawater desalination demonstration project that includes an aquarium, additional public displays, and desalinated water tasting. While environmental organizations encourage groundwater replenishment for the seawater barrier and IPR due to benefits of reducing wastewater discharges to the ocean, implementation of the desalination project is not yet fully committed.

Table 3-2 provides additional information gathered during the site visit and interviews with WBMWD staff.

3.3 Los Angeles Department of Water and Power

The Los Angeles Department of Water and Power (LADWP) began planning for IPR in the 1990s. Infrastructure to support IPR were constructed, but the project was not implemented due to several factors, including public opposition, insufficient or ineffective public outreach and engagement, active political opposition and absence of documented community and political support. Furthermore, the use of tertiary treated effluent for IPR did not demonstrate a strong commitment to water quality. The infrastructure was converted to non-potable water recycling uses.

LADWP is currently re-establishing an IPR program in its Recycled Water Master Plan effort, which already includes a demonstration facility producing highly-purified recycled water and a public outreach strategy modeled after OCWD's GWRS success. LADWP is conducting public forums, and geographically-based Community Leadership Action Committees have been established to engage the public. Additionally, LADWP must consider the environmental needs of riparian habitat in reaches of the Los Angeles River, which is similar to challenges regarding the riparian habitat in the effluent-dominated reach of the Santa Cruz River in Pima County. LADWP's recycled water program also includes non-potable irrigation and industrial uses, which are being expanded in parallel with IPR implementation efforts. LADWP has secured committed funding for its recycled water programs via revenue from surcharges.

Table 3-3 provides additional information gathered during the site visit and interviews with LADWP staff.

3.4 City of San Diego Public Utilities Department

The City of San Diego Public Utilities Department began IPR efforts in the 1990s in conjunction with the San Diego County Water Authority. Public and political opposition prevented the project from being implemented. The City of San Diego has re-committed to a program of highly-purified recycled water for IPR in recent years and is currently constructing a demonstration treatment facility and following the OCWD model for public outreach strategy. One significant difference of San Diego's planned IPR program is the use of the City's San Vicente Reservoir for blending of highly-purified recycled water with surface water prior to further treatment at the City's Alvarado Water Treatment Plant. California Department of Public Health (CDPH) draft regulations for IPR do not provide specific requirements for replenishing a surface water reservoir with highly purified recycled water, which presents permitting issues for San Diego. Business and environmental groups have formed coalitions in support of the IPR project. In addition, after a long history of negative media and political controversy, local media have recently supported the IPR project.

Table 3-4 provides additional information gathered during the site visit and interviews with City of San Diego staff.

Table 3-1. OCWD Technical and Public Outreach Information

Technical Information (information current as of April 2011)	
Total project cost	$481 million
Finding sources (including grant contributions)	Project cost was shared between OCWD and Orange County Sanitation District (OCSD). $92 million in State and Federal grants were received for the project, and Metropolitan Water District provides a subsidy of $4 million per year (21 years) for operation and maintenance. In 2010, the costs were $480 per acre-ft ($850 per acre-ft without subsidies).
What kind of permit types and key conditions were required?	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Water quality goals	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Treatment plant capacity and average flows	70 MGD
Source of wastewater treatment plant effluent	OCSD provides 96 MGD of secondary treated effluent, without cost, to OCWD. OCSD and OCWD agreed to share the cost to construct GWS, which was $481 million USD. OCWD agreed to manage and fund the operations of the facility into the future.
Treatment process for producing recycled water for groundwater recharge	Microfiltration, reverse osmosis, and UVAOP.
Method of blending recycled water with other water sources before groundwater recharge	CDPH approval stipulates a blending requirement of 75% recycled water with 25% dilution water. That permit requirement for the seawater barrier was lifted in 2010. The blending requirement is still in place for the GWRS water that is pumped to the recharge basins. Recycled water is blended with Santa Ana River water and imported waters.

Method of groundwater recharge	Approximately 35 million gallons (132,500 cubic meters) per day of the GWRS water are pumped into injection wells to create a seawater intrusion barrier. Another 35 million gallons (132,500 cubic meters) are pumped daily to Orange County Water District's percolation basins in Anaheim, where the GWRS water naturally filters through sand and gravel to the deep aquifers of the groundwater basin. In 1936, OCWD began purchasing portions of the Santa Ana River channel to actively manage capture of the river water as a source of supply for the groundwater basin. Today, OCWD owns approximately 1,000 acres contained within a six-mile section of the Santa Ana River from Imperial Highway to Ball Road in Anaheim, California. There are more than two dozen recharge basins in this area that range in depth from 5 to 150 feet (1.5 to 45 meters).
Minimum and average residence time before recovery	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Recovery and monitoring of recycled water	The groundwater is pumped from over 400 wells operated by local water agencies, cities and other groundwater users. Each agency monitors for compliance with the Safe Drinking Water Act standards.
Additional treatment for recovered water before delivery to customers	Residual disinfection.
Percentage of drinking water that is recycled water	GWRS contributes approximately 23% of the water supply for groundwater basin recharge.
Public Outreach Information (information current as of April 2011)	
Methods used to evaluate outreach efforts	Surveys and stakeholder support.
Nature of organized groups in opposition to the reuse program	No active opposition groups.
Advanced customer research, including statistically valid surveys	Two studies of representative voters within service areas in 1997 and 2000.
Mid-term or end-of-project customer research	Not discussed
Selection and role of spokespeople in the organization	Very important that spokesman is enthusiastic about the project, skilled at public speaking, and represents the organization well.
Project champions and political supporters	Key to successful outreach is targeted outreach to key leaders, political, business, environmental, media, community, etc. Written support is required from these leaders.

Use of technology in public outreach (i.e., pilot plant tours)	Tours of facility included in public outreach activities.
Public outreach obstacles and their impacts on implementation and schedule	Not discussed
Project impact on customer water and wastewater bills	Project impact on customer water and wastewater bills vary by member utilities.
Public outreach best practices	Proactive, face-to-face outreach with more than 1,200 presentations, 700 tours, and many news stories. Focus on leaders and gain their acceptance in writing and they communicate downward to all of their centers of influence.

Table 3-2. WBMWD Technical and Public Outreach Information

Technical Information (information current as of April 2011)	
Total project cost	Average cost of 5 types of recycled water products (filtered, RO, 2 pass RO, 2 pass with UVAOP, and nitrified) is $1,650/AF.
Finding sources (including grant contributions)	Not discussed
What kind of permit types and key conditions were required?	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Water quality goals	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Treatment plant capacity and average flows	Not discussed
Source of wastewater treatment plant effluent	Secondary effluent from the City of Los Angeles' Hyperion Wastewater Treatment Plant.
Treatment process for producing recycled water for groundwater recharge	The Edward C. Little Water Recycling Facility (ELWRF) produces five types of "designer waters," including Barrier Water: secondary treated wastewater purified by micro-filtration, reverse osmosis, UVAOP, and disinfection for groundwater recharge.
Method of blending recycled water with other water sources before groundwater recharge	The Los Angeles County Department of Public Works (LACDPW) owns and maintains the West Coast Seawater Intrusion Barrier, from the Blend Stations to the injection wells. West Basin supplies stabilized RO water (Barrier Water) from ELWRF to the West Basin Blend Station, where the Barrier Water is blended with imported potable water from Metropolitan Water District of Southern California (MWD). West Basin currently supplies 12.5 MGD of Barrier Water, which is approximately 75 percent of overall supply to the Seawater Intrusion Barrier.
Method of groundwater recharge	Injection wells (see above).
Minimum and average residence time before recovery	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Recovery and monitoring of recycled water	Not discussed
Additional treatment for recovered water before delivery to customers	Not discussed

Percentage of drinking water that is recycled water	Sixty years ago the average customer agency in West Basin's service area relied completely on groundwater. Today, however, it relies on a more diverse mix of water resources: 21% groundwater, 65% imported water, 7% recycled water and 7% conservation efforts.
Public Outreach Information (information current as of April 2011)	
Methods used to evaluate outreach efforts	Evaluate outreach efforts with formal phone surveys of high propensity and regular voters.
Nature of organized groups in opposition to the reuse program	Normally, women, pregnant women, and elderly people are more prone to oppose recycling that gets near consumption.
Advanced customer research, including statistically valid surveys	Statistically valid surveys that show 70% or higher support from registered or high propensity voter means the project will be accepted and would even win a vote on the project.
Mid-term or end-of-project customer research	Formal statistically valid surveys should be completed every 3 to 4 years. Give enough time in between surveys to see if your outreach has had an impact and if not to make adjustments.
Selection and role of spokespeople in the organization	Very important that spokesman is enthusiastic about the project, skilled at public speaking, and represents the organization well.
Project champions and political supporters	Key to successful outreach is targeted outreach to key leaders, political, business, environmental, media, community, etc. Written support is required from these leaders.
Use of technology in public outreach (i.e., pilot plant tours)	Visiting the plant is one of the best outreach tools. You can develop a rapport with the VIP guests.
Public outreach obstacles and their impacts on implementation and schedule	Make sure you engage all those who oppose your project and continue a dialogue with them. Try to move them from no to “I don’t support it, but will not actively oppose it.”
Project impact on customer water and wastewater bills	Water and wastewater bill impacts should be communicated as “adds a postage stamp on your bill.”
Public outreach best practices	Focus on leaders and gain their acceptance in writing and they communicate downward to all of their centers of influence.

Table 3-3. LADWP Technical and Public Outreach Information

Technical Information (information current as of April 2011)	

Total project cost	• Groundwater Replenishment (GWR) Phase 1
	  ○ 15,000 AFY with groundwater replenishment at the Hansen Spreading Grounds: $285M
	• GWR Phase 1 and 2 Without Injection Wells
	  ○ 30,000 AFY with groundwater replenishment at the Hansen and Pacoima Spreading Grounds: $379M
	• GWR Phase 1 and 2 With Injection Wells
	  ○ 30,000 AFY with groundwater replenishment at the Hansen and Pacoima Spreading Grounds; additional recharge through potential injection and/or surface spreading at the Strathern Wetlands Project if spreading capacity is inadequate during extreme wet years: $415M
	• Information updated from the 2012 LADWP Recycled Water Master Planning Executive Summary

Finding sources (including grant contributions)	• Sixty percent of capital expenditures are to be financed over 30 years at 5% interest, resulting in an annual amortized payment • The remaining forty percent of capital expenditures plus O&M costs are to be paid using the “pay-as-you-go” method in each future year • Source: 2012 LADWP Recycled Water Master Planning Executive Summary
What kind of permit types and key conditions were required?	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Water quality goals	Water quality results from pilot testing confirmed that all existing and draft drinking water and recycled water regulations can successfully be met using the proposed treatment processes
Treatment plant capacity and average flows	• Current plant 2,000 acre-ft/yr for seawater intrusion barrier • Future plant 30,000 acre-ft/yr for groundwater replenishment

Source of wastewater treatment plant effluent	• Dominguez Gap Seawater Intrusion Barrier currently uses between 2,000-3,000 acre-ft/yr of effluent from the Terminal Island Water Reclamation Plant • Recycled water from Donald C. Tillman Water Reclamation Plant is expected to meet existing and planned non-potable reuse demands, both phases of GWR, as well as other current uses.
Treatment process for producing recycled water for groundwater recharge	• Microfiltration and reverse osmosis for seawater intrusion barrier • Microfiltration, reverse osmosis, and advanced oxidation (UV/peroxide or ozone/peroxide) for planned advanced water purification facility
Method of blending recycled water with other water sources before groundwater recharge	Blending with non-recycled water sources, such as imported water or stormwater, depends on the level of treatment applied to the recycled water
Method of groundwater recharge	Surface spreading will take place at existing spreading grounds
Minimum and average residence time before recovery	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Recovery and monitoring of recycled water	Not discussed
Additional treatment for recovered water before delivery to customers	Not discussed (customer is the seawater barrier)
Percentage of drinking water that is recycled water	Not discussed (none that is purposeful)
Public Outreach Information (information current as of April 2011)	
Methods used to evaluate outreach efforts	Not discussed
Nature of organized groups in opposition to the reuse program	Opponents to the East Valley project in the 1990's included formal opposition by residents and politicians. The environmental community (e.g., Sierra Club) supported the project.
Advanced customer research, including statistically valid surveys	Not discussed
Mid-term or end-of-project customer research	Not discussed
Selection and role of spokespeople in the organization	LADWP has a speakers bureau, but it is not specifically geared towards recycled water (i.e., mostly recycled water staff did presentations on recycled water)
Project champions and political supporters	Current project champions and political supporters: • Written letters of support from city council district offices • Neighborhood leaders • Individual community groups

Use of technology in public outreach (i.e., pilot plant tours)	Recycled water advisory group did tour pilot and other full-scale recycled water treatment plants
Public outreach obstacles and their impacts on implementation and schedule	East Valley project in 1990's was stopped due to several factors, including: • Initial outreach was not sustained • Support was not provided in writing • Political issues • Yuck factor • Media coverage
Project impact on customer water and wastewater bills	Rate impacts have been evaluated, but the information is not included in the LADWP recycled water master plan
Public outreach best practices	Current project best practices: • Recycled Water Advisory Group (RWAG) provides input on recycled water expansion and groundwater replenishment • RWAG members represent a diverse cross-section of demographics, geography, and interests • Recycled Water Forums provide the opportunity for the general public to learn about LADWP's recycled water program and offer comments and concerns before the completion of the master planning process

Table 3-4. City of San Diego Public Utilities Department Technical and Public Outreach Information

Technical Information (information current as of April 2011)	
Total project cost	• Average gross cost of $1,700 to $1,900 per acre-foot depending on the Integrated Reuse Alternative • Source: 2012 San Diego Recycled Water Study final draft
Finding sources (including grant contributions)	To be determined for full scale facility, but the Demonstration Project was funded by a temporary water rate increase (3.08%).
What kind of permit types and key conditions were required?	The Draft Regulations for Groundwater Replenishment with Recycled Water were under development and discussed (Title 22 California Code of Regulations, Division 4 Environmental Heath, Chapter 3 Recycling Criteria).
Water quality goals	Ocean water quality and imported water quality improvements were taken into consideration in establishing the water reuse targets.
Treatment plant capacity and average flows	Variable depending on the Integrated Reuse Alternative and the start of operations (6.8-52.8 MGD).
Source of wastewater treatment plant effluent	Integrated Reuse Alternatives include: • North City Plant, Harbor Drive Plant, and new Mission Gorge Plant for the San Vicente Reservoir • South Bay Plant for the Otay Lakes
Treatment process for producing recycled water for groundwater recharge	Ultrafiltration, reverse osmosis, and UVAOP.
Method of blending recycled water with other water sources before groundwater recharge	Colorado River and Bay Delta water are used for blending.
Method of groundwater recharge	Not applicable. Purified water is to be conveyed to the San Vicente Reservoir.
Minimum and average residence time before recovery	Blending and residence time in San Vicente Reservoir has been subject of advanced modeling.
Recovery and monitoring of recycled water	Not discussed
Additional treatment for recovered water from the San Vicente Reservoir before delivery to customers	Coagulation, filtration, and disinfection (ozone and chlorine) at the Alvarado Water Treatment Plant.
Percentage of drinking water that is recycled water	Not discussed
Public Outreach Information (information current as of April 2011)	
Methods used to evaluate outreach efforts	Surveys and stakeholder support.
Nature of organized groups in opposition to the reuse program	Not discussed
Advanced customer research, including statistically valid surveys	Not discussed

Mid-term or end-of-project customer research	Not discussed
Selection and role of spokespeople in the organization	Not discussed
Project champions and political supporters	Not discussed
Use of technology in public outreach (i.e., pilot plant tours)	Periodic emails to a self-selective listserv
Public outreach obstacles and their impacts on implementation and schedule	In the 1990's, public and political opposition prevented an IPR project from being implemented.
Project impact on customer water and wastewater bills	Not discussed
Public outreach best practices	Current project best practices: • The Urban Water Cycle Tour consists of three facility tours, including drinking water treatment and distribution, wastewater treatment and management, and demonstration of the water purification process. The Water Purification Demonstration Project facility was intentionally built for tours.

4 Additional Water Reuse Programs Reviewed

This section presents a summary of additional water reuse programs in the U.S. and other countries that are relevant to Tucson Water's recycled water future. The summaries below were compiled based on available information in the literature.

4.1 Scottsdale Water Resource Department

The Scottsdale Water Resources Department's reuse program includes two treatment facilities at its Water Campus: a water reclamation plant (WRP) and an advanced water treatment (AWT) plant. The WRP has a capacity of 20 MGD for reclaiming water for irrigation of golf courses through a reclaimed water distribution system. The 12 MGD AWT plant consists of a 16 MGD microfiltration (MF) system and a 12 MGD reverse osmosis (RO) system for purifying the WRP tertiary effluent for subsequent vadose zone injection. During low effluent flow periods, the MF system also is used to treat Central Arizona Project (CAP) surface water for subsequent injection recharge. The AWT is currently undergoing improvements, including upgrades to the MF and RO membranes and addition of ultraviolet light (UV)-peroxide advanced oxidation processes (AOPs) for the removal of microconstituents. Additionally, ozonation will be utilized at Reservoir B, which stores tertiary treated effluent from the WRP prior to treatment at the AWT. The AWT upgrades are scheduled to be completed in 2011. Initial construction costs for Phase I and Phase II totaled $75 million. Phase III construction costs to convert the deep-bed filters to disc filters and to expand capacity of the WRP were $3.2 million and $20 million, respectively. Permit requirements include Arizona Department of Environmental Quality (ADEQ) water reuse permit and aquifer protection permit, Arizona Department of Water Resources (ADWR) underground storage facility permit, and Maricopa County air quality emissions permit and operating permit

Table 4-1 provides additional technical information on the Scottsdale Water Campus.

4.2 El Paso Water Utilities

The El Paso Water Utilities (EPWU) began delivering reclaimed water to customers in 1963 for nonpotable reuse applications. Several water management strategies were implemented in the 1980's to mitigate depletion of freshwater in the Hueco Bolson, including increased use of reclaimed water and IPR. The Fred Hervey Water Reclamation Plant (WRP) produces reclaimed water for multiple uses, including golf course irrigation, industrial cooling water, and groundwater recharge by injection wells and an infiltration basin. The IPR project is called the Hueco Bolson Recharge Project.

The current treatment system at the Fred Hervey WRP utilizes conventional biological treatment with powdered active carbon, high lime treatment, sand filtration, ozone disinfection, GAC filtration, and chlorination to prevent biological growth during storage and recharge. The Fred Hervey WRP design capacity is 10 MGD, and in 2006, the average flow was 5.2 MGD. Approximately 40 percent of the Fred Hervey WRP effluent is used for IPR, while the remaining effluent is used for nonpotable applications, including golf course irrigation and industrial cooling water. The facility has 10 injection wells and an infiltration basin, which was constructed as a pilot facility in 2000. Future expansion will likely utilize infiltration basins as the preferred method of groundwater replenishment. Four of the 10 injection wells have been replaced with PVC casings and screens due to corrosion of steel casings and screens. The Texas Department of Health requires a minimum two year residence time to ensure inactivation of viruses prior to extraction of the recycled water. Additionally, recovered water is blended with other well water and chlorinated prior to distribution as potable water. The project cost was $33 million and funding was provided by a 65% grant from the U.S. Environmental Protection Agency, while the remainder of the cost was provided through wastewater user rates.

In addition to the IPR project, EPWU also operates the largest inland desalination plant for municipal drinking water use (a joint project with Fort Bliss). The Joint Desalination Facility produces 27.5 MGD of drinking water and will increase El Paso's water supply by approximately 25% of the annual demand.

Table 4-2 provides additional technical information on the Hueco Bolson Recharge Project.

4.3 Singapore Public Utilities Board

The Singapore Public Utilities Board (PUB) developed the Four National Taps initiative in the 1990's to improve the robustness and resilience of the country's water supply. The four sources of water include local catchment water, imported water, desalinated water, and highly-purified recycled water known as NEWater. The NEWater Study began in 1998 to construct and operate an advanced water treatment plant to purify secondary effluent to better than World Health Organization (WHO) drinking water guidelines and U.S. Environmental Protection Agency (USEPA) drinking water standards. The NEWater Study also included a comprehensive sampling and monitoring plan and a health effects testing program, and routine testing includes constituents on the USEPA's Priority List of Contaminants. Currently, there are 5 NEWater plants in Singapore. NEWater is blended with imported raw water, rainwater, and desalinated water before being discharged to potable water reservoirs. Singapore's PUB recovers and treats the water from the reservoirs prior to distribution as potable water. The drinking water treatment process includes coagulation, flocculation, sand filters, ozonation, and disinfection.

A NEWater Visitor Centre was built as part of the PUB public education program to increase public awareness and acceptance of IPR. The 24,000 square-foot facility opened in 2003 and is located at the Bedok NEWater production plant. The Visitor Centre includes multimedia interactive displays and guided tours to educate the public. Additionally, the facility's product water is bottled and given to visitors and others in Singapore to demonstrate the high water quality.

Table 4-3 provides additional technical information on the NEWater Project.

Table 4-1. Scottsdale Water Resources Department Technical Information

Treatment plant capacity and average flows	The AWT has a capacity of 12 MGD.
Source of wastewater treatment plant effluent	Tertiary effluent from the WRP is further treated at the AWT.
Treatment process for producing recycled water for groundwater recharge	Microfiltration, reverse osmosis, UVAOP
Method of blending recycled water with other water sources before groundwater recharge	AWT product water is blended with CAP water that receives microfiltration treatment for vadose zone injection. The ratio of AWT product water to CAP water depends on irrigation demand. Generally, more CAP water is used in summer months during high irrigation demand.
Method of groundwater recharge	Vadose zone injection wells

Table 4-2. EPWU Technical Information

Treatment plant capacity and average flows	Design capacity of 10 MGD and average flow of 5.2 MGD in 2006
Source of wastewater treatment plant effluent	The Fred Hervey Water Reclamation Plant produces reclaimed water for multiple uses, including golf course irrigation, industrial cooling water, and groundwater recharge. The indirect potable reuse project is called the Hueco Bolson Recharge Project.
Treatment process for producing recycled water for groundwater recharge	• Secondary treatment combines conventional biological treatment with powdered active carbon process that provides organics removal, nitrification, and denitrification • High lime treatment for the removal of phosphorus and heavy metals • Sand filtration • Ozone disinfection • GAC filtration • Chlorination to prevent biological growth during storage and recharge
Method of blending recycled water with other water sources before groundwater recharge	Recycled water is not blended prior to groundwater recharge
Method of groundwater recharge	Injection wells and an infiltration basin

Table 4-3. Singapore Public Utilities Technical Information

Treatment plant capacity and average flows	Bedok and Kranji Water Factories have capacities of 11 MGD and 15 MGD, respectively. Both plants are undergoing expansion. Seletar and Ulu Pandan Water Factories have capacities of 6.3 MGD and 39 MGD, respectively. The newest facility, Changi, opened in 2010 with a capacity of 50 MGD.
Source of wastewater treatment plant effluent	Secondary effluent at various water reclamation plants.
Treatment process for producing recycled water for groundwater recharge	Microfiltration, reverse osmosis, and UV disinfection.
Method of blending recycled water with other water sources before groundwater recharge	NEWater is blended with imported raw water, rainwater, and desalinated water before being discharged to the potable water reservoirs.
Method of groundwater recharge	Not applicable.

5 References

City of San Diego Water Reuse website: http://www.sandiego.gov/water/waterreuse/

Crook, James. *Innovative Applications in Water Reuse and Desalination: Case Studies 2*. WateReuse Association: 2007.

Los Angeles Department of Water and Power Water Recycling website: http://www.ladwp.com/ladwp/cms/ladwp001294.jsp

NEWater website: http://www.pub.gov.sg/water/newater/Pages/default.aspx

Orange County Water District's Groundwater Replenishment Program website: http://www.gwrsystem.com/

West Basin Municipal Water District's Water Reliability 2020 website: http://www.westbasin.org/water-reliability-2020

APPENDIX B

MAYOR AND COUNCIL WATER POLICIES

CITY OF TUCSON

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MAYOR AND COUNCIL

WATER POLICIES

ADOPTED

JANUARY 26, 1998

RESOLUTION NO. 17929

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I. DEFINITIONS

A.	**ADEQ**	Arizona Department of Environmental Quality
B.	**ADWR**	Arizona Department of Water Resources
C.	**A MA**	Active Management Area
D.	**Applicant**	Owner, authorized representative, or corporation requesting service, use and/or construction of Tucson Water facilities
E.	**CAP**	Central Arizona Project
F.	**City**	City of Tucson
G.	**Cost of Service**	Charges for water service shall be made in direct proportion to the cost of securing, developing and delivering water to the Utility's various customer classes.
H.	**CWAC**	Citizens' Water Advisory Committee
I.	**Effluent**	The product of a treatment plant, having received primary and/or secondary treatment.
J.	**EPA**	U.S. Environmental Protection Agency
K.	**GWMA**	1980 Groundwater Management Act
L.	**Hydraulically Connected Riparian Area**	An aquatic or terrestrial ecosystem that relies, at least in part, on subsurface water flows.
M.	**IGA**	Intergovernmental Agreement
N.	**Non-potable water**	Water not fit for human consumption, such as effluent, reclaimed water and untreated CAP water.
O.	**Potable water**	Water which meets EPA and ADEQ water drinking water standards
P.	**Reclaimed**	Effluent receiving post-secondary water treatment.
Q.	**Utility**	The Tucson Water Department
R.	**Water Provider**	Private water companies, districts, or municipalities that provide water service.
S.	**Tucson Water Department**	The City Of Tucson's municipally-owned water utility
T.	**Tucson Water Service Area**	The lands represented on the service area maps filed annually with the Arizona Department of Water Resources
U.	**Waste water**	Water which carries waste to a treatment facility through a conveyance system.
V.	**Water revenue**	Revenue derived from the operations of Tucson Water.
W.	**Emergency Supply**	A temporary water supply provided by Tucson Water to local private water companies for equipment or system failures and not for the purpose of resolving deficiencies in the system requesting the emergency supply

II. ASSUMPTIONS

A. All financing shall be done in accordance with all city, state and federal requirements.

B. To the extent that conservation programs succeed in reducing demand, capital improvement programs may be deferred and rate increases adjusted accordingly.

III. POLICIES

A. Finance

1. Enterprise Basis

   a. The Utility shall be a self-supporting enterprise with all costs associated with the Utility to be funded from revenues derived from the sale of water and other water-related income sources.

   b. An annual average debt service coverage of 1.75 shall be maintained.

   c. Revenues collected in excess of operating needs of the Utility shall be carried forward for future capital bond funding requirements and shall not be transferred to the City's General Fund.

   d. The Utility shall maintain cash reserves adequate for known future obligations plus an allowance for unbudgeted contingencies set at five percent (5%) of revenues from water sales.

   e. Low-income water users living within the City may be supplied a minimum amount of water at reduced rates or other form of subsidized water service at the discretion of Mayor and Council. The cost of this subsidy will be funded from the general fund of the City and not from water rates.

2. Water Rates and Charges

   a. cost-of-service basis

      (1) Insofar as possible charges for water utility service shall be made on a cost-of-service basis.

      (2) Marginal cost aspects of the water utility will be continually studied by staff and considered as a factor in the making of rates.

(3) The substitution of effluent and reclaimed water for potable water is an important element in achieving safe yield in the Tucson Basin. Rate setting for effluent shall be in accordance with the following precepts:

(a) charges for effluent and reclaimed water shall be based on the cost of service whenever possible;

(b) to the extent that charges for effluent and reclaimed water based on cost of service do not provide an adequate price incentive, the price of reclaimed water shall be based on a market value which encourages its use;

(c) CWAC shall review and make recommendations and the Mayor and Council shall hold a duly advertised public hearing prior to entering into any agreement to sell reclaimed water to any customer at a rate other than that rate established by ordinance and contained in the Tucson Code.

(4) In the event that Tucson Water enters into contract with other water providers for treatment and delivery of CAP allocations, the City shall recover its total cost of providing this service.

b. water rate design elements

(1) Commodity charges shall reflect the costs of service across customer classes and seasons, using rate structure features such as: seasonal rates; isolated areas service charge and reserve fund surcharge.

(2) Customers shall be charged for fixed and recurring costs of service such as:

(a) new connections

(b) re-connections

(c) meter reading

(d) billing

(3) Rate structures shall be designed so as to encourage water conservation and to control peak demand.

(4) Water rates and charges shall be reviewed annually and changes in the rate structure shall be implemented so as to avoid sudden and large-scale shifts in water rates.

(5) Water rates for customers inside and outside the City limits shall be the same within each customer class unless there is reasonable justification based on cost-of-service rate differentials.

(6) The City shall provide an open process for determination of competitive wholesale water service rates. This process shall include formal participation by the governing bodies of other cities and towns within which wholesale water service may occur.

(7) The City shall work cooperatively with wholesale water customers to develop rate structures which avoid excessive retail water rate increases in any given year, with appropriate consideration for City policy regarding full cost recovery.

(8) The City shall work cooperatively with wholesale water customers to establish rate structures which comply with Arizona Corporation Commission requirements.

(9) With regard to existing agreements for wholesale water service, the City will develop rates consistent with the provisions of the agreements.

3. System Development Requirements

a. All costs of water system facilities necessary to serve a new applicant shall be paid by that applicant.

b. A provision shall be made to refund that portion of the costs not directly attributable to the development as follows:

(1) the cost differential of any oversizing of mains beyond what is required for the applicant shall be refunded by Tucson Water; and

(2) properties not financially participating in the construction of certain Tucson Water facilities shall be assessed a charge upon connection. Funds collected shall be reimbursed to the party that financed the original facility installation. The charge shall be updated annually to reflect current construction costs.

c. Area-specific charges shall be assessed to developments within Tucson Water Service Area where significant capital investment for the importation and distribution of water solely to serve the specific area is required.

4. Service Area Expansion

a. The City shall not expand its water utility service area into areas not presently served by other providers unless:

(1) Costs to existing rate-payers are considered;

(2) Water supply factors are considered; and

(3) Regional plans are considered.

5. Capital Improvements

a. Various combinations of revenue, general obligation bonds, tax-secured bonds and water revenues shall be used to finance water capital improvements.

b. Repayment of the bonds shall be made from water system revenues.

c. The type of bond financing to be used shall result in the least total cost to rate-payers based on present value.

d. The term of repayment of debt shall not exceed the useful life of the improvement funded by such debt.

e. Capital requirements for relocations or other modifications to the water system required to accommodate other public works shall be derived from sources other than the water utility.

f. Revenues accumulated in any reserve fund shall be set aside for specific purposes, such as water augmentation or water quality projects.

B. Acquisitions

1. Systems Acquisitions

a. The City shall purchase other water delivery systems only if such purchase is beneficial to the customers of Tucson Water. Delivery systems whose purchase may contribute to the achievement of Tucson Water's aims should:

(1) possess water resources that might have a significant effect on water quality, availability, and supply;

(2) be located adjacent to or near the Utility's existing service area; and

(3) not raise the cost of providing water to existing customers of the Utility.

b. The CWAC shall review all potential water system acquisitions and make recommendations to the Mayor and Council.

c. Whenever Tucson Water supplies water to another water provider, the contract or agreement governing this transaction shall encourage the water provider to implement a program that includes conservation incentives.

2. Water Rights Acquisitions & Sales

a. The City may purchase or sell grandfathered water rights or stored water credits when the Mayor and Council determine the transaction is consistent with short and long-term goals and policies of the City.

b. Water rights and stored water credits may be considered in price negotiations for reclaimed water and CAP water.

C. Water Supply, Management and Development

1. Water Quality

a. Tucson Water shall provide all customers water which is safe and palatable, and which meets all primary Federal and State standards, including that all water shall:

(1) contain no substance naturally occurring or man-made in amounts that exceed the maximum contaminant level established by the EPA Interim Drinking Water Standards, the Arizona Department of Environmental Quality or the Arizona Department of Health Services

(2) meet local standards to protect health and safety in the absence of national or state standards

(3) contain no pathogens

(4) be tested for contaminants at representative locations throughout the distribution system as appropriate or required by regulatory agencies to apprehend possible health, economic, or environmental threats

b. All non-potable water use shall be consistent with all local, state, and federal regulations.

c. Tucson Water shall be responsive and responsible to concerns regarding water quality and will provide the public with timely and accurate information on matters relating to water quality issues.

d. Tucson Water will fund remediation of groundwater contamination commensurate with its responsibility for the problem.

2. Contingency Plans

a. The Utility shall develop and maintain contingency plans to manage a water loss, shortage, delivery interruption, contamination, severe land subsidence or other water emergency. Any emergency demand reduction strategy will not be based solely on an across-the-board-percentage reduction on historic, residential, commercial or industrial water usage. The emergency conservation measure shall focus on the reduction or elimination of water intensive uses that don't affect public health or safety.

b. Emergency water supplies shall be provided to local private water companies subject to Tucson Water's ability to meet the demands of its customers.

3. Service Area Management

a. The City shall maintain the right of control of effluent in accordance with adopted IGA's.

b. Tucson Water shall maintain a 100-year assured water supply in accordance with ADWR assured water supply rules.

c. The City shall encourage other water providers to participate financially in the regional management of water.

d. The City shall continue to work cooperatively with all potential CAP water users in Pima County and with all agencies of government to facilitate implementation of the CAP in Pima County.

e. The City may enter into agreements to treat and deliver CAP water to other water providers to ensure that their CAP allocations are utilized in the Tucson AMA.

f. The City shall cooperate fully with the ADWR to develop augmentation programs that may include water importation and storage and/or artificial groundwater recharge.

g. Tucson Water shall cooperate in the planning and implementation of regional recharge programs.

h. The City shall continue to seek Tucson AMA wide groundwater management through cooperation between water users and agencies of government, including ADWR.

i. In considering funding projects which are sponsored by entities other than the Tucson Water Department, CWAC shall review the rate impacts and policy implications of participation in the project.

j. The City of Tucson shall strive to become the sole retail water provider within its corporate boundaries, as they may exist, now or in the future.

k. The City shall offer to negotiate intergovernmental agreements with other cities and towns governing the provision of new retail water service within the boundaries of those jurisdictions in order to clarify the relationship among the City, the other cities and towns and the affected retail customers.

l. Where legally and physically feasible, ownership and control of existing Tucson Water retail service facilities within the boundaries of other cities and towns shall be negotiated with those entities. The City shall work in cooperation with those entities to determine fair market value of the facilities.

4. Non-Potable Water

Priority shall be given to the development of treatment capacity and delivery systems for non-potable water. Wherever possible, the use of non-potable water in place of potable water shall be required for landscape irrigation and industrial uses.

a. The following shall be considered for potential uses of non-potable water:

(1) Landscape irrigation and industrial uses

(2) Direct recharge

(3) Agricultural irrigation and livestock watering

b. The following priorities, from highest to lowest, are established for utilization of non-potable water:

(1) Direct use to replace an existing use of potable water

(2) Storage and recovery within the area of hydrologic impact to replace an existing use of potable water

(3) Direct use to replace a new use of potable water

(4) Storage and recovery within the area of hydrologic impact to serve a new use that otherwise would use potable water

(5) Storage and recovery outside the area of hydrologic impact to replace either an existing or a new use of potable water

c. Since contractual rights to the use of effluent may result in added value to a user's property, contracts shall recognize that possibility and require waiver by the owner of any such added value in the event of purchase or condemnation of the property by the City through negotiation.

d. The City shall monitor effluent sales and deliveries by the Pima County Wastewater Management Department to ensure compliance with the sewer system transfer IGA and shall take steps to correct any failure to so conform when necessary.

e. The potential for using reclaimed water shall be evaluated and included in all new and existing water and land use plans.

f. Tucson Water shall actively work with new and existing large water users, including golf courses, parks, schools, cemeteries, industrial and multi-family complexes, to provide practical and economic service by the reclaimed water system.

g. New turf facilities and golf course development shall use effluent or reclaimed water for irrigation purposes.

h. Any conditions of interim use of potable water shall be made a part of water service agreements and other appropriate contracts to assure prompt action converting to the maximum use of effluent or reclaimed water for irrigation purposes. These conditions shall include, but not be limited to:

(1) the date by which the City is required to have its portion of the system in place;

(2) requirements for financial participation by the developer in the construction of the project;

(3) penalties for non-compliance; and

(4) a surcharge equaling 50% of the potable water rate in addition to the regular rates and charges. This surcharge shall not apply when the continued use of potable water is required solely due to deficiencies in the City's system or delays in City construction.

i. When private development requires reclaimed water service in advance of the City's construction schedule, developers shall work with Tucson Water to formulate a plan of service to be implemented at the sole expense of the developer with facilities to be dedicated to Tucson Water upon completion.

j. When funding is available, the City will finance or participate in the construction of reclaimed water pipelines in the Tucson Water service area to serve customers whose estimated reclaimed water usage is sufficient to justify pipeline construction on the basis of economic feasibility.

k. effluent control (IGA)

(1) Effluent use shall be controlled as follows:

(a) The use of all effluent derived from water developed by the City, including the City's allocation of CAP water, shall be directly controlled by the City.

(b) Effluent from any County treatment plant derived from water developed by entities other than the City may be controlled by the City on a case-by-case basis through contracts between the City and others subject to applicable conditions to include:

i) conditions requested by Pima County in the development of their waste water systems that are consistent with the water management plans and goals of the Tucson AMA.

ii) that the use of effluent shall reduce the amount of groundwater which the other party could otherwise lawfully have pumped.

iii) that the terms of the contract shall be sufficient to amortize the cost of system improvements.

(2) The City may only enter a contract with the County under the terms of which the County would control the effluent under conditions mutually agreed upon, with no payment by the County to the City, except for sharing net profits as provided in the Sewer Transfer IGA, when the City:

(a) is not using the effluent;

(b) has no plans to use the effluent;

(c) has no contract with another party for use of effluent;

(d) has no plans for entering into a contract with another for the use of the effluent;

(e) has no existing or proposed projects which could be negatively impacted.

5. Recharge

a. Groundwater recharge shall be used as a strategy for augmenting the groundwater and for providing long-term operational flexibility to Tucson Water's supply system.

b. Tucson Water shall develop demonstration projects as required to assess the feasibility of recharging various water sources for operational and long-term storage.

c. Tucson Water shall fully participate with other agencies to develop programs for water supply augmentation within the Tucson AMA.

d. The City may provide recharge water only to entities which have the legal authority to store water.

6. Wholesale Water Service

a. Tucson Water shall offer to provide wholesale water service to other retail water providers in the region.

b. Tucson Water shall offer both interruptible and non-interruptible water service to wholesale customers.

c. Tucson Water shall be responsible for delivering a specified flow rate at a specified pressure range to the point of delivery to wholesale customers.

d. Each wholesale customer shall be responsible for all necessary storage and transmission facilities beyond the point of wholesale delivery, unless otherwise provided for in separately negotiated agreements.

e. Tucson Water shall be responsible for delivering wholesale water in accordance with the primary water quality standards established pursuant to the Federal Safe Drinking Water Act (42 United States Code Sections 300F et seq.) at the point of delivery to the retail water service provider.

f. Each wholesale customer shall be solely responsible for maintaining water quality within its own retail water distribution system.

g. Tucson Water shall deliver to a wholesale customer only water which is not debited against a City of Tucson groundwater account established by the Arizona Department of Water Resources.

h. Central Arizona Project water held under subcontract by any wholesale water customer may be treated and directly delivered or may be stored underground by Tucson Water on behalf of the wholesale customer.

i. Agreements to treat and deliver or to recharge wholesale customers' CAP water shall be separately negotiated.

7. Design Standards

a. Tucson Water shall utilize its published design criteria for the development of all utility facilities, except when rezoning, neighborhood plans, or other Mayor and Council actions set aesthetic standards for the area that differ from Tucson Water's standard. In these cases, Tucson Water shall work with the City Planning Department, the developer and the neighborhood to design facilities that are consistent with the architectural theme or prevailing landscape type of the area.

8. Avra Valley Land

a. Ground water use, storage, and recovery

(1) No lands with appurtenant water rights shall be sold.

(2) City staff shall take all necessary actions to establish, maximize and preserve water rights on lands.

(3) No users other than Tucson Water shall export any ground water extracted from Tucson Water Avra Valley properties.

(4) Facilities to store and recover imported water may be constructed on Avra Valley lands.

(5) Imported water , including CAP and effluent, which is recharged on Avra Valley lands, may be recovered within the area of hydrologic impact.

b. Land use

(1) Land use shall:

(a) Benefit the Tucson Water Department rate payers

(b) Be consistent with all land use requirements and environmental regulations

(c) Be undertaken only in conjunction with notice to adjoining property owners and/or a public process to inform area residents of the use

(d) To the extent possible, preserve those lands having abundant vegetative cover in their natural state

(e) In conjunction with on-site construction, vegetation shall be replaced or restored as part of the project.

c. Leases

(1) Use shall include all economically reasonable water-saving designs, techniques and equipment.

(2) The quantity of water to be used as well as other non-monetary benefits to Tucson Water rate payers shall be considered

(3) Any use shall result in reduction or elimination of the City's maintenance costs.

(4) Use shall produce significant income to Tucson Water and/or value in excess of the City's cost of contract administration benefiting Tucson Water rate payers.

(5) In flood-prone areas, uses shall conform to flood plain regulations.

(6) Lessees shall be responsible for all necessary licenses, permits and all applicable fees and taxes.

(7) User shall be required to post a bond at the beginning of the lease guaranteeing reclamation and revegetation of the land at lease expiration.

(8) Where appropriate users shall be required in the lease to construct and/or maintain appropriate fencing.

(9) Leases shall contain provisions to protect against risk of environmental damage, including groundwater pollution.

(10) Where appropriate all users shall be required to construct and/or maintain all necessary on-site flood control structures.

9. Protection of Hydraulically-Connected Riparian Areas

a. identification of areas

(1) the areas on the City's Environmental Resource Zone and Pima County Flood Control District maps shall be subject to the policies described in this section.

b. drilling of new wells

(1) except under circumstances involving special conditions in which no hydrologic impacts can be identified, Tucson Water shall not drill any new wells inside or within one (1) mile of designated hydraulically-connected riparian areas.

c. operation and evaluation of existing wells

(1) Tucson Water wells located inside or within one (1) mile of designated hydraulically-connected riparian areas shall be operated so as to preserve these riparian areas

(2) the feasibility of CAP recharge inside or within one (1) mile of designated hydraulically-connected riparian areas shall be evaluated.

d. preservation through conservation

(1) Tucson Water shall utilize conservation as a mechanism to reduce the need for local pumping in areas having designated hydraulically-connected riparian habitats.

(2) Tucson Water shall work with private water companies and private well owners to develop conservation programs to reduce local groundwater pumping in areas having designated hydraulically-connected riparian habitats.

D. Conservation

1. The City of Tucson is required to meet conservation targets as established by the Arizona Department of Water Resources. Conservation program elements, such as public information and education, incentives and ordinances, will be developed and implemented to achieve conservation targets.

2. The City of Tucson will "Lead by Example" by promoting water conservation and environmental aesthetics by applying the principles of Xeriscape to public projects and following adopted regulations.

E. Policy Review Process

1. Policies review

a. Mayor and Council policies shall be reviewed annually or more frequently as warranted.

2. Long-range plan

a. The long-range plan, including a comprehensive water conservation program, shall be annually reviewed and revised.

Resolutions

17929

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Resolution No. 17929
Adopted: 01/26/1998
Folder 3

City Clerk- Legislative Management
City of Tucson Archive
002-003-0006 0007

CITY OF TUCSON

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ADOPTED BY THE
MAYOR AND COUNCIL

JAN 26 1998

RESOLUTION NO. 17929

RELATING TO WATER; APPROVING AMENDMENTS TO CITY WATER POLICIES.

WHEREAS, from time to time the Mayor and Council has, by resolution, adopted water policies as recommended by the Citizens' Water Advisory Committee; and

WHEREAS, the Citizens' Water Advisory Committee has reviewed those policies, and recommends that additions and changes be made to them to reflect current concerns;

NOW, THEREFORE, BE IT RESOLVED BY THE MAYOR AND COUNCIL OF THE CITY OF TUCSON, ARIZONA, AS FOLLOWS:

SECTION 1. The revised and amended water policies of the City of Tucson set forth in Exhibit A attached hereto and incorporated as if fully set forth herein are hereby approved.

SECTION 2. The various City officers and employees are authorized and directed to perform all acts necessary or desirable to give effect to this resolution.

SECTION 3. WHEREAS, it is necessary for the preservation of the peace, health and safety of the City of Tucson that this resolution become immediately effective, an emergency is hereby declared to exist, and this resolution shall be effective immediately upon its passage and adoption.

PASSED, ADOPTED AND APPROVED by the Mayor and Council of the

City of Tucson, Arizona, JAN 26 1998.

George Miller
MAYOR

ATTEST:

for C. P. Campbell
CITY CLERK

APPROVED AS TO FORM:

CITY ATTORNEY

REVIEWED BY:

CITY MANAGER

DH:lr
1/14/98

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EXHIBIT A TO RESOLUTION NO. 17929 ATTACHMENT

CITY OF TUCSON

MAYOR AND COUNCIL

WATER POLICIES

BOLD CAPITALS REPRESENT NEW LANGUAGE
~~STRIKEOUTS~~ REPRESENT DELETED LANGUAGE

January 1998

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I. DEFINITIONS

A. ADEQ	Arizona Department of Environmental Quality
B. ADWR	Arizona Department of Water Resources
C. AMA	Active Management Area
D. Applicant	Owner, Authorized representative, or corporation requesting service, use and/or construction of Tucson Water facilities
E. CAP	Central Arizona Project
F. City	City of Tucson
G. Cost of Service	Charges for water service shall be made in direct proportion to the cost of securing, developing and delivering water to the Utility's various customer classes.
H. CWAC	Citizens' Water Advisory Committee
I. Effluent	The product of a treatment plant, having received primary and/or secondary treatment.
J. EPA	U.S. Environmental Protection Agency
K. GWMA	1980 Groundwater Management Act
L. Hydraulically Connected Riparian Area	An aquatic or terrestrial ecosystem that relies, at least in part, on subsurface water flows.
M. IGA	Intergovernmental Agreement
N. Non-potable water	water not fit for human consumption, Such as effluent, reclaimed water and untreated CAP water.
O. Potable	Water which meets EPA and ADEQ water drinking water standards
P. Reclaimed	effluent receiving post-secondary Water treatment.
Q. **UTILITY**	**THE TUCSON WATER DEPARTMENT**
R.~~Q.~~Water Provider	Private water companies, districts, or municipalities that provide water service.
S. **TUCSON WATER DEPARTMENT**	**THE CITY OF TUCSON'S MUNICIPALLY OWNED WATER UTILITY**
T.~~R.~~Tucson Water Service Area	The lands represented on the service area maps filed annually with the Arizona Department of Water Resources
U.~~S.~~Waste water	Water which carries waste to a treatment facility through a conveyance system.
V.~~T.~~Water revenue	Revenue derived from the operations of Tucson Water.
W.~~U.~~Emergency Supply	A temporary water supply provided by Tucson Water to local private water companies for equipment or system failures and not for the purpose of resolving deficiencies in the system requesting the emergency supply.

II. ASSUMPTIONS

A. All financing shall be done in accordance with all city, state and federal requirements.

B. To the extent that conservation programs succeed in reducing demand, capital improvement programs may be deferred and rate increases adjusted accordingly.

III. POLICIES

A. Finance

1. Enterprise basis
   a. The Utility shall be a self-supporting enterprise with all costs associated with the Utility to be funded from revenues derived from the sale of water and other water-related income sources.
   b. An annual average debt service coverage of 1.75 shall be maintained.
   c. Revenues collected in excess of operating needs of the Utility shall be carried forward for future capital bond funding requirements and shall not be transferred to the **CITY'S** General Fund.
   d. The Utility shall maintain cash reserves adequate for known future obligations plus an allowance for unbudgeted contingencies set at five percent (5%) of revenues from water sales.
   e. Low-income water users living within the City may be supplied a minimum amount of water at reduced rates or other form of subsidized water service at the discretion of Mayor and Council. The cost of this subsidy will be funded from the general fund of the City and not from water rates.
2. Water rates and charges
   a. cost-of-service basis
      (1) Insofar as possible charges for water utility service shall be made on a cost-of-service basis.
      (2) Marginal cost aspects of the water utility will be continually studied by staff and considered as a factor in the making of rates.
      (3) The substitution of effluent and reclaimed water for potable water is an important element in achieving safe yield in the Tucson Basin. Rate setting for effluent shall be in accordance with the following precepts:
         (a) charges for effluent and reclaimed water shall be based on the cost of service whenever possible;
         (b) to the extent that charges for effluent and reclaimed water based on cost of service do not provide an adequate price incentive, the price of reclaimed water shall be based on a market value which encourages its use;
         (c) **CWAC SHALL REVIEW AND MAKE RECOMMENDATIONS AND THE MAYOR AND COUNCIL SHALL HOLD A DULY ADVERTISED PUBLIC HEARING PRIOR TO ENTERING INTO ANY AGREEMENT TO SELL RECLAIMED WATER TO ANY CUSTOMER AT A RATE OTHER THAN THAT RATE ESTABLISHED BY ORDINANCE AND CONTAINED IN THE TUCSON CODE.**
      (4) In the event that Tucson Water enters into contract with other water providers for treatment and delivery of CAP allocations, the City shall recover its total cost of providing this service.
   b. water rate design elements
      (1) Commodity charges shall reflect the costs of service across customer classes and seasons, using rate structure features such as: seasonal rates; isolated areas service charge and reserve fund surcharge.
      (2) Customers shall be charged for fixed and recurring costs of service such as:

(a) new connections
(b) re-connections
(c) meter reading
(d) billing

(3) Rate structures shall be designed so as to encourage water conservation and to control peak demand.

(4) Water rates and charges shall be reviewed annually and changes in the rate structure shall be implemented so as to avoid sudden and large-scale shifts in water rates.

(5) Water rates for customers inside and outside the City limits shall be the same within each customer class unless there is reasonable justification based on cost-of-service rate differentials.

(6) The City shall provide an open process for determination of competitive wholesale water service rates. This process shall include formal participation by the governing bodies of other cities and towns within which wholesale water service may occur.

(7) The City shall work cooperatively with wholesale water customers to develop rate structures which avoid excessive retail water rate increases in any given year, with appropriate consideration for City policy regarding full cost recovery.

(8) The City shall work cooperatively with wholesale water customers to establish rate structures which comply with Arizona Corporation Commission requirements.

(9) With regard to existing agreements for wholesale water service, the City will develop rates consistent with the provisions of the agreements.

3.~~C.~~ System development requirements

a.~~(1)~~ All costs of water system facilities necessary to serve a new applicant shall be paid by that applicant.

b.~~(2)~~ A provision shall be made to refund that portion of the costs not directly attributable to the development as follows:

(1)~~(a)~~ the cost differential of any oversizing of mains beyond what is required for the applicant shall be refunded by Tucson Water; and

(2)~~(b)~~ properties not financially participating in the construction of certain Tucson Water facilities shall be assessed a charge upon connection. Funds collected shall be reimbursed to the party that financed the original facility installation. The charge shall be updated annually to reflect current construction costs.

c.~~(3)~~ Area-specific charges shall be assessed to developments within Tucson Water Service Area where significant capital investment for the importation and distribution of water solely to serve the specific area is required.

4. **SERVICE AREA EXPANSION**

a. **THE CITY SHALL NOT EXPAND ITS WATER UTILITY SERVICE AREA INTO AREAS NOT PRESENTLY SERVED BY OTHER PROVIDERS UNLESS:**

(1) COSTS TO EXISTING RATE-PAYERS ARE CONSIDERED;

(2) WATER SUPPLY FACTORS ARE CONSIDERED; AND

(3) REGIONAL PLANS ARE CONSIDERED

5. Capital improvements

a. Various combinations of revenue, general obligation bonds, tax-secured bonds and water revenues shall be used to finance water capital improvements.
b. Repayment of the bonds shall be made from water system revenues.
c. The type of bond financing to be used shall result in the least total cost to rate-payers based on present value.
d. The term of repayment of debt shall not exceed the useful life of the improvement funded by such debt.
e. Capital requirements for relocations or other modifications to the water system required to accommodate other public works shall be derived from sources other than the water utility.
f. Revenues accumulated in any reserve fund shall be set aside for specific purposes, such as water augmentation or water quality projects.

B. ~~System~~ Acquisitions

1. **SYSTEMS ACQUISITIONS**

a.~~1.~~ The City shall purchase other water delivery systems only if such purchase is beneficial to the customers of Tucson Water. Delivery systems whose purchase may contribute to the achievement of Tucson Water's aims should:
(1)~~a.~~ possess water resources that might have a significant effect on water **QUALITY**, availability, and supply;
(2)~~b.~~ be located adjacent to or near the Utility's existing service area; and
(3)~~c.~~ not raise the cost of providing water to existing customers of the Utility.

b. **THE CWAC SHALL REVIEW ALL POTENTIAL WATER SYSTEM ACQUISITIONS AND MAKE RECOMMENDATIONS TO THE MAYOR AND COUNCIL.**

c ~~2.~~ Whenever Tucson Water supplies water to another water provider, the contract or agreement governing this transaction shall encourage the water provider to implement a program that includes conservation incentives.

~~3. The City shall not expand its water utility service area into area not presently served by other providers unless:~~

~~a. the cost to existing rate payers is neutral;~~
~~b. water supply factors are considered; and~~
~~c. regional plans are considered.~~

2. **WATER RIGHTS ACQUISITIONS & SALES**

a. **THE CITY MAY PURCHASE, OR SELL GRANDFATHERED WATER RIGHTS OR STORED WATER CREDITS WHEN THE MAYOR AND COUNCIL DETERMINE THE TRANSACTION IS CONSISTENT WITH SHORT AND LONG-TERM GOALS AND POLICIES OF THE CITY.**
b. **WATER RIGHTS AND STORED WATER CREDITS MAY BE CONSIDERED IN PRICE NEGOTIATIONS FOR RECLAIMED WATER AND CAP WATER.**

C. Water Supply, Management and Development

1. Water quality

a. Tucson Water shall provide all customers water which is safe and palatable, and which meets all **PRIMARY** Federal and State standards, including that all water shall:

(1) contain no substance naturally occurring or man-made in amounts that exceed the maximum contaminant level established by the EPA Interim Drinking Water Standards, the Arizona Department of Environmental Quality or the Arizona Department of Health Services

(2) meet local standards to protect health and safety in the absence of national or state standards

(3) contain no pathogens

(4) be tested for contaminants at representative locations throughout the distribution system as appropriate or required by regulatory agencies to apprehend possible health, economic, or environmental threats

~~b. Tucson water shall cooperate with all regulatory agencies to assure that CAP water treatment provides safe water that meets or exceeds all federal and state standards.~~

b.~~c.~~ ALL ~~No~~ non-potable water use shall be ~~permitted which significantly degrades groundwater quality~~ **CONSISTENT WITH ALL LOCAL, STATE, AND FEDERAL REGULATIONS.**

c.~~d.~~ Tucson Water shall be responsive and responsible to concerns regarding water quality and will provide the public with timely and accurate information on matters relating to water quality issues.

d.~~e.~~ Tucson Water will fund remediation of groundwater contamination commensurate with its responsibility for the problem.

2. Contingency Plans

a. The Utility shall develop and maintain contingency plans to manage a water loss, shortage, delivery interruption, contamination, severe land subsidence or other water emergency. Any emergency demand reduction strategy will not be based solely on an across-the-board-percentage reduction on historic, residential, commercial or industrial water usage. The emergency conservation measure shall focus on the reduction or elimination of water intensive uses that don't affect public health or safety.

b. Emergency water supplies shall be provided to local private water companies subject to Tucson Water's ability to meet the demands of its customers.

3. Service area management

a.~~i.~~ The City shall maintain the right of control of effluent in accordance with adopted IGA's.

b.~~f.~~ Tucson Water shall maintain a 100-year-assured water supply in accordance with ADWR assured water supply rules.

c.~~k.~~ The City shall encourage other water providers to participate financially in the regional management of water.

d.~~e.~~ The City shall continue to work cooperatively with all potential CAP water users in Pima County and with all agencies of government to facilitate implementation of the CAP in Pima County.

e.~~l.~~ The City may enter into agreements to treat and deliver CAP water to other water providers to ensure that their CAP allocations are utilized in the Tucson AMA.

f.~~g.~~ The City shall cooperate fully with the ADWR to develop augmentation programs that may include water importation and storage and/or artificial groundwater recharge.

g.~~j.~~ Tucson Water shall cooperate in the planning and implementation of regional recharge programs.

~~h. The City shall seek legislation which recognizes that water resource management activities including retirement of farmland, use of effluent and recharge and recovery of non-potable water enhance and contribute to the Tucson AMA's water supply~~.

h.~~d.~~ The City shall continue to seek Tucson-AMA wide groundwater management through cooperation between water users and agencies of government, including ADWR.

i. **IN CONSIDERING FUNDING PROJECTS WHICH ARE SPONSORED BY ENTITIES OTHER THAN THE TUCSON WATER DEPARTMENT, CWAC SHALL REVIEW THE RATE IMPACTS AND POLICY IMPLICATIONS OF PARTICIAPTION IN THE PROJECT.**

j.~~a.~~ The City of Tucson shall strive to become the sole retail water provider within its corporate boundaries, as they may exist, now or in the future.

k.~~b.~~ The City shall offer to negotiate intergovernmental agreements with other cities and towns governing the provision of new retail water service within the boundaries of those jurisdictions in order to clarify the relationship among the City, the other cities and towns and the affected retail customers.

l.~~c.~~ Where legally and physically feasible, ownership and control of existing Tucson Water retail service facilities within the boundaries of other cities and towns shall be negotiated with those entities. The City shall work in cooperation with those entities to determine fair market value of the facilities.

4. Non-potable water

PRIORITY SHALL BE GIVEN TO THE DEVELOPMENT OF TREATMENT CAPACITY AND DELIVERY SYSTEMS FOR NON-POTABLE WATER. Wherever possible, the use of non-potable water in place of potable water shall be required for landscape irrigation and industrial uses.

~~water priorities for a reclaimed and effluent reuse~~

~~(1) The following geographical allocation shall be included when considering potential uses of effluent:~~

~~(a) The Tucson Water service area;~~

~~(b) The Upper Santa Cruz sub-basin of the Tucson AMA;~~

~~(c) The Avra Valley sub-basin of the Tucson) AMA.~~

a. **THE FOLLOWING SHALL BE CONSIDERED FOR POTENTIAL USES OF NON-POTABLE WATER:**

1) **LANDSCAPE IRRIGATION AND INDUSTRIAL USES**
2) **DIRECT RECHARGE**
3) **AGRICULTURAL IRRIGATION AND LIVESTOCK WATERING**

b. **THE FOLLOWING PRIORITIES, FROM HIGHEST TO LOWEST, ARE ESTABLISHED FOR UTILIZATION OF NON-POTABLE WATER:**

1) **DIRECT USE TO REPLACE AN EXISTING USE OF POTABLE WATER**
2) **STORAGE AND RECOVERY WITHIN THE AREA OF HYDROLOGIC IMPACT TO REPLACE AN EXISTING USE OF POTABLE WATER**
3) **DIRECT USE TO REPLACE A NEW USE OF POTABLE WATER**
4) **STORAGE AND RECOVERY WITHIN THE AREA OF HYDROLOGIC IMPACT TO SERVE A NEW USE THAT OTHERWISE WOULD USE POTABLE WATER**
5) **STORAGE AND RECOVERY OUTSIDE THE AREA OF HYDROLOGIC IMPACT TO REPLACE EITHER AN EXISTING OR A NEW USE OF POTABLE WATER**

c. ~~(2)~~ Since contractual rights to the use of effluent may result in added value to a user's property, contracts shall recognize that possibility and require waiver by the owner of any such added value in the event of purchase or condemnation of the property by the City through negotiation.

d. ~~(3)~~ The City shall monitor effluent sales and deliveries by the Pima County Wastewater Management Department to ensure compliance with the sewer system transfer IGA and shall take steps to correct any failure to so conform when necessary.

e. ~~(4)~~ The potential for using reclaimed water shall be evaluated and included in all new and existing water ~~area~~ and land use plans.

f. ~~(5)~~ Tucson Water shall actively work with new and existing large water users, including golf courses, parks, schools, cemeteries, industrial and multi-family complexes, to provide practical and economic service by the reclaimed water system.

g. ~~(6)~~ New **TURF FACILITIES AND** golf course development shall use effluent or reclaimed water for irrigation purposes.

h. ~~(7)~~ Any conditions of interim use of potable water shall be made a part of water service agreements and other appropriate contracts to assure prompt action converting to the maximum use of effluent or reclaimed water for irrigation purposes. These conditions shall include, but not be limited to:

(1) (~~a~~) the date by which the City is required to have its portion of the system in place;
(2) (~~b~~) requirements for financial participation by the developer in the construction of the project;
(3) (~~c~~) penalties for non-compliance; and
(4) (~~d~~) a surcharge equaling 50% of the potable water rate in addition to the regular rates and charges. This surcharge shall not apply when the continued use of potable water is required solely due to deficiencies in the City's system or delays in City construction.

i. ~~(8)~~ When private development requires reclaimed water service in advance of the City's construction schedule, developers shall work with Tucson Water to formulate a plan of service to be implemented at the sole expense of the developer with facilities to be dedicated to Tucson Water upon completion.

j. ~~(9)~~ When funding is available, the City will finance **OR PARTICIPATE IN THE** construction of reclaimed water pipelines **IN THE TUCSON WATER SERVICE AREA** to serve customers whose estimated reclaimed water usage is sufficient to justify pipeline construction on the basis of economic feasibility. ~~Customers must use at least one acre-foot of reclaimed water per annum.~~ *

*As amended by Mayor & Council at the 1-26-98 meeting. (KSD;ap)

k. ~~b.~~ effluent control (IGA)

(1) Effluent use shall be controlled as follows:

(a) The use of all effluent derived from water developed by the City, including the City's allocation of CAP water, shall be directly controlled by the City.

(b) Effluent from any County treatment plant derived from water developed by entities other than the City may be controlled by the City on a case-by-case basis through contracts between the City and others subject to applicable conditions to include:

i) conditions requested by Pima County in the development of their waste water systems that are consistent with the water management plans and goals of the Tucson AMA;

ii) that the use of effluent shall reduce the amount of groundwater which the other party could otherwise lawfully have pumped. ~~Reduction may not be required if the use is recharge.~~

iii) that the terms of the contract shall be sufficient to amortize the cost of system improvements.

(2) The City may only enter a contract with the County under the terms of which the County would control the effluent under conditions mutually agreed upon, with no payment by the County to the City, except for sharing net profits as provided in the Sewer Transfer IGA, when the City:

(a) is not using the effluent;

(b) has no plans to use the effluent;

(c) has no contract with another party for use of effluent; and

(d) has no plans for entering into a contract with another for the use of the effluent.

(e) **HAS NO EXISTING OR PROPOSED PROJECTS WHICH COULD BE NEGATIVELY IMPACTED.**

5. ~~c.~~ recharge

(a) ~~(1)~~ Groundwater recharge shall be used as a strategy for augmenting the groundwater and for providing long-term operational flexibility to Tucson Water's supply system.

(b) ~~(2)~~ Tucson Water shall develop demonstration projects as required to assess the feasibility of recharging various water sources for operational and long-term storage.

(c) ~~(3)~~ Tucson Water shall fully participate with other agencies to develop programs for water supply augmentation within the Tucson AMA.

(d) **THE CITY MAY PROVIDE RECHARGE WATER ONLY TO ENTITIES WHICH HAVE THE LEGAL AUTHORITY TO STORE WATER.**

6. ~~5.~~ wholesale water service

a. Tucson Water shall offer to provide wholesale water service to other retail water providers in the region.

b. Tucson Water shall offer both interruptible and non-interruptible water service to wholesale customers.

c. Tucson Water shall be responsible for delivering a specified flow rate at a specified pressure range to the point of delivery to wholesale customers.

d. Each wholesale customer shall be responsible for all necessary storage and transmission facilities beyond the point of wholesale delivery, unless otherwise provided for in separately negotiated agreements.

e.~~d.~~ Tucson Water shall be responsible for delivering wholesale water in accordance with the primary water quality standards established pursuant to the Federal Safe Drinking Water Act (42 United States Code Sections 300F et seq.) at the point of delivery to the retail water service provider.

f. ~~The retail service provider~~ Each wholesale customer shall be solely responsible for maintaining water quality within its own retail water distribution system.

g.~~e.~~ Tucson Water shall deliver to a wholesale customer only water which is not debited against a City of Tucson groundwater account established by the Arizona Department of Water Resources.

h.~~f.~~ Central Arizona Project water held under subcontract by any wholesale water customer may be treated and directly delivered or may be stored underground by Tucson Water on behalf of the wholesale customer.

i. Agreements to treat and deliver or to recharge wholesale customers' CAP water shall be separately negotiated.

~~6. Land use policies~~

7. ~~a.~~ Design Standards

~~(1)~~ a. Tucson Water shall utilize its published design criteria for the development of all utility facilities, except when rezoning, neighborhood plans, or other Mayor and Council actions set aesthetic standards for the area that differ from Tucson Water's standard. In these cases, Tucson Water shall work with the City Planning Department, the developer and the neighborhood to design facilities that are consistent with the architectural theme or prevailing landscape type of the area.

8. ~~b.~~ Avra Valley Land

a. ~~(1)~~ Ground water **USE, STORAGE, AND RECOVERY**

(1)~~a~~ No lands with appurtenant water rights shall be sold.

(2)~~b~~ City staff shall take all necessary actions to establish, maximize and preserve water rights on lands.

(3)~~c.~~ No users other than Tucson Water shall export any GROUND water extracted from Tucson Water Avra Valley properties.

(4) **FACILITIES TO STORE AND RECOVER IMPORTED WATER MAY BE CONSTRUCTED ON AVRA VALLEY LANDS.**

(5) **IMPORTED WATER , INCLUDING CAP AND EFFLUENT, WHICH IS RECHARGED ON AVRA**

VALLEY LANDS, MAY BE RECOVERED WITHIN THE AREA OF HYDROLOGIC IMPACT.

b.(~~2.~~) Land use

(1)(~~1.~~) Land use shall: ~~disturb land and vegetation as little as possible~~. ~~Land shall be used in the following priority:~~

~~i).~~ ~~disturbed lands~~;

~~ii).~~ ~~disturbed lands returning to adaptive vegetation;~~

~~iii).~~ ~~undisturbed lands~~.

(a) **BENEFIT THE TUCSON WATER DEPARTMENT RATE PAYERS**

(b) **BE CONSISTENT WITH ALL LAND USE REQUIREMENTS AND ENVIRONMENTAL REGULATIONS**

(c) **BE UNDERTAKEN ONLY IN CONJUNCTION WITH NOTICE TO ADJOINING PROPERTY OWNERS AND/OR A PUBLIC PROCESS TO INFORM AREA RESIDENTS OF THE USE**

(d) **TO THE EXTENT POSSIBLE, PRESERVE THOSE LANDS HAVING ABUNDANT VEGETATIVE COVER IN THEIR NATURAL STATE**

(e) **IN CONJUNCTION WITH ON-SITE CONSTRUCTION, VEGETATION SHALL BE REPLACED OR RESTORED AS PART OF THE PROJECT.**

~~(b)~~ ~~Use of Avra Valley land by the City or its lessees shall:~~

~~i)~~ ~~create no nuisance;~~

~~ii)~~ ~~damage no persons or property; and~~

~~iii)~~ ~~conform with all applicable land use policies and regulations.~~

c.~~(3)~~ ~~lesses~~ **LEASES**

(1)~~(c)~~ Use shall include all economically reasonable water-saving designs, techniques and equipment.

(2)~~(d)~~ The quantity of water to be used as well as other non-monetary benefits to Tucson Water rate payers shall be considered~~in bid evaluations.~~

(3) ~~(a)~~ Any use shall result in reduction or elimination of the City's maintenance costs.

(4) ~~(b)~~ Use shall produce significant income to Tucson Water and/or value in excess of the City's cost of contract administration benefiting Tucson Water rate payers.

(5) ~~(c)~~ In flood-prone areas ~~only the Pima County Flood Plain Ordinance~~ ~~appropriate and legal~~ uses shall conform to **FLOOD PLAIN** regulations

(6)~~(d)~~ Lessees shall be responsible for all necessary licenses, permits and all applicable fees and taxes.

(7)~~(e)~~ User shall be required to post a bond at the beginning of the lease guaranteeing reclamation and revegeatation of the land at lease expiration.

(8) ~~(f)~~ Where appropriate users shall be required in the lease to construct and/or maintain appropriate fencing.

(9) ~~(g)~~ Leases shall contain provisions to protect against risk of environmental damage, including groundwater pollution.

(10) ~~(h)~~ Where appropriate all users shall be required to construct and/or maintain all necessary on-site flood control structures.

9.~~7.~~ Protection of Hydraulically-Connected ~~(H-C)~~ Riparian Areas

a. identification of areas

(1) the areas on the City's Environmental Resource Zone and Pima County Flood Control District maps shall be subject to the policies described in this section.

b. drilling of new wells

(1) except under circumstances involving special conditions in which no hydrologic impacts can be identified, Tucson Water shall not drill any new wells inside or within one (1) mile of designated ~~H-C~~ **HYDRAULICALLY-CONNECTED** riparian areas.

c. operation and evaluation of existing wells

(1) Tucson Water wells located inside or within one (1) mile of designated ~~H-C~~ **HYDRAULICALLY-CONNECTED** riparian areas shall be operated so as to preserve these riparian areas

(2) the feasibility of **CAP RECHARGE** ~~using wells~~ inside or within one (1) mile of designated ~~H-C~~ **HYDRAULICALLY-CONNECTED** riparian areas ~~for CAP recharge~~ shall be evaluated.

d. preservation through conservation

(1) Tucson Water shall utilize conservation as a mechanism to reduce the need for local pumping in areas having designated ~~H-C~~ **HYDRAULICALLY-CONNECTED** riparian habitats.

(2) Tucson Water shall work with private water companies and private well owners to develop conservation programs to reduce local groundwater pumping in areas having designated ~~H-C~~ **HYDRAULICALLY-CONNECTED** riparian habitats.

D. Conservation

1. The City of Tucson is required to meet conservation targets as established by the Arizona Department of Water Resources. Conservation program elements, such as public information and education, incentives and ordinances, will be developed and implemented to achieve conservation targets.

2. The City of Tucson will "Lead by Example" by promoting water conservation and environmental aesthetics by applying the principles of Xeriscape to public projects and following adopted regulations.

E. Policy Review Process

1. Policies review

a. Mayor and Council policies shall be reviewed annually or more frequently as warranted.

2. Long-range plan

a. The long-range plan, including a comprehensive water conservation program, shall be annually reviewed and revised.

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MAYOR & COUNCIL COMMUNICATION

August 4, 2010

Subject: Adoption of Tucson Water Service Area Policy (City-Wide and Outside City)

Issue – Adoption of Tucson Water Service Area Policy as directed by the Governing Body at the June 15, 2010, Study Session.

City Manager's Office Recommendation – The Mayor and Council is respectfully requested to adopt the attached resolution establishing the refined Water Service Area policy.

Background – In December 2007, the City enacted an Interim Water Service policy that restricted extension of water service to areas in which the City was legally obligated to serve. That interim policy was intended to limit expansion of the water service area until the Mayor and Council could adopt a rational policy integrating planning for water resources and growth.

Shortly thereafter, in the Spring of 2008 the Mayor and Council and the Pima County Board of Supervisors created the City/County Water & Wastewater Study Committee, composed of representatives of the Citizens' Water Advisory Committee, the Pima County Regional Wastewater Reclamation Advisory Committee, and the citizen planning committees from both the City and the County. The City Manager and County Administrator proposed a scope of work for the Study Committee that was subsequently refined to incorporate feedback from the Mayor and Council and the Board of Supervisors.

The title of the overall study, the *Water Infrastructure, Supply, and Planning Study*, reflects its purpose, to help the regional entities integrate planning for water resources and growth.

The Study Committee's Phase 1 report was endorsed by the Mayor and Council in April 2009, and its Phase 2 report endorsed by the Council in February 2010. These two reports examine the water resources, system capacities, and growth issues impacting Tucson Water and the Pima County Regional Wastewater Reclamation Department.

The Phase 2 Report recommended that the City maintain a water service area boundary but consider expansions to the current obligated area based on a set of economic and environmental factors. After discussing the Phase 2 report on February 17, 2010, the Council directed staff to return within 45 days with proposed refinements to Tucson Water's service area.

On April 13, 2010, staff brought forward a discussion of refinements to the Tucson Water service area, and a proposed service area policy. The Mayor and Council directed that an additional 30 days be provided to allow for more public input on the proposed policy.

The 30-day comment period resulted in a variety of feedback about the proposed service area policy; a number of comments recommended that the service area be expanded more than was

proposed by staff, while other comments recommended a smaller service area than proposed by staff.

On June 2, 2010, staff briefed the Citizens' Water Advisory Committee (CWAC) on the proposed Tucson Water Service Area Policy and discussed the comments received. After the briefing and question and answer period, CWAC voted 8-0 (with one abstention) to support the proposed Tucson Water Service Area Policy.

On June 15, 2010, staff provided all of the comments received during the 30 day period to the Mayor and Council, and summarized the results. After the staff presentation, the Mayor and Council concurred with staff's recommended Service Area Policy and directed staff to return with a resolution to formally adopt the policy. The Mayor and Council also directed that the resolution include several related provisions, discussed below.

Present Considerations – The attached resolution incorporates the June 15th motion from Council Member Uhlich below, as amended, to adopt the proposed water service area policy and related provisions, which the Mayor and Council passed by a vote of 7 to 0:

> Council Member Uhlich moved to direct staff to return within 30 days with a resolution for the adoption of the proposed Tucson Water Service Area Policy, with the exception of the pink-shaded areas on the map abutting the Painted Hills area in the Tucson Mountains. The resolution should formalize the policy and include a review of the policy when the Water Checkbook Balance is updated. The resolution should note the continuation of the existing appeals board to hear appeals from property owners whose land is not within the approved expansion area.
>
> It was further moved that the resolution should direct staff to work with other jurisdictions and water providers on comprehensive, collaborative water planning recommendations by sub-regions, including the possibilities of wheeling and water credit agreements. These discussions should include Metro Water, the Pasqua Yaqui Tribe, Oro Valley, Marana, the Vail Water Company, Pima County, the Tohono O'odham Nation and others. This direction coincides with recommendation 3.1 and 3.2 in the comprehensive planning section of the City/County Water and Wastewater Study.
>
> Council Member Romero requested a friendly amendment to the motion, accepted by the maker, to reference in the resolution the City's continued policies for rain water and gray water harvesting.

Staff notes that Exhibit A to the attached resolution is a service area map that generally depicts the current Tucson Water service area as well as the current obligated area (e.g., within the City limits or contracted service areas), and expansion areas (where agreement to annex into the City may or may not be required, depending on the specific location). As explained in the resolution,

the Exhibit A map is for illustration only. Tucson Water will maintain a service area map of record that is updated regularly to reflect both water service extensions as they occur as well as approved annexations and pre-annexation agreements.

Finally, the Water Department's existing administrative review procedures will remain in place. In cases where the Water Department denies a water system extension and the applicant administratively appeals that determination, a staff review committee composed of the City Attorney, the Director of Housing and Community Development, and a representative of the City Manager's Office (currently, Nicole Ewing-Gavin) will continue to review the denial to assure that the Water Department has followed the City's adopted Water Service Area policy.

Financial Considerations – Adoption of the proposed Tucson Water Service Area will have no immediate financial impact. Once adopted, the service area policy will establish planning parameters related to system growth, which will facilitate Tucson Water's long term infrastructure planning and budgeting, as well as planning for long term water resource requirements.

Legal Considerations – The attached resolution has been prepared by the City Attorney's Office to incorporate the Mayor and Council direction as discussed above.

Respectfully submitted,

for

Mike Letcher
City Manager

ML/jt/Jeff B. Biggs
Tucson Water Director

Attachment: Resolution

APPENDIX C

EFFLUENT PROJECTIONS AND ENTITLEMENTS

Recycled Water Master Plan

Appendix C: Effluent Projections and Entitlements

December 2013

The Water Division of ARCADIS

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NOTES TO READER:

Appendix C, entitled *"Effluent Projections and Entitlements,"* presents the details of how Tucson Water's effluent entitlements were projected through 2030 and extrapolated to 2050. The Appendix also presents the details of how the availability of unutilized recycled water would vary annually based on seasonal demands within the Tucson Water Reclaimed Water System and other reclaimed water uses.

The initial effluent entitlement projections were completed in October 2011 and were based on the most recent "official" regional wastewater flow projections prepared by Pima County Regional Wastewater Reclamation Department in 2006 and 2008. No further wastewater flow projections have been made by Pima County since that time. The wastewater flow projections were compared to actual 2010 wastewater flows to determine a range of entitlement projections for use in the Recycled Water Master Plan evaluations. To facilitate completion of the Recycled Water Master Plan report, the actual wastewater flows presented in the Appendix were not updated to include data through 2012.

The Recycled Water Master Plan report does, however (in Chapters 4 and 5), present updated wastewater flows and effluent entitlements through 2012 and discusses how the range of entitlements presented in the Appendix does account for the observed recent decreasing trends in wastewater flows and effluent entitlements. Based on the updated comparison, the Recycled Water Master Plan report also provides justification for use of the range of effluent entitlement projections presented in the Appendix.

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Attachments

A. Effluent Flow and Entitlement Projections

1 Introduction

This technical memorandum describes the projection of Tucson Water's recycled water entitlement through 2030 (and extrapolated to 2050). In Chapter 3 of the Recycled Water Master Plan, the principal agreements between Tucson Water, Pima County, and several other local communities were described that form the basis for water and wastewater management in the Tucson area for the next thirty years. The agreements, or series of intergovernmental agreements (IGAs), specify how the wastewater that is generated within the Tucson Water service area would be apportioned into effluent entitlements for each entity. The entitlements that remain after all entities have received their allocations, and after Tucson Water has satisfied its reclaimed water demands, are currently discharged to the Santa Cruz River. An objective of the Recycled Water Master Plan is to investigate how the effluent entitlements currently being discharged can be put to beneficial use via groundwater replenishment and eventual recovery of the water to supplement future drinking water supplies.

Updated projections of wastewater generation through 2030 were developed in consultation with the Pima County Regional Wastewater Reclamation Department (PCRWRD). The updated projections were based on population growth projections and assumptions regarding per capita potable water usage, sewer return flow rates, septic tank usage, and so on. Projections of effluent entitlements were then developed based the apportionments specified in the IGAs. Finally, the portion of Tucson Water's effluent entitlements that could be available for a future recycled water program (e.g., groundwater replenishment) was determined by considering existing and future demands in the Reclaimed Water System (RWS), as well as other existing consumptive uses of reclaimed water.

2 Wastewater Flow Projections

Wastewater flow projections were updated based on consultation with the PCRWRD and Tucson Water. The most recent wastewater flow projections for the region are contained within the following regional planning efforts:

- The 2006 PCRWRD Facility Plan Update contains projections based on the Pima Association of Governments (PAG) traffic analysis zone (TAZ) population data from 2005 (Brown and Caldwell, 2006).
- A November 29, 2005 joint memorandum between Pima County and Tucson Water that developed common population and wastewater flow projections for regional planning purposes (reference). Both entities agreed to develop projections based on the PAG TAZ population data (2005 dataset), a common per capita wastewater generation rate (85 gpcd), and common assumptions of sewered and unsewered populations.
- Similar to the 2006 Facility Plan Update, the 2007 PCWRD Regional Optimization Master Plan (ROMP) utilized updated wastewater flow projections for regional treatment facility capacity evaluations (Greeley and Hanson, 2007). The projections for the "metropolitan" treatment facilities in ROMP are identical to those developed in the 2006 Facility Plan Update. The projections for the "outlying" treatment facilities were developed based on the November 29, 2005 joint memorandum assumptions.

PCRWRD develops wastewater flow projections for areas served by metropolitan treatment facilities, outlying treatment facilities, and for undeveloped areas. The metropolitan facilities include: Roger Road Wastewater Reclamation Facility (WRF) which is now called the Water Campus, Ina Road WRF, and Randolph Park WRF. The outlying facilities include Avra Valley WRF, Marana WRF, Corona de Tucson WRF, Green Valley WRF, and Mt. Lemmon WRF. The undeveloped areas include Southlands and the Southeast Area. Since the Southeast Area is tributary to the metropolitan facilities, flows for this area were not projected separately, but are included in the metropolitan facility projections. Figure 2-1 shows the locations of the metropolitan, outlying, and planned facilities.

The location of the planned Southlands WRF is based on the Verano Offsite Sewer Basin Study (Westland Resources, Inc., 2009). The location of the planned Southeast Area WRF is based on the Southeast Area Sub-regional Wastewater Reclamation Study (Pirnie/ARCADIS, 2011). Table 2-1 shows the most recent wastewater flow projections for the region that were utilized to project Tucson Water effluent entitlements. The flow projections for the metropolitan facilities are from the

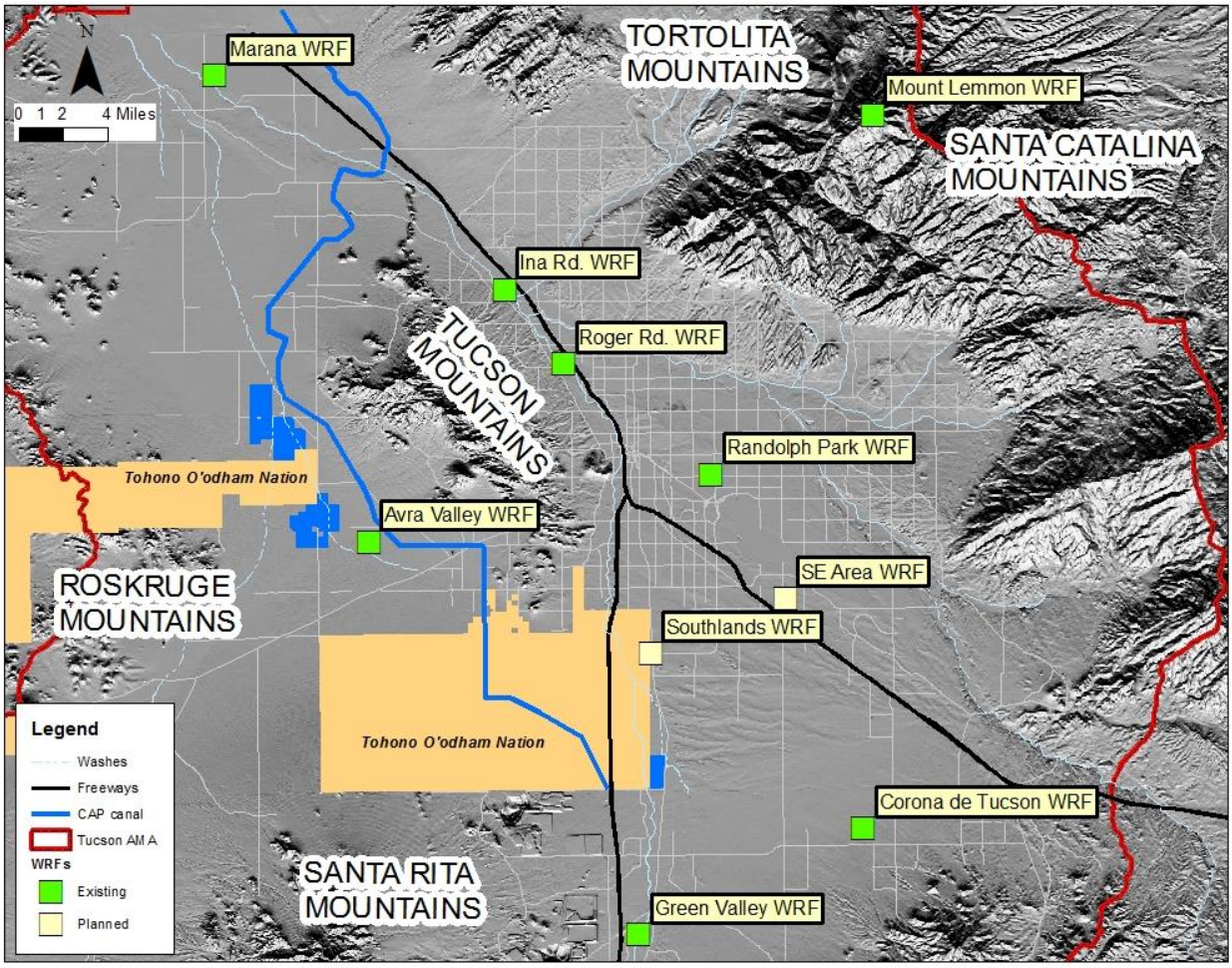


Figure 2-1. Existing and Planned PCRWRD WRFs

2006 Facility Plan Update, while the flow projections for Southlands and the outlying facilities are from the 2007 ROMP.

Table 2-1. Wastewater Flow Projections

Treatment Facility	Projected Flow (AFY)[1]					
	2005	**2010**	**2015**	**2020**	**2025**	**2030**
Metropolitan Treatment Facilities						
Roger Road	44,100	43,200	32,100	36,300	40,600	35,900
Ina Road	25,500	26,200	42,000	42,000	42,000	56,000
Randolph	0	3,360	3,360	3,360	3,360	3,360
Subtotal	69,600	72,800	77,400	81,700	86,000	95,300
Southlands (Undeveloped)	0	1,340	4,030	6,720	9,190	11,760
Outlying Treatment Facilities						
Avra Valley	1,210	1,570	2,020	2,460	2,910	3,360
Marana	170	1,790	2,580	3,360	4,150	4,930
Corona de Tucson	160	560	1,008	1,456	1,904	2,352
Green Valley	1,970	3,020	3,470	4,030	4,480	4,930
Mt. Lemmon	14.6	14.6	14.6	14.6	14.6	14.6
Subtotal	3,520	8,300	9,090	11,300	13,500	15,600
Grand Total	**73,100**	**81,100**	**90,600**	**99,700**	**108,600**	**122,600**

[1] *Acre-feet per year (AFY)*

The wastewater flow projections were compared to actual flows from 2003 to 2010. Figure 2-2 shows the flow comparisons. The actual wastewater flows for the metropolitan facilities have generally been following flow projections until 2007 when they flattened out and even decreased. Flow patterns since 2007 have generally been attributed to the national economic crisis (slowdown in development, vacancies, etc.). The 2010 actual flows are approximately 8 percent less than the projected flows for 2010. There is a greater difference between the actual and projected flows for the outlying facilities (21 to 100 percent less), primarily because the flows in these areas are much smaller. A comparison between total actual flows and total projected flows indicates that the 2010 actual flows are 13 percent less than the 2010 projected flows.

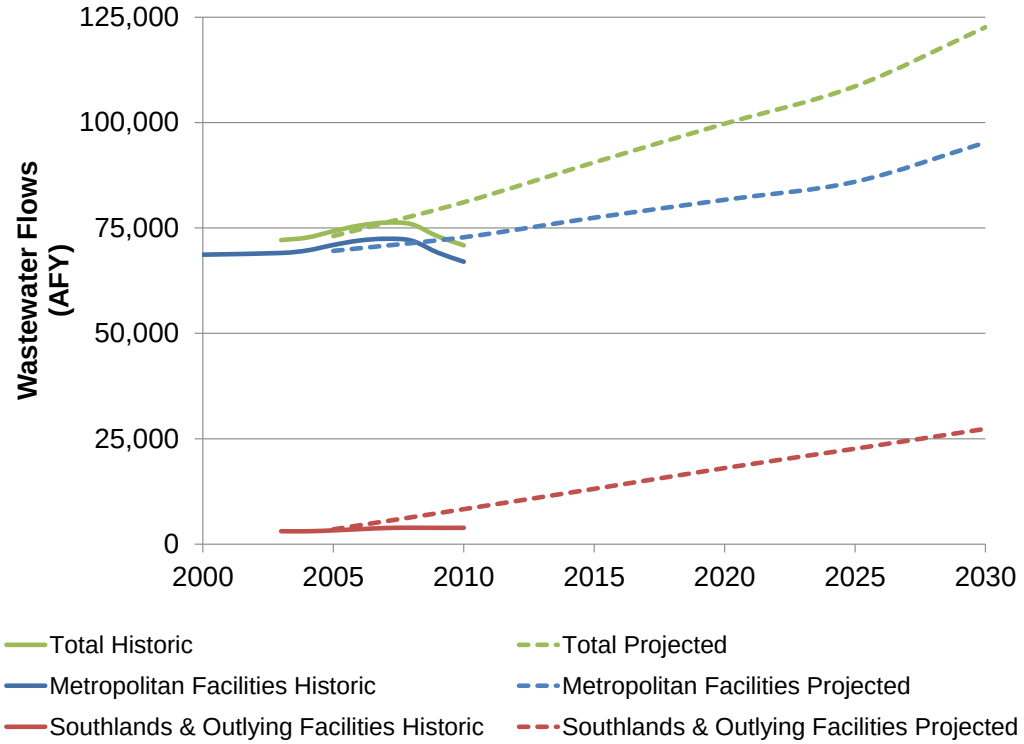


Figure 2-2. Comparison of Historic and Projected Wastewater Flows

Given the uncertainty in the assumptions and basis for the flow projections and the continued impacts of the economy, a range of wastewater flow projections was developed for purposes of the Recycled Water Master Plan evaluations:

- A “High” range based on the most recent regional wastewater flow projections.
- Based on the comparison of actual and projected wastewater flows, a “Low” range based on 90 percent of the regional wastewater flow projections.

3 Effluent Entitlement Projections

The series of IGAs between Tucson Water, the County, and several other local entities specify how the wastewater that is generated within the Tucson Water service area is to be apportioned into effluent entitlements for each entity. The IGAs are described in Chapter 3 of the Recycled Water Master Plan. The key agreements and stipulations that formed the basis of effluent entitlement projections herein are listed below:

- The City of Tucson and Pima County 1979 IGA transferred the City's sewer system to the County and allocated 90 percent of the effluent generated from metropolitan facilities to the City and 10 percent to the County (City of Tucson and Pima County, 1979).
- In 1983, the Southern Arizona Water Rights Settlement Act (SAWRSA) resolved litigation between the City and the Tohono O'Odham Nation by delegating 28,200 AFY of the City's annual effluent entitlement to the Secretary of Interior to hold for the benefit of the Nation (SAWRSA, 1983). The SAWRSA effluent is deducted from the total effluent prior to calculating the entitlements for the City, County, and other water providers.
- The City of Tucson and Pima County 2000 Supplemental IGA defined the metropolitan and non-metropolitan facilities and stipulated that up to 10,000 AFY of effluent known as the Conservation Effluent Pool (CEP) shall be made available for riparian projects that are a part of a habitat conservation plan, or that are mutually agreed upon by the City and County (City of Tucson and Pima County, 2000). Similar to SAWRSA, the CEP effluent is deducted from the total effluent prior to calculating the entitlements for the City, County, and other water providers. To date, none of the CEP has been designated for any projects.
- The City of Tucson and Pima County 2003 Wheeling IGA was related to treatment of the County's effluent and delivery of reclaimed water to the County through the City's RWS (City of Tucson and Pima County, 2003). Based on the 2000 Supplemental IGA and the 2003 Wheeling Agreement, effluent generated at outlying facilities belongs to the County up to the capacities of the facilities as of March 14, 2000. Any future effluent produced that is greater than the March 14, 2000 capacities is split between City and County, 90 percent and 10 percent, respectively.
- The City of Tucson and Town of Oro Valley 2001 IGA established relationships between the City and Oro Valley regarding effluent derived from the Oro Valley service area (City of Tucson and Town of Oro Valley, 2001). This IGA established the Effluent Allocation Formula that reflects the water provider's control of the effluent generated from within its

water service area. The Effluent Allocation Formula has since been used in all IGAs between the City and other water providers.

- The City of Tucson and Metropolitan Domestic Water Improvement District (MDWID) 2001 IGA established relationships between the City and MDWID regarding effluent derived from the MDWID service area (City of Tucson and Metropolitan Domestic Water Improvement District, 2001).
- The City of Tucson and Flowing Wells Irrigation District (FWID) 2009 IGA established relationships between the City and FWID regarding effluent derived from the FWID service area (City of Tucson and Flowing Wells Irrigation District, 2009).
- The City of Tucson and Spanish Trail 2009 IGA established relationships between the City and Spanish Trail regarding effluent derived from the Spanish Trail service area (City of Tucson and Spanish Trail, 2009).

Tucson Water's share of effluent influent to the metropolitan facilities is allotted to the other water providers (MDWID, Oro Valley, FWID, and Spanish Trail) based on wastewater contributions from their service areas, and after their share of contributions to SAWRSA, CEP, and Pima County effluent. The water providers' projected wastewater contributions are based on their projected non-turf potable water deliveries within their service areas, and an agreed upon water to wastewater factor (0.62 of non-turf potable water deliveries become wastewater). Contributions to SAWRSA, CEP, and Pima County are based on the water providers' pro rata contribution of wastewater to total wastewater influent to the metropolitan facilities.

A final consideration is that effluent production must account for losses within the facility treatment processes (solids, sludge, evaporation, etc.). Based on data from 2003 to 2010, facility losses have ranged from 1 to 6 percent for the metropolitan facilities. Treatment process losses at the outlying facilities should be similar due to similar treatment processes. The flow-weighted average plant loss for the metropolitan facilities from 2003 to 2010 was 3.4 percent. Based on the data, a single plant loss factor of 5 percent of influent flows was assumed for the effluent entitlement projections herein.

Table 3-1 summarizes the projected effluent entitlements for the Low and High range wastewater flow projections through 2030. Actual wastewater flows are shown for 2010. The resulting Tucson Water effluent entitlements are shown for two cases: 1) the full CEP is utilized for non-Tucson Water uses (Without CEP), and 2) the full CEP is not utilized for non-Tucson Water uses and the CEP is reverted back to the contributing entities (With CEP). The detailed calculations for the wastewater flow and effluent entitlement projections are provided in Attachment A.

Table 3-1. Projected Wastewater Flows and Effluent Entitlements

	Flows / Entitlements (AFY)								
	2010[1]	2015		2020		2025		2030	
	Actual Flows	Low Range	High Range	Low Range	High Range	Low Range	High Range	Low Range	High Range
Metropolitan Facilities Total Effluent Production[2]	63,700	66,200	73,600	69,800	77,600	73,500	81,700	81,500	90,500
SAWRSA Allotment	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200
CEP Allotment	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Tucson Water Entitlement	19,200	20,600	26,600	23,200	29,500	25,400	32,100	31,000	38,400
Pima County Entitlement	2,550	2,800	3,540	3,160	3,940	3,530	4,350	4,330	5,230
Oro Valley Entitlement	1,490	1,910	2,170	2,310	2,590	2,930	3,250	3,850	4,200
MDWID Entitlement	1,740	2,170	2,460	2,460	2,760	2,850	3,160	3,450	3,760
FWID Entitlement	441	467	531	500	560	530	587	586	638
Spanish Trail Entitlement	34	36	41	39	43	41	45	45	49
Southlands WRF Effluent Production[2]	0	3,450	3,830	5,750	6,390	7,850	8,730	10,060	11,170
Tucson Water Entitlement	0	3,100	3,450	5,170	5,750	7,070	7,850	9,050	10,060
Pima County Entitlement	0	350	380	580	640	790	870	1,010	1,120
Outlying Facilities Total Effluent Production[2]	399	4,100	4,960	6,010	7,090	7,830	9,110	9,650	11,130
Tucson Water Entitlement	359	3,690	4,460	5,410	6,380	7,050	8,200	8,690	10,020
Pima County Entitlement	40	410	496	601	709	783	911	965	1,113
Total Tucson Water Entitlement (Without CEP)	19,600	27,400	34,500	33,700	41,600	39,500	48,100	48,700	58,500
Tucson Water CEP Contribution	7,380	7,180	7,370	7,140	7,320	7,000	7,200	6,960	7,170
Total Tucson Water Entitlement (With CEP)	26,900	34,600	41,900	40,900	49,000	46,500	55,300	55,700	65,700

[1] *Actual flows are used for 2010.*

[2] *Influent flows less 5% for treatment plant losses.*

4 Tucson Water Effluent Entitlement Projections

All Recycled Water Master Plan evaluations are based on wastewater flow and effluent entitlement projections through 2030. For the purposes of the Tucson Water *2012 Update to Water Plan: 2000-2050*, wastewater flow and effluent entitlement projections were extrapolated to 2050. The extrapolation to 2050 was developed based on the shape of the potable water demand projections curve through 2050 (Tucson Water Resource Planning Tool, February 2010). Attachment A includes the extrapolation information.

Figure 4-1 shows the projected Tucson Water effluent entitlements, extrapolated through 2050. Considering the High and Low range wastewater flow projections, Tucson Water would have access to between 28,000 and 42,000 AFY of effluent entitlement in 2015, increasing to between 49,000 and 66,000 AFY in 2030, depending on actual utilization of the City's contribution to the CEP. In 2050, Tucson Water would have access to between 58,000 and 78,000 AFY.

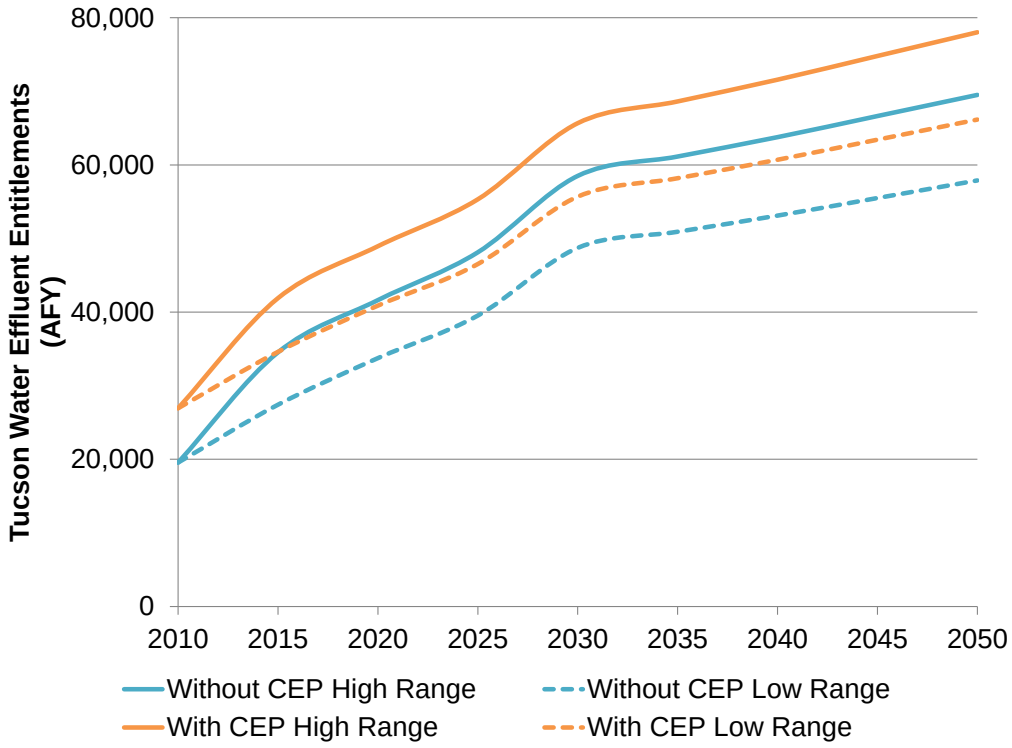


Figure 4-1. Tucson Water's Effluent Entitlement Projections

5 Effluent Availability for Other Recycled Water Programs

The previous analyses provided projected effluent entitlements on an annual average basis, and included all entitlements available for any recycled water program purpose, including delivering to reclaimed water customers. In order to determine how much of the projected entitlements might be available for other purposes, such as a groundwater replenishment program, the RWS demands and other existing consumptive uses of reclaimed water must be factored out. Also, the seasonal nature of RWS demands and other consumptive uses must be considered in order to determine how the excess effluent entitlements might be available on a seasonal basis. The seasonal availability of unused entitlements would form the flow basis for sizing and evaluating recharge, treatment and recovery facilities that might form a groundwater replenishment program for instance. The effluent availability for other recycled water programs was determined as follows:

- Only projected entitlements from the metropolitan facilities were considered since the majority of Tucson Water's entitlement is from these facilities. The entitlements from the outlying facilities would be managed separately.
- The seasonal distribution of effluent available for other recycled water programs was determined by evaluating the 2010 Tucson Water effluent entitlements, RWS deliveries, and other consumptive uses of reclaimed water during the year.
- Projected demands for the RWS were determined based on information provided by Tucson Water.
- The effluent entitlement projections, seasonal distribution of effluent availability, and RWS demand projections were combined to develop projections of seasonal effluent availability for other recycled water programs.

5.1 Seasonal Distribution of Effluent Entitlement Usage

Figure 5-1 shows the 2010 distribution of recycled water resources, including Tucson Water's effluent entitlement, total reclaimed water deliveries, and consumptive uses of recycled water. The effluent entitlement that is not utilized could be available for other recycled water programs. The existing consumptive uses of reclaimed water include the Sweetwater Wetlands (750 AFY), flow to maintain the mound at the Sweetwater Underground Storage and Recovery (US&R) facility (300 AFY), and the Silverbell Golf Course (152 AFY). The consumptive uses are assumed to stay constant throughout the planning horizon. The 2010 seasonal demand curve for the RWS was also assumed to stay constant throughout the planning period. The shape of the 2010 seasonal

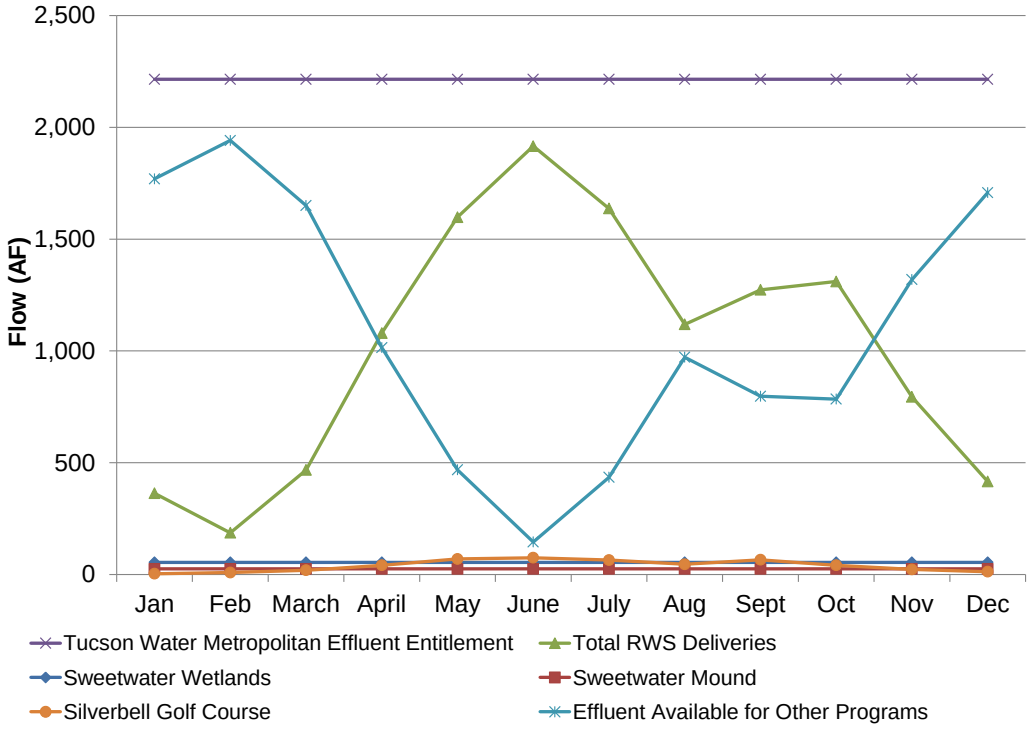


Figure 5-1. 2010 Seasonal Distribution of Recycled Water Resources

RWS demand curve was applied to the reclaimed water demand projections throughout the planning horizon. The RWS demand projections are discussed in the following section.

5.2 Reclaimed Water Demand Projections

Table 5-1 summarizes Tucson Water's reclaimed water demand projections. Reclaimed water demand through 2016 is based on fiscal year 2012 financial and rate projections provided by Tucson Water Financial Services. For 2020, the demand increases by 800 AFY to account for the new University of Arizona Bio5 Institute golf course. Beyond 2020, reclaimed water demand increases by 500 AFY every five years based on historic new connections to the RWS. The reclaimed water demand projections include deliveries to the service areas of Tucson Water, University of Arizona, Davis Monthan AFB, and FWID. Deliveries to Oro Valley, MDWID, and the County are not included in the Tucson Water reclaimed water demand projections.

Table 5-1. Reclaimed Water Demand Projections

	Projected Demand (AFY)						
	2010	2015	2020	2025	2030	2040	2050
Tucson Water RWS Deliveries	12,500	13,060	13,860	14,360	14,860	15,360	15,860

5.3 Projections of Effluent Entitlements Available for other Recycled Water Programs

A range of projections of seasonal availability of effluent entitlements for other recycled water programs was developed as follows:

- Low Range: based on 90 percent of the most recent wastewater flow projections, and the assumption that the full CEP is utilized for non-Tucson Water uses.
- High Range: based on 100 percent of the most recent wastewater flow projections, and the assumption that the full CEP is not utilized for non-Tucson Water uses and Tucson Water's CEP contribution is reverted back to Tucson Water.

Figures 5-2, 5-3, and 5-4 illustrate the projections of monthly distribution of recycled water resources for 2020, 2030, and 2050, respectively. The figures indicate the minimum and maximum month availability of Tucson Water's unutilized effluent entitlements for each time period.

Table 5-2 summarizes Tucson Water's unutilized effluent entitlements that could be available for other recycled water programs, also for 2020, 2030 and 2050. The table summarizes the minimum and maximum month availability of unutilized effluent entitlements for each time interval, as well as the annual totals. Attachment A contains detailed calculations for the distribution of recycled water resources.

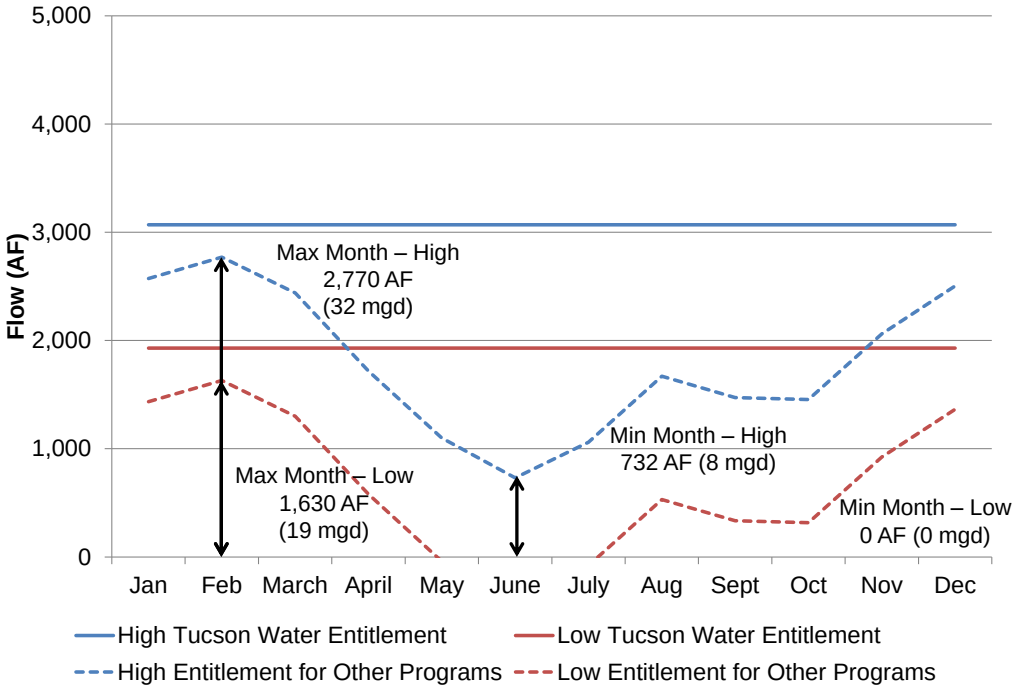


Figure 5-2. 2020 Seasonal Distribution of Recycled Water Resources

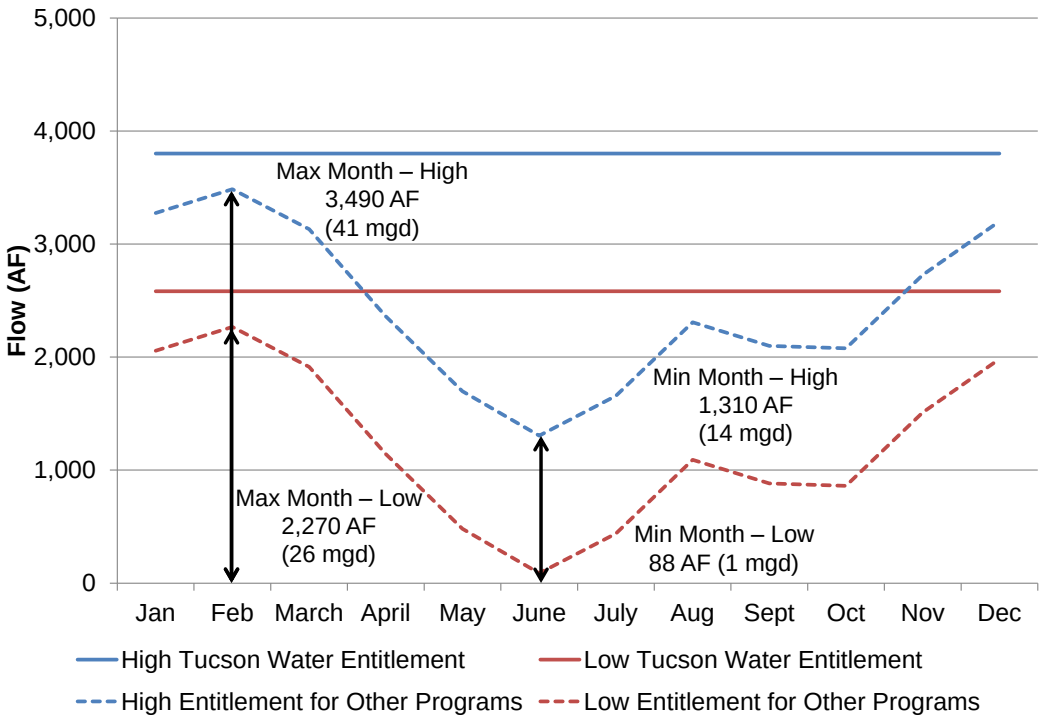


Figure 5-3. 2030 Seasonal Distribution of Recycled Water Resources

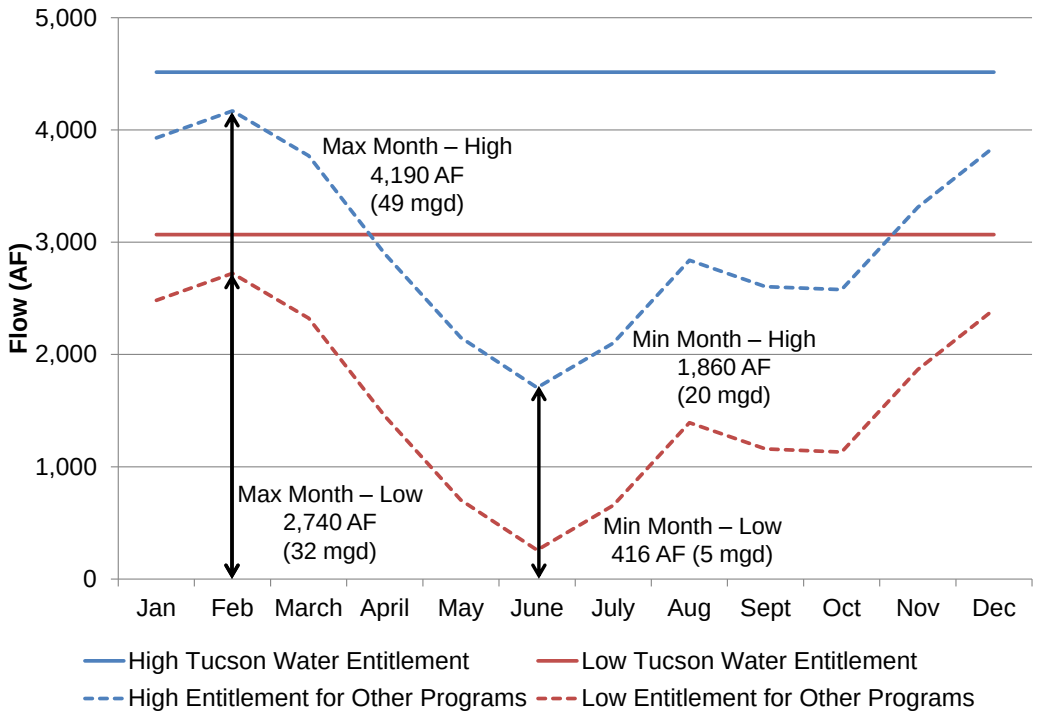


Figure 5-4. 2050 Seasonal Distribution of Recycled Water Resources

Table 5-2. Summary of Unutilized Effluent Entitlements Available for Other Recycled Water Programs

Available	2020		2030		2050	
	Low Range	High Range	Low Range	High Range	Low Range	High Range
Minimum Month	0 AF (0 MGD)	732 AF (8 MGD)	88 AF (1 MGD)	1,310 AF (14 MGD)	416 AF (5 MGD)	1,860 AF (20 MGD)
Maximum Month	1,630 AF (19 MGD)	2,770 AF (32 MGD)	2,270 AF (26 MGD)	3,490 AF (41 MGD)	2,740 AF (32 MGD)	4,190 AF (49 MGD)
Annual Total	7,890 AF/YR (7 MGD)	21,600 AF/YR (19 MGD)	14,700 AF/YR (13 MGD)	29,300 AF/YR (26 MGD)	19,500 AF/YR (17 MGD)	36,900 AF/YR (33 MGD)

6 References

Brown and Caldwell. *Metropolitan Area Facility Plan Update*. Pima County Regional Wastewater Reclamation Department. February 2006.

City of Tucson and Flowing Wells Irrigation District. *Intergovernmental Agreement with the Flowing Wells Irrigation District Relating to Effluent*. December 7, 2009.

City of Tucson and Metropolitan Domestic Water Improvement District. *Intergovernmental Agreement Relating to Effluent*. June 11, 2001.

City of Tucson and Pima County. *Intergovernmental Agreement with Pima County Providing for the Transfer of the City Sewerage System and for the Disposition of Treated and Reclaimed Water*. June 26, 1979.

City of Tucson and Pima County. *Supplemental Intergovernmental Agreement RE: Effluent*. February 7, 2000.

City of Tucson and Pima County. *Intergovernmental Agreement between the City of Tucson and Pima County for Treating Effluent and Wheeling Reclaimed Water*. December 8, 2003.

City of Tucson and Pima County Joint Planning Group – Population and Effluent Projections. *Resolution of Population and Effluent Variances between the Tucson Water and Pima County Wastewater Management Long-Range Plans*. November 29, 2005.

City of Tucson and Spanish Trail. *Intergovernmental Agreement with the Spanish Trail Water Company Relating to Effluent*. December 7, 2009.

City of Tucson and Town of Oro Valley. *Intergovernmental Settlement Agreement with the Town of Oro Valley Regarding Potable Water and Effluent*. November 5, 2001.

Greeley and Hanson. *Regional Optimization Master Plan*. Pima County Regional Wastewater Reclamation Department. November 2007.

Malcolm Pirnie/ARCADIS. *Southeast Area Sub-regional Wastewater Reclamation Facility Site Study*. Pima County Regional Wastewater Reclamation Department. August 2011.

Tucson Water. *2012 Update to Water Plan: 2000-2050.* 2012.

Southern Arizona Water Rights Settlement Act. 1983.

WestLand Resources, Inc. *Verano Offsite Sewer Basin Study*. South Wilmot Land Investors, LLC. August 2009.

ATTACHMENT A

EFFLUENT FLOW AND ENTITLEMENT PROJECTIONS

90% Wastewater Flow Projections (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Roger Road[1]	35,279	28,863	32,684	36,535	32,311
Ina Road[1]	28,982	37,805	37,805	37,805	50,406
Randolph[1]	2,739	3,024	3,024	3,024	3,024
Metro Subtotal	67,000	69,692	73,513	77,364	85,741
Southlands[2]	0	3,629	6,049	8,267	10,585
Avra Valley[2]	1,236	1,815	2,218	2,621	3,024
Marana[2]	292	2,319	3,024	3,730	4,436
Corona de Tucson[2]	284	907	1,311	1,714	2,117
Green Valley[2]	2,065	3,125	3,629	4,033	4,436
Mt. Lemmon[2]	3.5	13.1	13.1	13.1	13.1
Outlying Facilities Subtotal	3,881	11,808	16,244	20,377	24,611
Total	**70,881**	**81,500**	**89,757**	**97,741**	**110,353**

Source:

1. 2006 Facility Plan Update
2. 2007 Regional Optimization Master Plan

Non-Metropolitan WRFs - Treatment Capacity as of 2000			
	MGD	acre-ft/yr	Source
Avra Valley	1.2	1,344	2006 Facility Plan Update
Marana	0.023	26	2006 Facility Plan Update
Corona de Tucson	0.117	131	2006 Facility Plan Update
Green Valley	2	2,352	2006 Facility Plan Update and 1999 Green Valley Wastewater Treatment Facility Upgrade and BNROD Project Technical Design Report
Mt. Lemmon	0.013	14.6	2006 Facility Plan Update

Non-Metropolitan WRFs - Flow Available to COT after 2000 (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Avra Valley	0	470	874	1,277	1,680
Marana	267	2,293	2,999	3,704	4,410
Corona de Tucson	153	776	1,180	1,583	1,986
Green Valley	0	773	1,277	1,680	2,083
Mt. Lemmon	0	0	0	0	0
Total	420	4,313	6,329	8,244	10,160

Effluent Entitlement Projections with WRF Losses (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Roger Road	35,279	28,863	32,684	36,535	32,311
Ina Road	28,982	37,805	37,805	37,805	50,406
Randolph	2,739	3,024	3,024	3,024	3,024
Subtotal	67,000	69,692	73,513	77,364	85,741
WRF losses (5%)	3,350	3,485	3,676	3,868	4,287
SAWRSA	28,200	28,200	28,200	28,200	28,200
CEP	10,000	10,000	10,000	10,000	10,000
Tucson	22,905	25,207	28,473	31,766	38,929
Pima County	2,545	2,801	3,164	3,530	4,325
Southlands	0	3,629	6,049	8,267	10,585
WRF losses (5%)	0	181	302	413	529
Tucson	0	3,103	5,172	7,068	9,050
Pima County	0	345	575	785	1,006
Outlying Facilities Subtotal	420	4,313	6,329	8,244	10,160
WRF losses (5%)	21	216	316	412	508
Tucson	359	3,687	5,411	7,049	8,687
Pima County	40	410	601	783	965

Effluent entitlement calculations are based on the Effluent Allocation Formula that is outlined in the 2001 City of Tucson and Metropolitan Domestic Water Improvement District Intergovernmental Agreement

Constants

Loss factor, L	0.96
Agreed factor, F	0.62

Water Provider Non-Turf Potable Delivery Projections (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Oro Valley[1]	6,946	8,414	9,519	11,385	13,549
MDWID[2]	8,138	9,570	10,135	11,084	12,131
FWID[3]	2,061	2,061	2,061	2,061	2,061
Spanish Trail[3]	159	159	159	159	159

Source:

1. Oro Valley Water Utility. 2010 value from Tucson Water.
2. MDWID. 2010 value from Tucson Water.
3. No projected increase for potable deliveries. Based on 2010 value from Tucson Water.

GAE - Gross Amount of Effluent (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Oro Valley	4,134	5,008	5,666	6,777	8,064
MDWID	4,844	5,696	6,032	6,597	7,221
FWID	1,226	1,226	1,226	1,226	1,226
Spanish Trail	95	95	95	95	95

S - SAWRSA Effluent (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Tucson	20,817	20,258	20,123	19,742	19,631
Pima County	2,820	2,820	2,820	2,820	2,820
Oro Valley	1,832	2,133	2,288	2,600	2,792
MDWID	2,146	2,426	2,436	2,531	2,500
FWID	543	522	495	471	425
Spanish Trail	42	40	38	36	33
Total	28,200	28,200	28,200	28,200	28,200

CEP - Conservation Effluent Pool (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Tucson	7,382	7,184	7,136	7,001	6,961
Pima County	1,000	1,000	1,000	1,000	1,000
Oro Valley	649	756	811	922	990
MDWID	761	860	864	898	886
FWID	193	185	176	167	151
Spanish Trail	15	14	14	13	12
Total	10,000	10,000	10,000	10,000	10,000

PE - Pima County Effluent (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Oro Valley	165	212	257	325	428
MDWID	194	241	273	317	383
FWID	49	52	56	59	65
Spanish Trail	4	4	4	5	5

Effluent Allocations (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Tucson	19,199	20,628	23,165	25,415	30,992
Pima County	2,545	2,801	3,164	3,530	4,325
Oro Valley	1,488	1,907	2,310	2,929	3,854
MDWID	1,743	2,169	2,459	2,851	3,451
FWID	441	467	500	530	586
Spanish Trail	34	36	39	41	45

Effluent Projections and Allocations (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
RR, IR, RP Projections (minus 5% loss)	63,650	66,207	69,837	73,496	81,454
SAWRSA	28,200	28,200	28,200	28,200	28,200
CEP	10,000	10,000	10,000	10,000	10,000
Tucson	19,199	20,628	23,165	25,415	30,992
Pima County	2,545	2,801	3,164	3,530	4,325
Oro Valley	1,488	1,907	2,310	2,929	3,854
MDWID	1,743	2,169	2,459	2,851	3,451
FWID	441	467	500	530	586
Spanish Trail	34	36	39	41	45
Southlands (minus 5% loss)	0	3,448	5,746	7,853	10,056
Tucson	0	3,103	5,172	7,068	9,050
Pima County	0	345	575	785	1,006
Outlying Facility Total (minus 5% loss)	399	4,097	6,012	7,832	9,652
Tucson	359	3,687	5,411	7,049	8,687
Pima County	40	410	601	783	965

	2010	**2015**	**2020**	**2025**	**2030**
Tucson Total without CEP	19,558	27,419	33,748	39,532	48,729
Tucson CEP Contribution	7,382	7,184	7,136	7,001	6,961
Tucson Total with CEP	26,940	34,602	40,884	46,532	55,691

City of Tucson Reclaimed System Demand Projections (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Reclaimed Demand Projections	12,500	13,060	13,860	14,360	14,860

Source: Tucson Water

	2010	**2015**	**2020**	**2025**	**2030**
Tucson Total after Reclaimed Demand (without CEP)	7,058	14,359	19,888	25,172	33,869
Tucson Total after Reclaimed Demand (with CEP)	14,440	21,542	27,024	32,172	40,831

Flow Available to COT by WRF (minus 5% losses and without CEP; acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Roger Road	10,109	8,543	10,299	12,002	11,679
Ina Road	8,305	11,190	11,913	12,419	18,220
Randolph	785	895	953	994	1,093
Subtotal	19,199	20,628	23,165	25,415	30,992
Southlands	0	3,103	5,172	7,068	9,050
Avra Valley	0	402	747	1,092	1,437
Marana	228	1,960	2,564	3,167	3,771
Corona de Tucson	131	664	1,008	1,353	1,698
Green Valley	0	661	1,092	1,437	1,781
Mt. Lemmon	0	0	0	0	0
Subtotal	359	6,790	10,583	14,117	17,737
Total	19,558	27,419	33,748	39,532	48,729

Flow Available to COT by WRF (minus 5% losses and with CEP; acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Roger Road	13,996	11,518	13,472	15,308	14,302
Ina Road	11,498	15,087	15,583	15,840	22,313
Randolph	1,087	1,207	1,247	1,267	1,339
Subtotal	26,581	27,812	30,301	32,415	37,954
Southlands	0	3,103	5,172	7,068	9,050
Avra Valley	0	402	747	1,092	1,437
Marana	228	1,960	2,564	3,167	3,771
Corona de Tucson	131	664	1,008	1,353	1,698
Green Valley	0	661	1,092	1,437	1,781
Mt. Lemmon	0	0	0	0	0
Subtotal	359	6,790	10,583	14,117	17,737
Total	26,940	34,602	40,884	46,532	55,691

100% Wastewater Flow Projections (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Roger Road[1]	35,279	32,070	36,315	40,594	35,901
Ina Road[1]	28,982	42,005	42,005	42,005	56,007
Randolph[1]	2,739	3,360	3,360	3,360	3,360
Metro Subtotal	67,000	77,436	81,681	85,960	95,268
Southlands[2]	0	4,033	6,721	9,185	11,762
Avra Valley[2]	1,236	2,016	2,464	2,912	3,360
Marana[2]	292	2,576	3,360	4,145	4,929
Corona de Tucson[2]	284	1,008	1,456	1,904	2,352
Green Valley[2]	2,065	3,472	4,033	4,481	4,929
Mt. Lemmon[2]	3.5	14.6	14.6	14.6	14.6
Outlying Facilities Subtotal	3,881	9,088	11,328	13,456	15,585
Total	**70,881**	**90,556**	**99,730**	**108,601**	**122,614**

Source:

1. 2006 Facility Plan Update
2. 2007 Regional Optimization Master Plan

Non-Metropolitan WRFs - Treatment Capacity as of 2000			
	MGD	acre-ft/yr	Source
Avra Valley	1.2	1,344	2006 Facility Plan Update
Marana	0.023	26	2006 Facility Plan Update
Corona de Tucson	0.117	131	2006 Facility Plan Update
Green Valley	2	2,352	2006 Facility Plan Update and 1999 Green Valley Wastewater Treatment Facility Upgrade and BNROD Project Technical Design Report
Mt. Lemmon	0.013	14.6	2006 Facility Plan Update

Non-Metropolitan WRFs - Flow Available to COT after 2000 (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Avra Valley	0	672	1,120	1,568	2,016
Marana	267	2,551	3,335	4,119	4,903
Corona de Tucson	153	877	1,325	1,773	2,221
Green Valley	0	1,120	1,680	2,128	2,576
Mt. Lemmon	0	0	0	0	0
Total	420	5,220	7,460	9,588	11,717

Effluent Entitlement Projections with WRF Losses (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Roger Road	35,279	32,070	36,315	40,594	35,901
Ina Road	28,982	42,005	42,005	42,005	56,007
Randolph	2,739	3,360	3,360	3,360	3,360
Subtotal	67,000	77,436	81,681	85,960	95,268
WRF losses (5%)	3,350	3,872	4,084	4,298	4,763
SAWRSA	28,200	28,200	28,200	28,200	28,200
CEP	10,000	10,000	10,000	10,000	10,000
Tucson	22,905	31,827	35,457	39,116	47,074
Pima County	2,545	3,536	3,940	4,346	5,230
Southlands	0	4,033	6,721	9,185	11,762
WRF losses (5%)	0	202	336	459	588
Tucson	0	3,448	5,746	7,853	10,056
Pima County	0	383	638	873	1,117
Outlying Facilities Subtotal	420	5,220	7,460	9,588	11,717
WRF losses (5%)	21	261	373	479	586
Tucson	359	4,463	6,378	8,198	10,018
Pima County	40	496	709	911	1,113

Effluent entitlement calculations are based on the Effluent Allocation Formula that is outlined in the 2001 City of Tucson and Metropolitan Domestic Water Improvement District Intergovernmental Agreement

Constants

Loss factor, L	0.96
Agreed factor, F	0.62

Water Provider Non-Turf Potable Delivery Projections (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Oro Valley[1]	6,946	8,414	9,519	11,385	13,549
MDWID[2]	8,138	9,570	10,135	11,084	12,131
FWID[3]	2,061	2,061	2,061	2,061	2,061
Spanish Trail[3]	159	159	159	159	159

Source:

1. Oro Valley Water Utility. 2010 value from Tucson Water.
2. MDWID. 2010 value from Tucson Water.
3. No projected increase for potable deliveries. Based on 2010 value from Tucson Water.

GAE - Gross Amount of Effluent (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Oro Valley	4,134	5,008	5,666	6,777	8,064
MDWID	4,844	5,696	6,032	6,597	7,221
FWID	1,226	1,226	1,226	1,226	1,226
Spanish Trail	95	95	95	95	95

S - SAWRSA Effluent (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Tucson	20,817	20,770	20,649	20,305	20,206
Pima County	2,820	2,820	2,820	2,820	2,820
Oro Valley	1,832	1,920	2,059	2,340	2,513
MDWID	2,146	2,184	2,192	2,278	2,250
FWID	543	470	446	424	382
Spanish Trail	42	36	34	33	30
Total	28,200	28,200	28,200	28,200	28,200

CEP - Conservation Effluent Pool (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Tucson	7,382	7,365	7,322	7,201	7,165
Pima County	1,000	1,000	1,000	1,000	1,000
Oro Valley	649	681	730	830	891
MDWID	761	774	777	808	798
FWID	193	167	158	150	136
Spanish Trail	15	13	12	12	10
Total	10,000	10,000	10,000	10,000	10,000

PE - Pima County Effluent (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Oro Valley	165	241	288	361	466
MDWID	194	274	306	351	417
FWID	49	59	62	65	71
Spanish Trail	4	5	5	5	5

Effluent Entitlements (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
RR, IR, RP Projections (minus 5% loss)	63,650	73,564	77,597	81,662	90,505
SAWRSA	28,200	28,200	28,200	28,200	28,200
CEP	10,000	10,000	10,000	10,000	10,000
Tucson	19,199	26,625	29,508	32,077	38,437
Pima County	2,545	3,536	3,940	4,346	5,230
Oro Valley	1,488	2,167	2,589	3,246	4,195
MDWID	1,743	2,464	2,756	3,160	3,756
FWID	441	531	560	587	638
Spanish Trail	34	41	43	45	49
Southlands (minus 5% loss)	0	3,831	6,385	8,726	11,173
Tucson	0	3,448	5,746	7,853	10,056
Pima County	0	383	638	873	1,117
Outlying Facility Total (minus 5% loss)	399	4,959	7,087	9,109	11,131
Tucson	359	4,463	6,378	8,198	10,018
Pima County	40	496	709	911	1,113

	2010	**2015**	**2020**	**2025**	**2030**
Tucson Total without CEP	19,558	34,535	41,633	48,128	58,511
Tucson CEP Contribution	7,382	7,365	7,322	7,201	7,165
Tucson Total with CEP	26,940	41,901	48,955	55,329	65,676

City of Tucson Reclaimed System Demand Projections (acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Reclaimed Demand Projections	12500	13060	13860	14360	14860

Source: Tucson Water

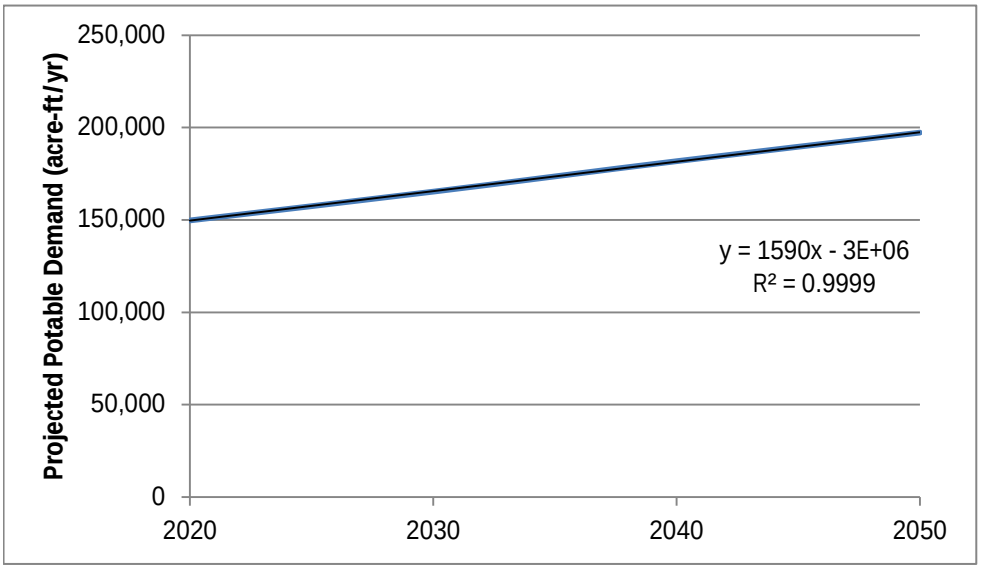
	2010	**2015**	**2020**	**2025**	**2030**
Tucson Total after Reclaimed Demand (without CEP)	7,058	21,475	27,773	33,768	43,651
Tucson Total after Reclaimed Demand (with CEP)	14,440	28,841	35,095	40,969	50,816

Flow Available to COT by WRF (minus 5% losses and without CEP; acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Roger Road	10,109	11,026	13,119	15,148	14,484
Ina Road	8,305	14,443	15,175	15,675	22,597
Randolph	785	1,155	1,214	1,254	1,356
Subtotal	19,199	26,625	29,508	32,077	38,437
Southlands	0	3,448	5,746	7,853	10,056
Avra Valley	0	575	958	1,341	1,724
Marana	228	2,181	2,851	3,522	4,192
Corona de Tucson	131	750	1,133	1,516	1,899
Green Valley	0	958	1,437	1,820	2,203
Mt. Lemmon	0	0	0	0	0
Subtotal	359	7,911	12,125	16,051	20,074
Total	19,558	34,535	41,633	48,128	58,511

Flow Available to COT by WRF (minus 5% losses and with CEP; acre-ft/yr)					
	2010	**2015**	**2020**	**2025**	**2030**
Roger Road	13,996	14,077	16,375	18,549	17,185
Ina Road	11,498	18,438	18,940	19,193	26,809
Randolph	1,087	1,475	1,515	1,535	1,609
Subtotal	26,581	33,990	36,830	39,277	45,602
Southlands	0	3,448	5,746	7,853	10,056
Avra Valley	0	575	958	1,341	1,724
Marana	228	2,181	2,851	3,522	4,192
Corona de Tucson	131	750	1,133	1,516	1,899
Green Valley	0	958	1,437	1,820	2,203
Mt. Lemmon	0	0	0	0	0
Subtotal	359	7,911	12,125	16,051	20,074
Total	26,940	41,901	48,955	55,329	65,676

Effluent Entitlement Projections
Extrapolation to 2050

Year	Projected Potable Demand (acre-ft)	Δ (acre-ft/yr)	% Change	Slope
2020	149,748			
2030	165,318	15,570	9%	1557
2040	181,795	16,477	9%	1648
2050	197,254	15,459	8%	1546



Tucson Water's Projected Effluent Entitlements (acre-ft/yr)							
Low Range (90% of Wastewater Flow Projections)							
	2010	2015	2020	2025	2030	2040	2050
Tucson Total without CEP	19,558	27,419	33,748	39,532	48,729	53,115	57,895
Tucson CEP Contribution	7,382	7,184	7,136	7,001	6,961	7,588	8,271
Tucson Total with CEP	26,940	34,602	40,884	46,532	55,691	60,703	66,166
High Range (100% of Wastewater Flow Projections)							
	2010	2015	2020	2025	2030	2040	2050
Tucson Total without CEP	19,558	34,535	41,633	48,128	58,511	63,777	69,517
Tucson CEP Contribution	7,382	7,365	7,322	7,201	7,165	7,810	8,513
Tucson Total with CEP	26,940	41,901	48,955	55,329	65,676	71,587	78,030

Note: 2040 and 2050 projections based on Tucson Water potable demand projections

Percent of Reclaimed Water Deliveries	
TW	80%
Oro Valley	13%
Pima Co	7%

Source: 2010 Tucson Water Reclaimed Water Deliveries

Month	Reclaimed Water Deliveries - 2010				TW Entitlement Metro Only (acre-ft)	Flow to Wetlands (acre-ft)	Sweetwater Mound (acre-ft)	Silverbell Golf Course (acre-ft)	Effluent for New Programs (acre-ft)
	Total Pumped to System (MG)	Total Pumped to System (acre-ft)	TW Pumped to System (acre-ft)	TW Reclaimed Monthly Flow Dist.					
Jan	148	454	363	3%	2,215	54	25	3	1,770
Feb	76	233	186	2%	2,215	54	25	8	1,941
March	190	584	467	4%	2,215	54	25	19	1,650
April	440	1,350	1,080	9%	2,215	54	25	41	1,015
May	651	1,998	1,598	13%	2,215	54	25	69	468
June	780	2,395	1,916	16%	2,215	54	25	75	145
July	667	2,046	1,637	13%	2,215	54	25	64	434
Aug	456	1,398	1,119	9%	2,215	54	25	46	972
Sept	519	1,592	1,273	10%	2,215	54	25	66	797
Oct	534	1,638	1,311	11%	2,215	54	25	41	784
Nov	324	993	794	7%	2,215	54	25	23	1,319
Dec	169	520	416	3%	2,215	54	25	12	1,708
Total	**4,953**	**15,200**	**12,160**	**100%**	**26,581**	**650**	**300**	**467**	**13,004**

2015 - Tucson Water Entitlement for Roger Road, Ina Road, and Randolph Park WRFs only

Month	Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)	TW Reclaimed Monthly Flow Dist.	TW Projected Reclaimed System Demand (acre-ft)	Flow to Wetlands (acre-ft)	Sweetwater Mound (acre-ft)	Silverbell Golf Course (acre-ft)	Effluent Available for New Programs: Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)
Jan	1,719	2,318	2,219	2,832	3%	390	54	25	3	1,247	1,845	1,746	2,360
Feb	1,719	2,318	2,219	2,832	2%	200	54	25	8	1,431	2,030	1,931	2,545
March	1,719	2,318	2,219	2,832	4%	502	54	25	19	1,119	1,718	1,619	2,233
April	1,719	2,318	2,219	2,832	9%	1,160	54	25	41	439	1,038	939	1,552
May	1,719	2,318	2,219	2,832	13%	1,716	54	25	69	-146	453	354	967
June	1,719	2,318	2,219	2,832	16%	2,058	54	25	75	-493	106	7	621
July	1,719	2,318	2,219	2,832	13%	1,758	54	25	64	-183	416	317	931
Aug	1,719	2,318	2,219	2,832	9%	1,201	54	25	46	393	991	893	1,506
Sept	1,719	2,318	2,219	2,832	10%	1,367	54	25	66	207	805	706	1,320
Oct	1,719	2,318	2,219	2,832	11%	1,408	54	25	41	191	790	691	1,305
Nov	1,719	2,318	2,219	2,832	7%	853	54	25	23	764	1,363	1,264	1,878
Dec	1,719	2,318	2,219	2,832	3%	447	54	25	12	1,181	1,780	1,681	2,294
Total	**20,628**	**27,812**	**26,625**	**33,990**	**1**	**13,060**	**650**	**300**	**467**	**6,151**	**13,335**	**12,147**	**19,513**

2020 - Tucson Water Entitlement for Roger Road, Ina Road, and Randolph Park WRFs only

Month	Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)	TW Reclaimed Monthly Flow Dist.	TW Projected Reclaimed System Demand (acre-ft)	Flow to Wetlands (acre-ft)	Sweetwater Mound (acre-ft)	Silverbell Golf Course (acre-ft)	Effluent Available for New Programs: Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)
Jan	1,930	2,525	2,459	3,069	3%	414	54	25	3	1,434	2,029	1,963	2,573
Feb	1,930	2,525	2,459	3,069	2%	212	54	25	8	1,631	2,225	2,159	2,769
March	1,930	2,525	2,459	3,069	4%	533	54	25	19	1,300	1,895	1,829	2,439
April	1,930	2,525	2,459	3,069	9%	1,231	54	25	41	579	1,174	1,108	1,718
May	1,930	2,525	2,459	3,069	13%	1,822	54	25	69	-40	555	489	1,099
June	1,930	2,525	2,459	3,069	16%	2,184	54	25	75	-407	187	121	732
July	1,930	2,525	2,459	3,069	13%	1,866	54	25	64	-79	516	450	1,060
Aug	1,930	2,525	2,459	3,069	9%	1,275	54	25	46	531	1,125	1,059	1,669
Sept	1,930	2,525	2,459	3,069	10%	1,451	54	25	66	334	929	863	1,473
Oct	1,930	2,525	2,459	3,069	11%	1,494	54	25	41	316	911	845	1,455
Nov	1,930	2,525	2,459	3,069	7%	905	54	25	23	923	1,518	1,452	2,062
Dec	1,930	2,525	2,459	3,069	3%	474	54	25	12	1,365	1,960	1,894	2,504
Total	**23,165**	**30,301**	**29,508**	**36,830**	**1**	**13,860**	**650**	**300**	**467**	**7,888**	**15,024**	**14,231**	**21,553**

2025 - Tucson Water Entitlement for Roger Road, Ina Road, and Randolph Park WRFs only

Month	Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)	TW Reclaimed Monthly Flow Dist.	TW Projected Reclaimed System Demand (acre-ft)	Flow to Wetlands (acre-ft)	Sweetwater Mound (acre-ft)	Silverbell Golf Course (acre-ft)	Effluent Available for New Programs: Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)
Jan	2,118	2,701	2,673	3,273	3%	429	54	25	3	1,607	2,190	2,162	2,762
Feb	2,118	2,701	2,673	3,273	2%	220	54	25	8	1,810	2,394	2,366	2,966
March	2,118	2,701	2,673	3,273	4%	552	54	25	19	1,468	2,052	2,023	2,624
April	2,118	2,701	2,673	3,273	9%	1,275	54	25	41	722	1,306	1,278	1,878
May	2,118	2,701	2,673	3,273	13%	1,887	54	25	69	82	665	637	1,237
June	2,118	2,701	2,673	3,273	16%	2,262	54	25	75	-298	285	257	857
July	2,118	2,701	2,673	3,273	13%	1,933	54	25	64	41	625	596	1,196
Aug	2,118	2,701	2,673	3,273	9%	1,321	54	25	46	672	1,255	1,227	1,827
Sept	2,118	2,701	2,673	3,273	10%	1,504	54	25	66	469	1,053	1,025	1,625
Oct	2,118	2,701	2,673	3,273	11%	1,548	54	25	41	450	1,033	1,005	1,605
Nov	2,118	2,701	2,673	3,273	7%	938	54	25	23	1,078	1,661	1,633	2,233
Dec	2,118	2,701	2,673	3,273	3%	491	54	25	12	1,535	2,119	2,090	2,691
Total	**25,415**	**32,415**	**32,077**	**39,277**	**1**	**14,360**	**650**	**300**	**467**	**9,638**	**16,638**	**16,300**	**23,500**

2030 - Tucson Water Entitlement for Roger Road, Ina Road, and Randolph Park WRFs only

Month	Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)	TW Reclaimed Monthly Flow Dist.	TW Projected Reclaimed System Demand (acre-ft)	Flow to Wetlands (acre-ft)	Sweetwater Mound (acre-ft)	Silverbell Golf Course (acre-ft)	Effluent Available for New Programs: Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)
Jan	2,583	3,163	3,203	3,800	3%	444	54	25	3	2,057	2,637	2,677	3,274
Feb	2,583	3,163	3,203	3,800	2%	228	54	25	8	2,268	2,848	2,888	3,485
March	2,583	3,163	3,203	3,800	4%	571	54	25	19	1,914	2,494	2,534	3,131
April	2,583	3,163	3,203	3,800	9%	1,320	54	25	41	1,143	1,723	1,763	2,360
May	2,583	3,163	3,203	3,800	13%	1,953	54	25	69	481	1,061	1,102	1,699
June	2,583	3,163	3,203	3,800	16%	2,341	54	25	75	88	668	708	1,305
July	2,583	3,163	3,203	3,800	13%	2,000	54	25	64	439	1,019	1,059	1,656
Aug	2,583	3,163	3,203	3,800	9%	1,367	54	25	46	1,091	1,671	1,711	2,308
Sept	2,583	3,163	3,203	3,800	10%	1,556	54	25	66	882	1,462	1,502	2,099
Oct	2,583	3,163	3,203	3,800	11%	1,602	54	25	41	861	1,441	1,481	2,078
Nov	2,583	3,163	3,203	3,800	7%	971	54	25	23	1,510	2,090	2,131	2,728
Dec	2,583	3,163	3,203	3,800	3%	508	54	25	12	1,983	2,563	2,603	3,200
Total	**30,992**	**37,954**	**38,437**	**45,602**	**1**	**14,860**	**650**	**300**	**467**	**14,715**	**21,677**	**22,160**	**29,325**

2040 - Tucson Water Entitlement for Roger Road, Ina Road, and Randolph Park WRFs only

Month	Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)	TW Reclaimed Monthly Flow Dist.	TW Projected Reclaimed System Demand (acre-ft)	Flow to Wetlands (acre-ft)	Sweetwater Mound (acre-ft)	Silverbell Golf Course (acre-ft)	Effluent Available for New Programs: Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)
Jan	2,815	3,447	3,491	4,142	3%	474	54	25	3	2,259	2,892	2,935	3,586
Feb	2,815	3,447	3,491	4,142	2%	243	54	25	8	2,485	3,117	3,161	3,812
March	2,815	3,447	3,491	4,142	4%	609	54	25	19	2,108	2,740	2,784	3,435
April	2,815	3,447	3,491	4,142	9%	1,408	54	25	41	1,286	1,919	1,963	2,614
May	2,815	3,447	3,491	4,142	13%	2,084	54	25	69	582	1,214	1,258	1,909
June	2,815	3,447	3,491	4,142	16%	2,499	54	25	75	162	795	839	1,489
July	2,815	3,447	3,491	4,142	13%	2,135	54	25	64	536	1,169	1,213	1,864
Aug	2,815	3,447	3,491	4,142	9%	1,459	54	25	46	1,231	1,864	1,908	2,558
Sept	2,815	3,447	3,491	4,142	10%	1,661	54	25	66	1,010	1,642	1,686	2,337
Oct	2,815	3,447	3,491	4,142	11%	1,709	54	25	41	986	1,618	1,662	2,313
Nov	2,815	3,447	3,491	4,142	7%	1,036	54	25	23	1,677	2,310	2,354	3,004
Dec	2,815	3,447	3,491	4,142	3%	543	54	25	12	2,181	2,814	2,857	3,508
Total	**33,782**	**41,369**	**41,896**	**49,706**	**1**	**15,860**	**650**	**300**	**467**	**16,505**	**24,092**	**24,619**	**32,429**

2050 - Tucson Water Entitlement for Roger Road, Ina Road, and Randolph Park WRFs only

Month	Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)	TW Reclaimed Monthly Flow Dist.	TW Projected Reclaimed System Demand (acre-ft)	Flow to Wetlands (acre-ft)	Sweetwater Mound (acre-ft)	Silverbell Golf Course (acre-ft)	Effluent Available for New Programs: Low without CEP (acre-ft)	Low with CEP (acre-ft)	High without CEP (acre-ft)	High with CEP (acre-ft)
Jan	3,069	3,758	3,806	4,515	3%	503	54	25	3	2,483	3,172	3,220	3,929
Feb	3,069	3,758	3,806	4,515	2%	258	54	25	8	2,723	3,412	3,460	4,169
March	3,069	3,758	3,806	4,515	4%	648	54	25	19	2,323	3,012	3,060	3,769
April	3,069	3,758	3,806	4,515	9%	1,497	54	25	41	1,451	2,140	2,188	2,898
May	3,069	3,758	3,806	4,515	13%	2,216	54	25	69	704	1,393	1,441	2,151
June	3,069	3,758	3,806	4,515	16%	2,656	54	25	75	258	947	995	1,705
July	3,069	3,758	3,806	4,515	13%	2,270	54	25	64	655	1,344	1,392	2,102
Aug	3,069	3,758	3,806	4,515	9%	1,551	54	25	46	1,393	2,082	2,130	2,839
Sept	3,069	3,758	3,806	4,515	10%	1,765	54	25	66	1,158	1,848	1,895	2,605
Oct	3,069	3,758	3,806	4,515	11%	1,817	54	25	41	1,131	1,820	1,868	2,578
Nov	3,069	3,758	3,806	4,515	7%	1,101	54	25	23	1,865	2,555	2,602	3,312
Dec	3,069	3,758	3,806	4,515	3%	577	54	25	12	2,400	3,090	3,137	3,847
Total	**36,822**	**45,093**	**45,667**	**54,180**	**1**	**16,860**	**650**	**300**	**467**	**18,545**	**26,816**	**27,390**	**35,903**

APPENDIX D

RECLAIMED WATER SYSTEM EVALUATION

Recycled Water Master Plan

Appendix D: Reclaimed Water System Evaluation

December 2013

The Water Division of ARCADIS

Imagine the result

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Basis of Cost Opinions

1 Introduction

This technical memorandum summarizes the analysis of the Reclaimed Water System (RWS) to identify system improvements and costs that will allow Tucson Water to continue providing reliable reclaimed water service into the future. The analysis was conducted by utilizing the Tucson Water's existing hydraulic model of the RWS to assess system performance under current and potential future peak day reclaimed water demand conditions. Various system improvement options were identified and evaluated to address existing system deficiencies and to meet future Tucson Water customer demands (which includes existing Pima County and Oro Valley Water Utility demands). Once a recommended schedule of improvements and costs was identified for Tucson Water demands, additional analyses were completed to determine the impacts of potential future demands of Pima County and other water providers, including Oro Valley Water Utility, Metropolitan Domestic Water Improvement District (MDWID), Flowing Wells Irrigation District (FWID), and Spanish Trail Water Company.

1.1 Organization of Technical Memorandum

This technical memorandum is organized into the following Sections:

Section 1 – Introduction

Section 2 – Existing Reclaimed Water System Hydraulic Model

Section 3 – Evaluation of the Existing Reclaimed Water System

Section 4 – Evaluation of Future System

Section 5 – Evaluation of Impacts of Other Entity Future Reclaimed Water Demands

Section 6 – Recommended Schedule of System Improvements and Costs

Section 7 – References

2 Existing Reclaimed Water System Hydraulic Model

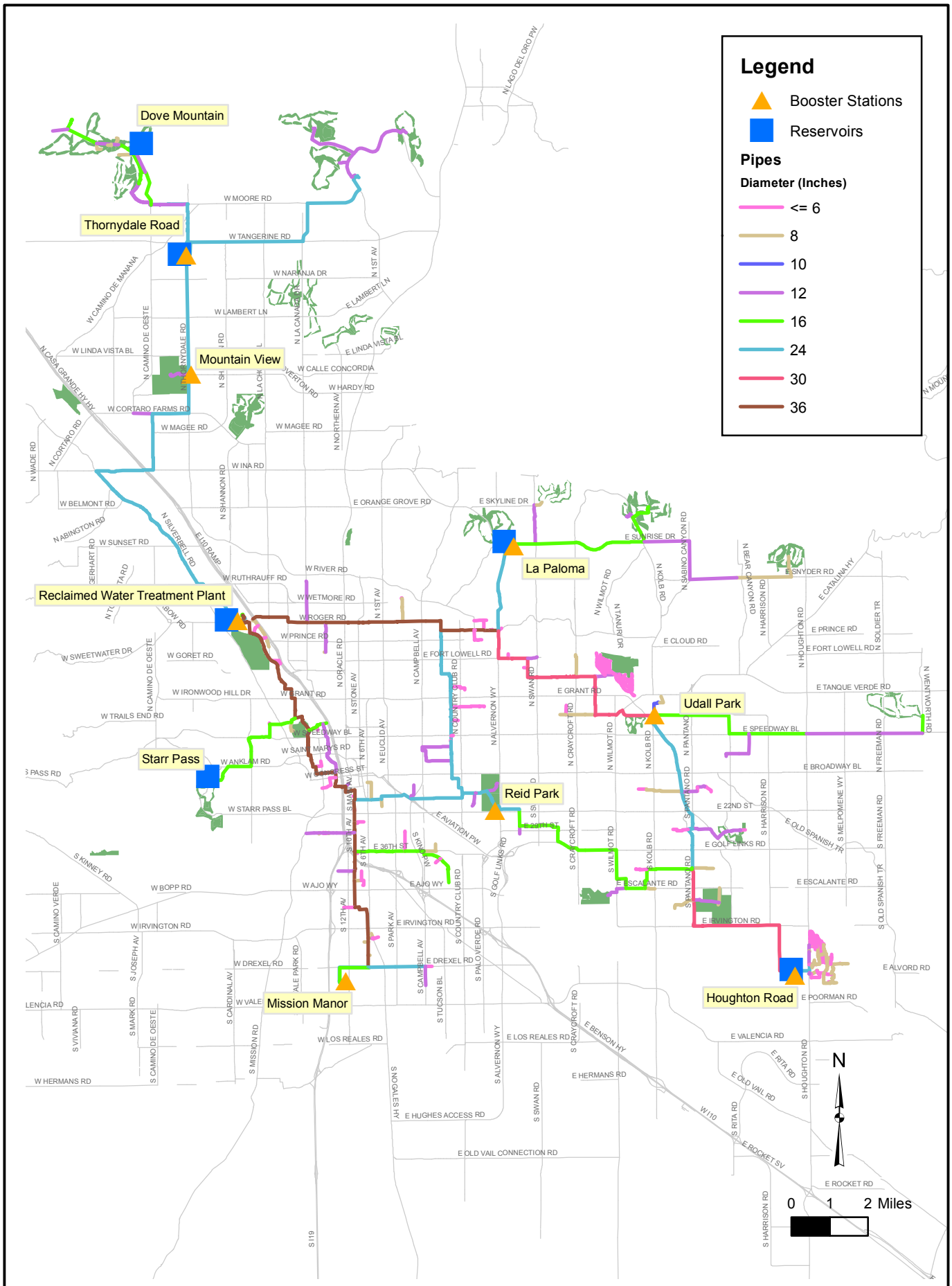
Tucson Water's existing RWS hydraulic model is a Bentley 08.11.01.32 WaterGEMS, V8i (SELECT series 1) model. The model contains attributes of the existing RWS distribution system, and the last update of the modeled infrastructure was performed in 2010. The model also contains peak day reclaimed water demands for each existing reclaimed water customer, which was last updated in 2010. It is important to understand that the modeled peak day demands are calculated demands that could be satisfied if the system had sufficient capacity. These demands are different than the reclaimed water deliveries that are discussed in Chapter 6 of the Recycled Water Master Plan report, which noted that the RWS, as it is configured and operated today, cannot meet the full peak day demands of all customers under all conditions. The capacity of the RWS to meet reclaimed water demands will be confirmed by the analyses herein.

The existing RWS model has never been formally calibrated. However, certain validation runs have been performed by Tucson Water which demonstrated that the model is suitable for master planning purposes. The RWS hydraulic model is an extended period simulation (EPS) model.

The following sections describe the current RWS, the RWS hydraulic model, how the model was updated to include recent additions and changes to the system, the existing reclaimed water demands, and modifications that were made to certain demand patterns.

2.1 Reclaimed Water System Configuration

Tucson Water's RWS includes production facilities, distribution pipelines, storage, and booster pumping facilities. Figure 2-1 shows the configuration of the existing reclaimed water system.



TUCSON WATER
RECYCLED WATER MASTER PLAN

Existing Reclaimed Water System

Figure 2-1

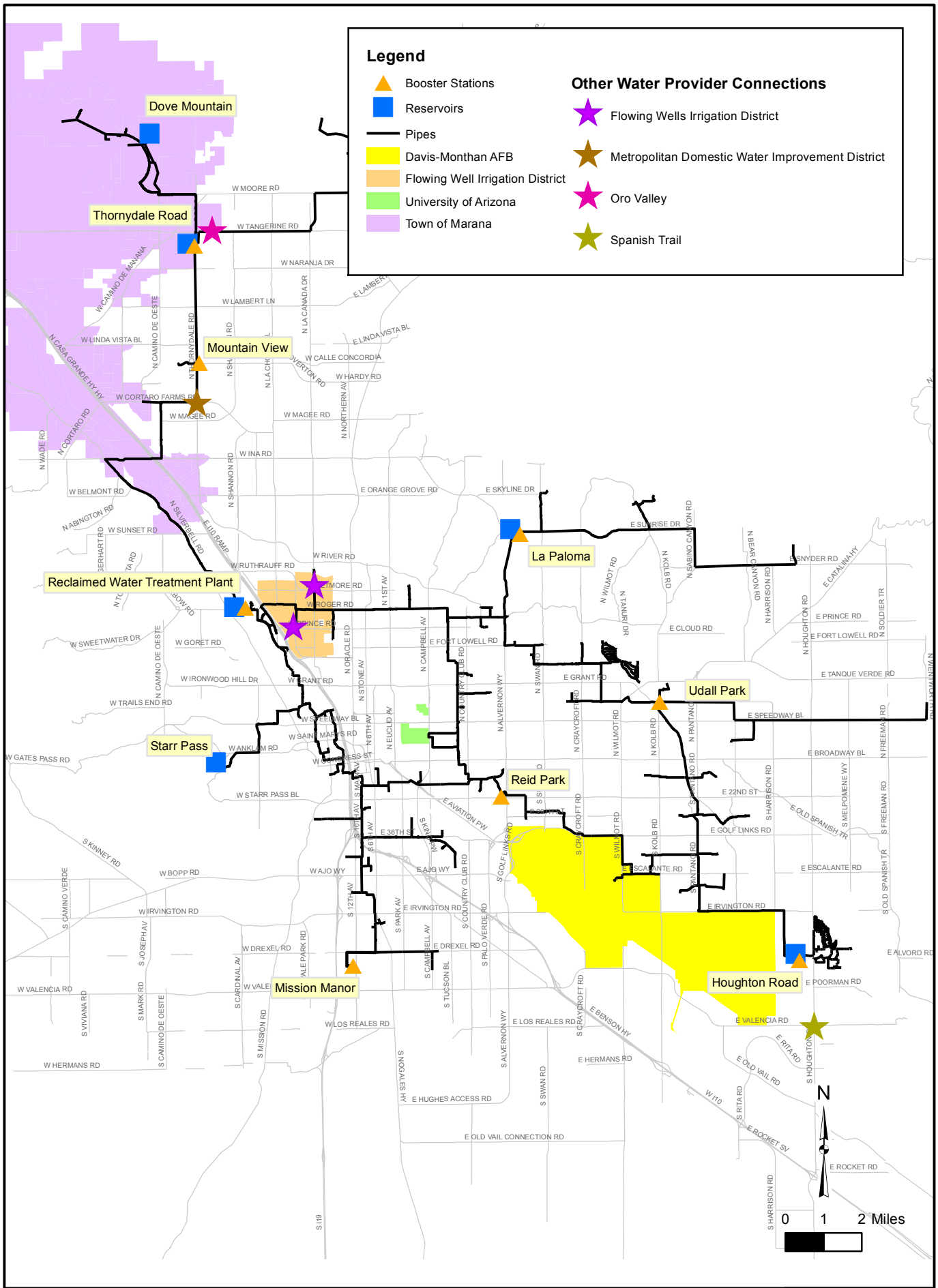
2.1.1 Reclaimed Water System Service Area

Tucson Water delivers reclaimed water to customers within its potable water service area and to the service areas of the University of Arizona, Davis-Monthan Air Force Base, Town of Marana, 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, and in unincorporated Pima County.

Tucson Water also treats and “wheels” (delivers) reclaimed water derived from the effluent entitlements of Pima County and Town of Oro Valley (Oro Valley) through the RWS. The 1979 intergovernmental agreement (IGA) between the City of Tucson and Pima County gave Pima County an effluent allocation which can be used for public use on any County property, including on parks, golf courses, street and highway landscaping, riparian projects, to replace the existing use of groundwater or to avoid a new use of groundwater, or for construction-related activities.

In 2000, after entering into an IGA with the City of Tucson for the ownership of effluent generated within its service area, Oro Valley constructed a reclaimed water system which delivers reclaimed water to its golf courses, parks, and schools. Under the terms of the IGA, Tucson Water wheels Oro Valley’s reclaimed water to a metering station at the boundary between the Oro Valley and Tucson Water reclaimed water systems. Under the 2000 City/Oro Valley IGA, Oro Valley’s effluent entitlement is subtracted from Tucson Water’s entitlement granted in the 1979 City/County IGA.

The Metropolitan Domestic Water Improvement District (MDWID) and FWID are in various stages of planning and development of reclaimed water systems. At this time, MDWID and FWID anticipate having Tucson Water treat and deliver a portion or all of their effluent entitlement to metering stations located at the boundaries between their systems and Tucson Water’s reclaimed water system. From the delivery points, MDWID and FWID will be responsible for the delivery of reclaimed water to customers in their service areas. Figure 2-2 shows the delivery point locations for Oro Valley, MDWID, FWID, and Spanish Trail. The service areas of the University of Arizona, Davis-Monthan Air Force Base, Town of Marana, and FWID are also shown on Figure 2-2.



TUCSON WATER
RECYCLED WATER MASTER PLAN

Other Water Provider Connections to RWS

Figure 2-2

2.1.2 Treatment and Production Facilities

The City's reclaimed water production facilities include a tertiary filtration plant, an underground storage and recovery facility (US&R), and a wetlands treatment system. Pima County's Randolph Park Water Reclamation Facility (WRF) also provides reclaimed water to the system. Figure 2-3 provides an overview of the RWS treatment and production facilities.

Secondary effluent produced at the Roger Road WRF (now called the Water Campus) is piped to the Tucson Water Reclaimed Water Treatment Plant (RWTP) for filtration through pressure filters. The filtered effluent is disinfected with chlorine to ADEQ standards for Class A reuse prior to distribution. The RWTP is designed to treat 10 million gallons per day (MGD) of secondary effluent from Roger Road WRF, but due to hydraulic limitations, the facility currently produces only 7 to 8 MGD. Reclaimed water is also produced at the Randolph Park WRF, which is designed to treat 3.0 MGD, but has recently produced between 1.7 and 2.5 MGD.

Secondary effluent from the Roger Road WRF is also piped to the Sweetwater US&R Facility located on the east and west banks of the Santa Cruz River near Sweetwater Road. The stored water is recovered primarily for blending with the reclaimed water produced by the RWTP to meet turbidity requirements for Class A reuse. The stored water is also recovered for use when reclaimed water demands exceed the capacity of the RWTP. The Sweetwater US&R Facility is permitted for annual storage of up to 13,000 acre-feet of reclaimed water. The US&R Facility has eight surface recharge basins with a combined daily average recharge capacity of 6 MGD; however, the recharge capacity has recently decreased to 4.2 MGD and less for unknown reasons.

The Sweetwater US&R Facility is equipped with a combined maximum extraction capacity of about 20.8 MGD as shown on Table 2-1. The maximum extraction capacities were determined by a hydraulic evaluation of the extraction wells and piping completed for Tucson Water in 2007 (CH2M Hill, May 2007). The capacities presented in Table 2-1 represent the maximum individual flow rates with all extraction wells operating, which was reportedly the best approximation of how the extraction wells would react hydraulically to one another under actual peak day operations.

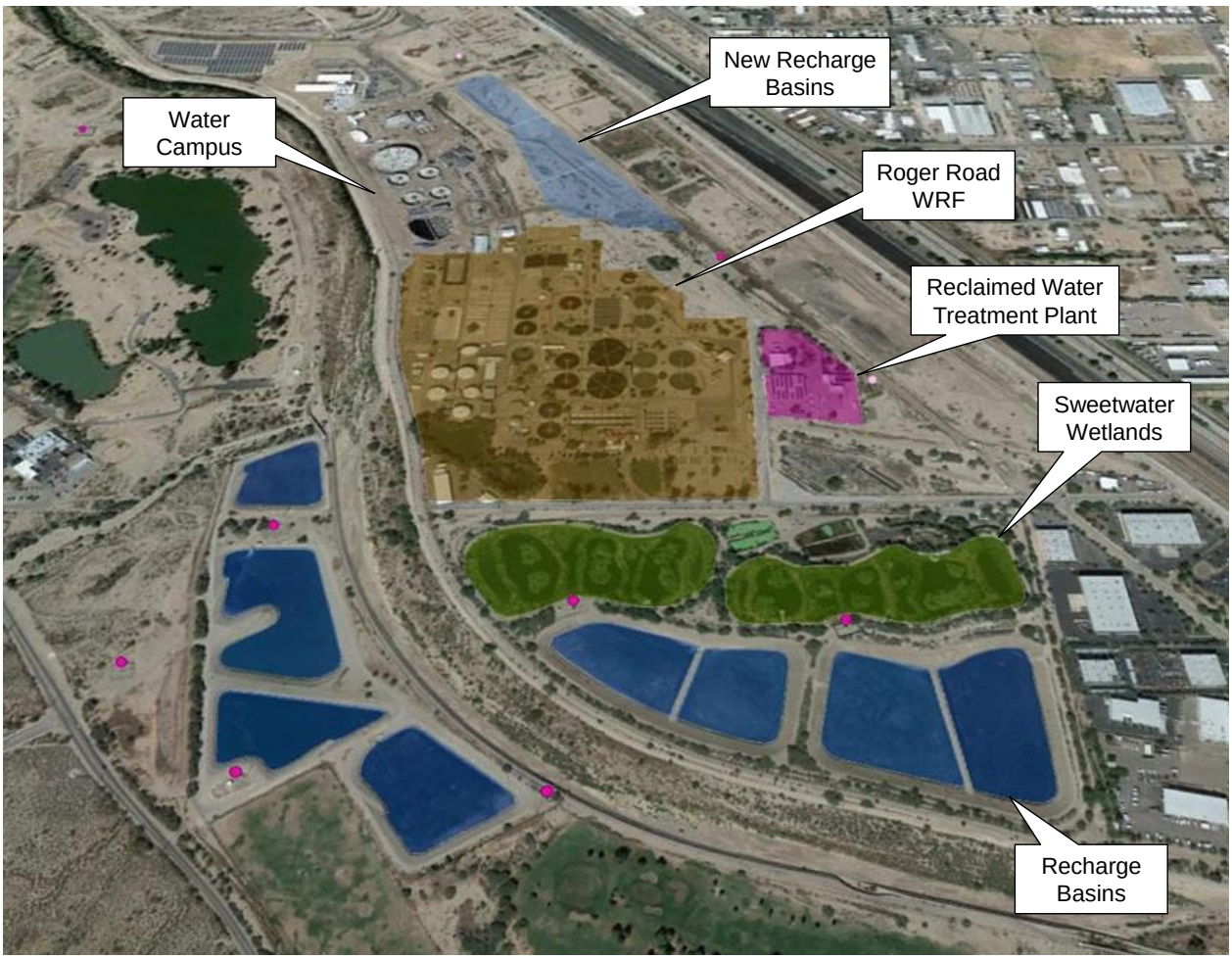


Figure 2-3. Reclaimed Water System Treatment and Production Facilities

Table 2-1. Existing Recovery Well Capacities

Well	Maximum Extraction Capacity (gpm)[1]	Maximum Extraction Capacity (MGD)[1]
Sweetwater US&R Facility		
EW-001	1,118	1.6
EW-002	949	1.4
EW-003[2]	2,326	3.3
EW-004	3,598	5.2
EW-005	2,258	3.3
EW-006	2,162	3.1
EW-008	2,015	2.9
Subtotal	**14,426**	**20.8**
Santa Cruz River Managed Underground Storage Facility		
EW-007	2,569	3.7
Total	**16,995**	**24.5**

[1]Maximum individual flow rates with all extraction wells operating (CH2M Hill, 2007)

[2]Well pump was downsized on 4/7/10 (from 3,174 gpm) and tested at 2,326 gpm on 9/9/11.

Expansion projects at the Sweetwater US&RF include the addition of three new recharge basins and two new extraction wells. The three new recharge basins will increase the effluent recharge capabilities of the Sweetwater US&R Facility from 10,000 acre-feet per year to 13,000 acre-feet per year. New extraction wells EW-009 and EW-010 are anticipated to provide an additional 6 MGD of recovery capacity for the Sweetwater US&R Facility.

Excess Tucson Water effluent entitlements are also discharged from both the Roger Road and Ina Road WRFs to two managed in-channel recharge projects. The Santa Cruz River Managed Underground Storage Facility (Phase I) spans from Roger Road to Ina Road and receives effluent from the Roger Road WRF. Phase I is managed under a partnership between Tucson Water and the U.S. Bureau of Reclamation. The Lower Santa Cruz River Managed Recharge Project (Phase II) spans from Ina Road to Trico Road and receives effluent from both the Roger Road WRF and the Ina Road WRF. Phase II partners include Tucson Water, the U.S. Bureau of Reclamation, Pima County, FWID, MDWID, the Town of Marana, the Cortaro-Marana Irrigation District, Oro Valley, and the Avra Valley Irrigation District. In order to recover some of the recharged effluent, an additional recovery well (Well EW-007), also shown on Table 2-1, was

installed and can recover up to 3.7 MGD from the Santa Cruz River Managed Underground Storage Facility.

Treated effluent from the RWTP and recovered water from the Sweetwater US&R Facility is sent to the RWTP chlorine contact chamber for disinfection prior to distribution. The Sweetwater Wetlands adjacent to the US&R facility receives backwash water from the RWTP filters and secondary effluent during low reclaimed water demand periods. Effluent from the Wetlands is directed into several of the Sweetwater US&R Facility recharge basins.

2.1.3 Distribution, Storage, and Pumping Facilities

The RWS hydraulic model is a skeletonized model, (i.e., the model is simplified by only including the major distribution pipelines). The modeled distribution piping network consists of approximately 167 miles of pipelines ranging in diameter from 6 to 36 inches. The reclaimed water system hydraulic model was updated to include additions or modifications to the system since the last update in 2010. The updates made to the existing RWS hydraulic model include the following:

- A new pipeline (3,000 feet, 12-inch diameter) was added near the Mountain View booster station to provide service to the Arthur Pack golf course.
- At the request of Tucson Water staff, several 4-inch, and 8-inch pipelines (30,500 feet total) were added in the Civano neighborhood and also at West 29th Street. Demands in this neighborhood were also added to the model based on recent metering data.

The reclaimed water system also has approximately 15.5 million gallons (MG) of total above ground storage in reservoirs and eight booster stations. Table 2-2 presents an inventory of the storage reservoirs, booster stations, and their capacities. The table also notes some modifications and updates that were made to the hydraulic model data.

Table 2-2. RWS Storage and Booster Pumping Inventory

Location	Reservoir Capacity (MG)	Booster Station			
		Number of Pumps	Total Capacity (MGD)	Firm Capacity[1] (MGD)	Total Head (ft)
Dove Mountain	0.1	-	-	-	-
Thornydale Road – Dove Mountain	4.2	4	6.8	4.8	343
Thornydale Road – Oro Valley		3	4.5	3.2	315
Mountain View[2]	-	3	15.1	10.1	290
La Paloma	2.0	4	4.8	2.6	340
Tucson Water Reclaimed Water Plant Pumps 1-5	3.1	5	15.8	12.7	430
Tucson Water Reclaimed Water Plant Pumps 5-10		5	18.0	14.4	430
Tucson Water Reclaimed Water Plant Pumps 12-15[3]		4	11.8	8.9	439
Udall Park	-	4	8.4	5.8	322
Starr Pass	1.6	-	-	-	-
Reid Park	-	4	3.2	1.7	245
Mission Manor	-	4	4.8	3.4	170
Houghton Road	4.5	2	1.2	0.4	265
Total	15.5	-	94.4	68	-

[1]*Firm capacity signifies largest pump out of service*

[2]*The hydraulic model was updated by removing controls. Tucson Water indicates that the pumps are operated manually*

[3]*The hydraulic model was updated by adding new Pumps 12 through 15, along with their pump curves*

In addition to the model updates and modifications described above, one additional modification was made in the way the model simulates the RWS. The existing hydraulic model had imposed controls on operation of the Tucson Water RWTP booster pumps based on water level in the La Paloma reservoir. These modeled controls kept the model from converging. The RWTP booster pump controls were removed to allow the hydraulic model to better simulate system operation.

2.2 Existing Reclaimed Water Demands

When discussing reclaimed water demands, it is important to distinguish between what has historically been delivered by the RWS and what the actual demands might be if the RWS could satisfy all demands at all times.

Chapter 6 of the *Recycled Water Master Plan* presents a summary of the existing RWS customers and reclaimed water deliveries to the customers. The deliveries represent what the

RWS is capable of supplying under its existing configuration and operations. In 2010, the RWS deliveries amounted to an average of 13.3 MGD over the year and approximately 30.5 MGD on the peak day.

Tucson Water's existing RWS hydraulic model contains all existing customers and their peak day demands, the peak demands in the existing model were last updated in 2010. The peak day demands were calculated by Tucson Water for all customers other than golf courses. The golf course peak demands are the contractual peak demands for each course, being delivered according to assigned water delivery (or water usage) patterns. The information in the model does not include detailed customer-specific information other than golf courses, schools, and parks because many of the individual demands are aggregate at a single node. The model includes the following existing peak day reclaimed water demands by customer type:

- Golf courses: 25.1 MGD
- Parks, schools and others: 10.7 MGD
- Total peak day demand: 35.8 MGD

Table 2-3 presents a comparison of actual 2010 reclaimed water deliveries and peak day demands used in the hydraulic model. The existing RWS peak day deliveries and peak day demands include Pima County and Oro Valley demands. The table illustrates that the RWS, as it is configured and operated today, cannot supply the full peak day demands in the system. The full peak day demands are not being met due to system constraints which will be identified later in this technical memorandum with hydraulic modeling analyses.

Table 2-3. 2010 Reclaimed Water Deliveries and Demands

	Actual Reclaimed Water Deliveries (MGD)	Modeled Reclaimed Water Demands (MGD)
Average	13.3	--
Peak Day	30.5	35.8

The average reclaimed water system peak day to average day factor from 1999 to 2011 was 2.31 (based on information provided by Tucson Water). Therefore, a peak day to average day factor of 2.31 was selected for the hydraulic analyses. This peaking factor was applied to all new demands other than golf course demands. Currently, golf course peak day demands are modeled as constant flow rates over a 6-hour period during the night that would equal the golf

course daily maximum allocations defined in their customer agreements with Tucson Water. Tucson Water staff indicated that the golf course usage patterns did not match the existing modeled usage patterns and needed to be updated based on actual usage.

The golf course water usage patterns (records of actual deliveries made to golf courses) obtained from Tucson Water's SCADA database were reviewed and the hydraulic model was updated to reflect the actual golf course usage patterns. Three weeks of hourly golf course delivery SCADA data from 2010, during the peak summer season was reviewed. The week of June 23, 2010 was selected for a detailed analysis as this week included a total system peak day delivery of approximately 30 MGD. The week of June 23, 2010 was used to assess usage patterns for 15 golf courses. Good SCADA data was not available for three of the golf courses during this week; therefore, the next best week of data, June 26 through July 2, 2010, was used to assess usage patterns for these three golf courses. The daily water usage pattern for each golf course was reviewed and a peak day usage pattern was selected for each golf course using one of three methods (the selected golf course usage patterns were developed such that the total daily volume supplied to each golf course was equal to the course's maximum daily allocation):

- If a consistent pattern in the usage data was evident, then that pattern was selected.
- If a consistent pattern in the usage data was not apparent, then an average usage pattern was estimated using graphical techniques.
- If data were unavailable or were not valid for a use site (e.g., Ventana, La Paloma, Skyline, Arizona National, Fred Enke, and all of the Oro Valley golf courses), a standard usage pattern was developed and applied that was based on providing a constant flow to the golf course such that the maximum daily allocation was provided over a single day.

Attachment A contains the updated golf course reclaimed water usage patterns for each golf course that includes:

- the weekday usage patterns (Monday through Friday),
- the weekend usage patterns (Saturday and Sunday), and
- the selected average peak usage pattern.

3 Evaluation of the Existing Reclaimed Water System

Tucson Water's existing RWS hydraulic model was used to simulate existing system performance under peak day demand conditions to identify any system deficiencies, and to evaluate alternative system improvements needed to correct the existing deficiencies.

3.1 System Performance Criteria

Tucson Water's existing system performance criteria for the RWS was evaluated and updated based on current industry guidance and actual system operations. The selected system performance criteria are those that were developed and used in the 1999 Reclaimed Water Master Plan (Malcolm Pirnie, Inc., 1999) with the following updates:

- The pipeline headloss performance criteria were updated based on current American Water Works Association (AWWA) guidance for pressurized water pipeline systems (i.e., establishing separate headloss criterion for pipes less than 12 inches in diameter and equal to or greater than 12 inches in diameter).

- Historically, the system storage performance criterion was based on providing one maximum day of system storage. However, this criterion relied on using the on-site storage at golf courses to provide a portion of the needed system storage volume. Based on the manner in which the golf courses actually operate their on-site storage, it is not feasible to continue to include this storage in the system storage inventory. The current system storage reportedly performs adequately under all but peak day demand conditions. The storage performance criterion has been updated so that system storage will provide hydraulic equalization under peak day demand conditions. Hydraulic equalization is the storage required to balance the supply with demands during the peak usage days. The existing storage capacity that was used in the modeling analyses, however, does not include the Sweetwater US&R Facility storage capacity or the RWTP reservoir.

The selected system performance criteria for the RWS evaluations are summarized in Table 3-1. The portions of the RWS that did not meet the criteria were determined to be deficient and alternatives were developed and evaluated that would allow those portions of the system to meet the performance criteria.

Table 3-1. RWS System Performance Criteria

Component	Performance Condition	Performance Criteria[1]
Pipelines	Peak hour demand	Maximum velocity: 5 feet per second Maximum head losses: < 10 ft / 1000 ft for < 12-inch diameter < 3 ft / 1000 ft for >= 12-inch diameter Allowable pressure range: 60 – 100 psi
Production Facilities	Peak day demand	Provide peak day demand, plus 10%
Storage	Peak day demand	Provide hydraulic equalization during peak demand day
Booster Stations	Peak hour demand	Meet peak hour demand with firm capacity

[1]*Criteria used to determine deficiencies in the existing system and/or used to size new facilities to correct deficiencies or to meet future demands.*

3.2 Production Analysis

Section 2.1 of this technical memorandum indicated that the RWS can be supplied with reclaimed water supply from the Tucson Water RWTP, seven Sweetwater US&R Facility recovery wells, one Santa Cruz Managed Underground Storage Facility recovery well, and the Pima County Randolph Park WRF. As noted in Section 2.1, Tucson Water staff indicated that recent operations show that some of the production facilities do not operate at their design capacities due to a number of operational and system constraints. The design and current operational production capacities of the production facilities are summarized in Table 3-2 and compared against existing peak day reclaimed water demands and the production system performance criterion.

Table 3-2. Comparison of Existing Reclaimed Water Production and Peak Day Demands

Component	Design Capacity (Maximum Extraction Capacity for Wells) (MGD)	Current Operational Capacity (MGD)
Tucson Water RWTP	10	7 - 8
Sweetwater US&R Facility Recovery Wells	20.8	20.8
Santa Cruz River Managed Underground Storage Facility Recovery Well	3.7	3.7
Randolph Park WRF	3.0	1.7 - 2.5
Total Production Capacity	37.5	33.2 – 35.0
Peak Day Demand	35.8	
Peak Day Demand, Plus 10%	39.4	

Table 3-2 indicates that if all production facilities are operating at design capacity, the RWS has adequate production capacity to supply the peak day demand, but not enough to meet the production system performance criteria. Under the current operational conditions, the RWS may not be able to supply existing peak day demands. Recognizing the operational constraints, Tucson Water has included the following new facilities in their current reclaimed water capital improvement program (CIP) to provide additional reclaimed water production capacity:

- Reclaimed extraction wells EW-009 and EW-010, scheduled to be in service in 2014 and 2015, respectively, which is anticipated to provide an additional 6 MGD of recovery capacity at the Sweetwater US&R Facility.
- Three new recharge basins will be added to the Sweetwater US&R Facility to increase the effluent recharge capabilities from 10,000 acre-feet per year to 13,000 acre-feet per year.
- The existing filters at the Tucson Water RWTP will be replaced to restore the full design capacity of the facility (10 MGD).
- The reclaimed booster pumps will be expanded from 46 MGD to 54 MGD in 2018.

If Tucson Water implements the planned construction of the new recovery wells at the Sweetwater US&R Facility and rehabilitation of the filter plant, the RWS will have sufficient production capacity to supply the existing peak day reclaimed water demands and to meet the production performance criterion.

3.3 System Storage Analysis

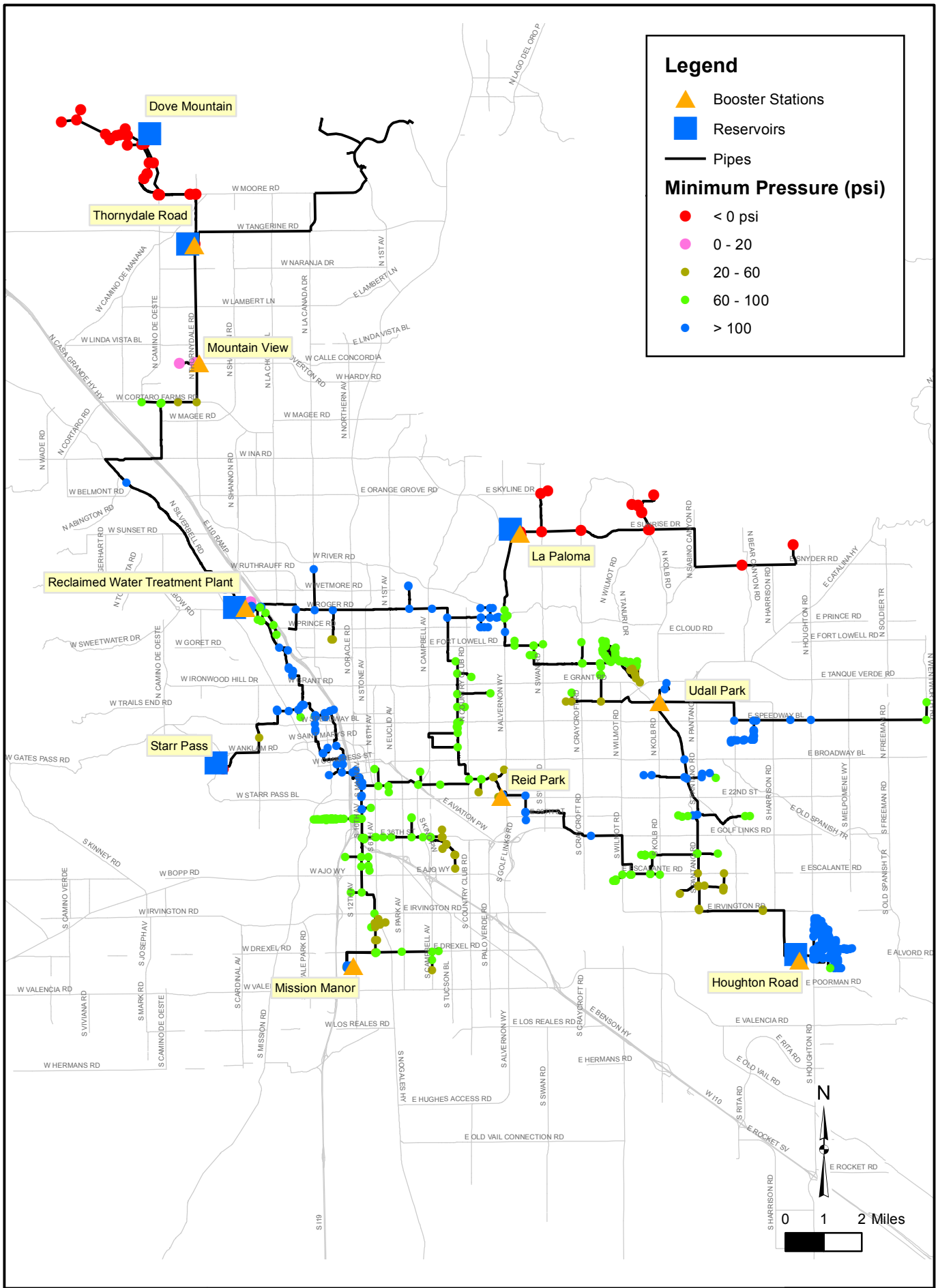
The existing RWS was modeled with EPS simulations to determine the required amount of system storage needed to provide hydraulic equalization (balance demands with supplies) under peak day reclaimed water demand conditions. The modeling results indicated that a total of 25.3 MG of RWS storage is required to balance demands and supplies under peak day demand conditions. The existing RWS has a total operational storage volume of approximately 12 MG, which does not include storage at the Sweetwater US&R Facility or the RWTP reservoir. Therefore, a total of 13.3 MG of additional operational storage is needed to provide adequate peak day system equalization. This additional system storage will be included in the evaluation of system improvement alternatives in subsequent sections of this technical memorandum.

3.4 RWS Model Peak Day Demand Analysis

The existing RWS was modeled under current peak day demand conditions to identify existing system deficiencies. The EPS analysis included existing reclaimed water demands from Tucson Water, Oro Valley, and Pima County. Figures 3-1, 3-2, and 3-3 show the results of the existing system peak day analysis including minimum pressures, maximum velocities, and maximum headlosses, respectively. The modeling identified several deficiencies in the existing system as summarized below:

- Negative pressures were identified in the portion of the system served by the Dove Mountain and La Paloma boosters (see Figure 3-1).
- High velocities and headlosses were identified in the 24-inch pipeline along Silverbell Road and Thoryndale Road from the Tucson Water RWTP to the Thornydale Road Reservoir and Booster station (see Figures 3-2 and 3-3).
- High headlosses were identified along Alvernon Way and along Sunrise Drive and Snyder Road, both near the La Paloma Booster Station.

These results, particularly the negative pressures, indicate that the RWS would be highly stressed during peak day demand conditions. The results confirm why the RWS is only able to deliver around 30 MGD on a peak demand day.



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Existing System - Peak Day Analysis
Minimum Pressure

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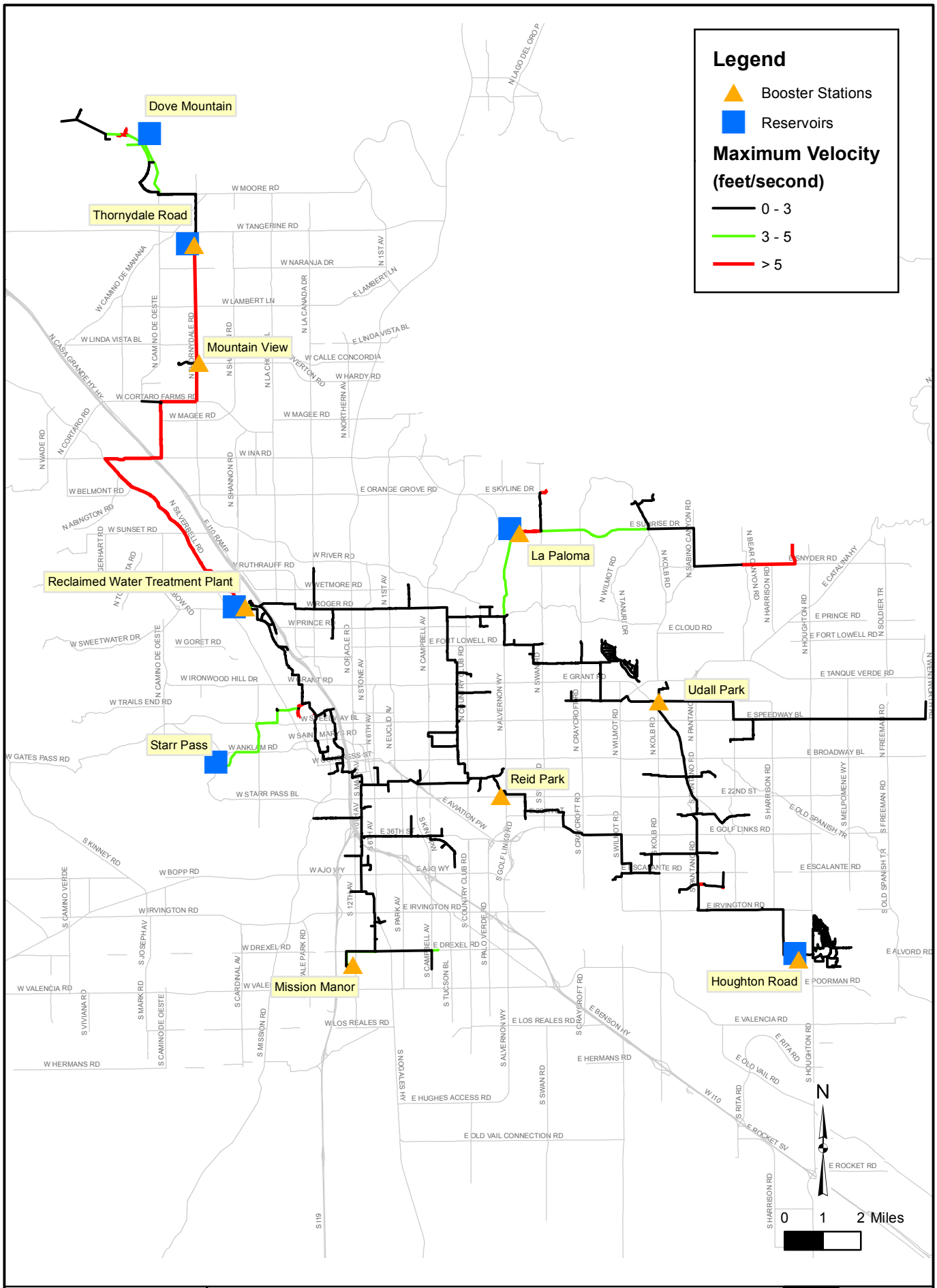
Figure 3-1



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Existing System - Peak Day Analysis
Maximum Velocity

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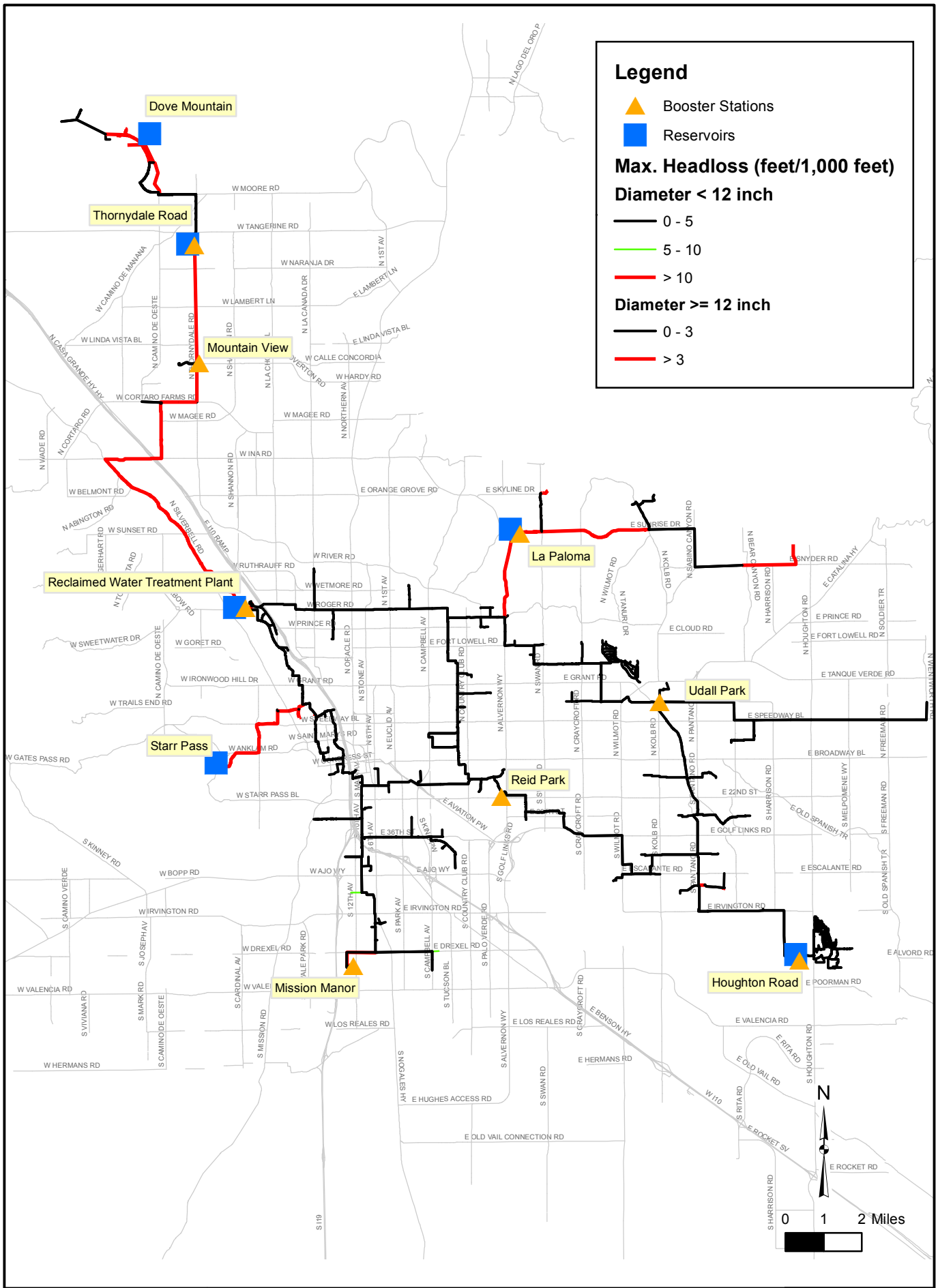
Figure 3-2



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Existing System - Peak Day Analysis
Maximum Headloss

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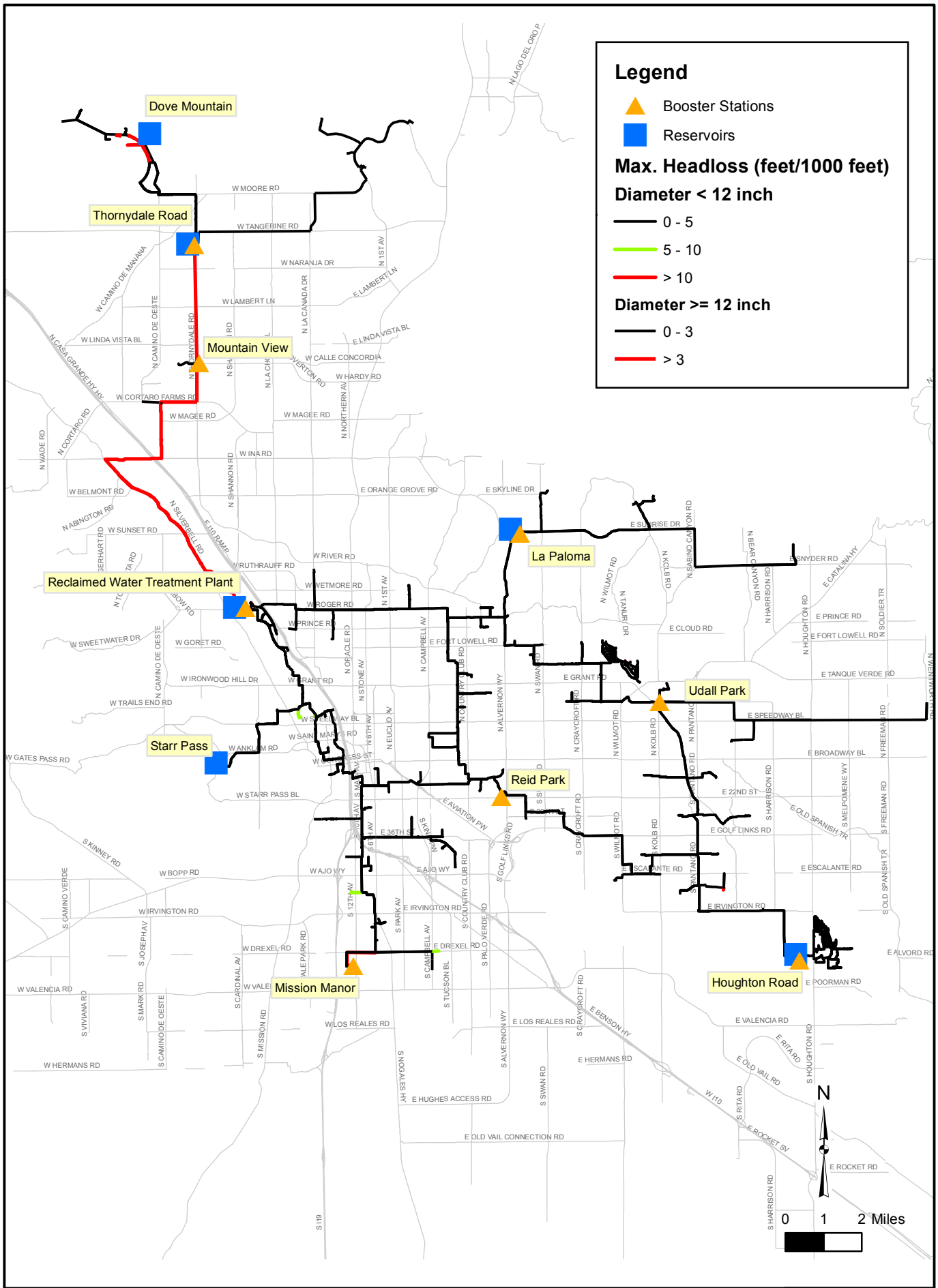
Figure 3-3

3.5 RWS Operational Peak Day Analysis

The existing RWS was also modeled under the maximum observed deliveries of 31 MGD. Tucson Water staff indicated that to make these peak day deliveries, they resort to operational practices such as staggering golf course deliveries, etc. The modeling analyses indicated no areas of negative pressures within the system; however, high velocities and headlosses were identified in the 24-inch pipeline along Silverbell Road and Thoryndale Road from the Tucson Water RWTP to the Thornydale Road Reservoir and Booster Station. The modeling results (headlosses) for the peak day operational deliveries are shown on Figure 3-4.



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Existing System - Operational Peak Day Analysis
Maximum Headloss

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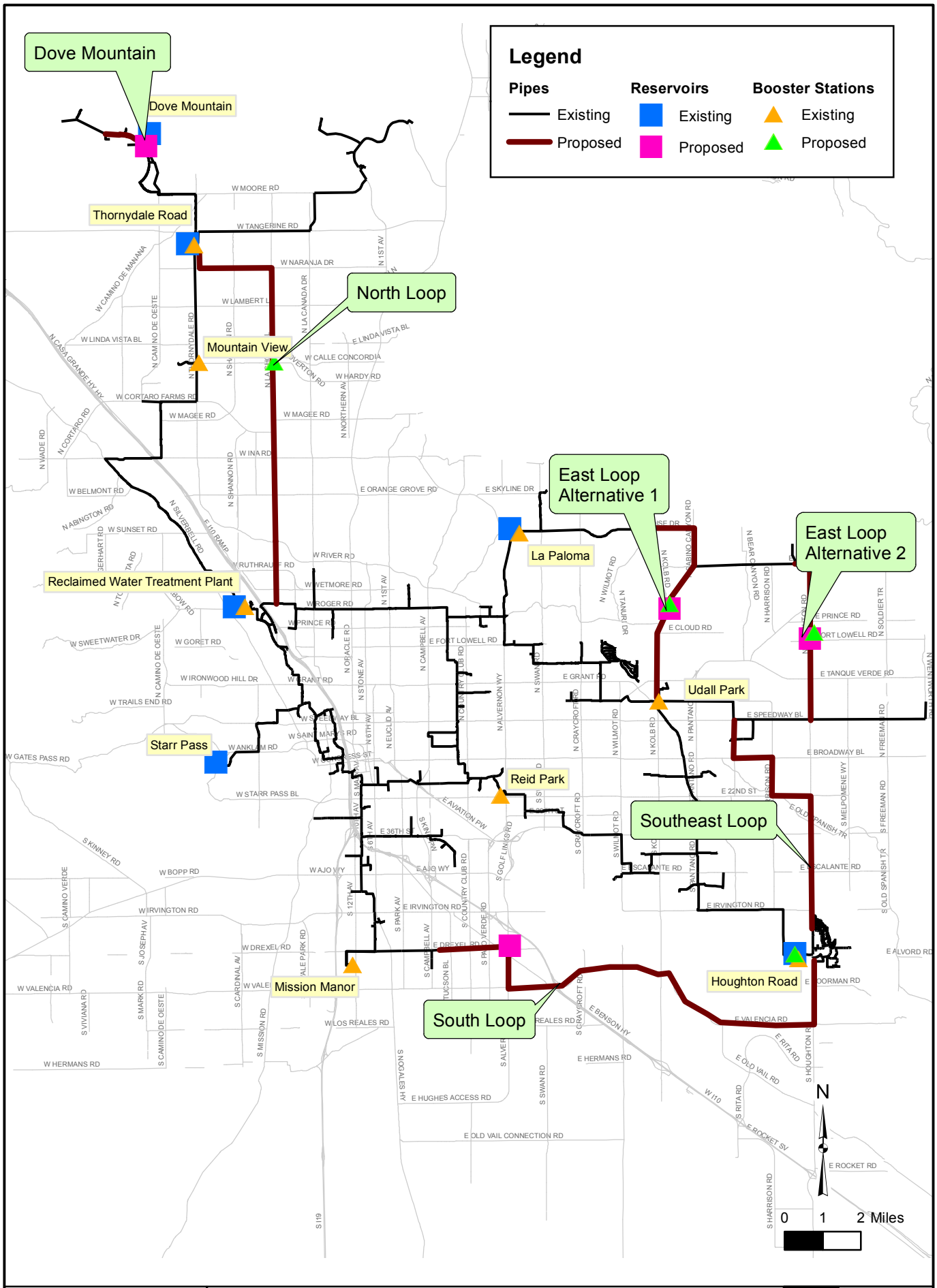
Figure 3-4

3.6 Development and Evaluation of System Improvement Alternatives

Various system improvement alternatives to address the existing deficiencies were developed in consultation with Tucson Water staff. Figure 3-5 shows the improvement alternatives that were identified and evaluated:

- The North Loop Alternative was developed to relieve high velocities and headlosses in the transmission main located in Silverbell Road and Thornydale Road.
- The East Loop Alternative 1 and East Loop Alternative 2 were developed to relieve high velocities and headlosses in the area served by the La Paloma Reservoir and Booster Station.
- The Southeast Loop would also help to relieve deficiencies in the area served by the La Paloma Reservoir and Booster Station.
- The South Loop would extend service to areas south of the Houghton Road Reservoir.
- The Dove Mountain Alternative was developed to address storage deficiencies and high velocities and headlosses in the Dove Mountain Area.



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Existing System Improvement Alternatives

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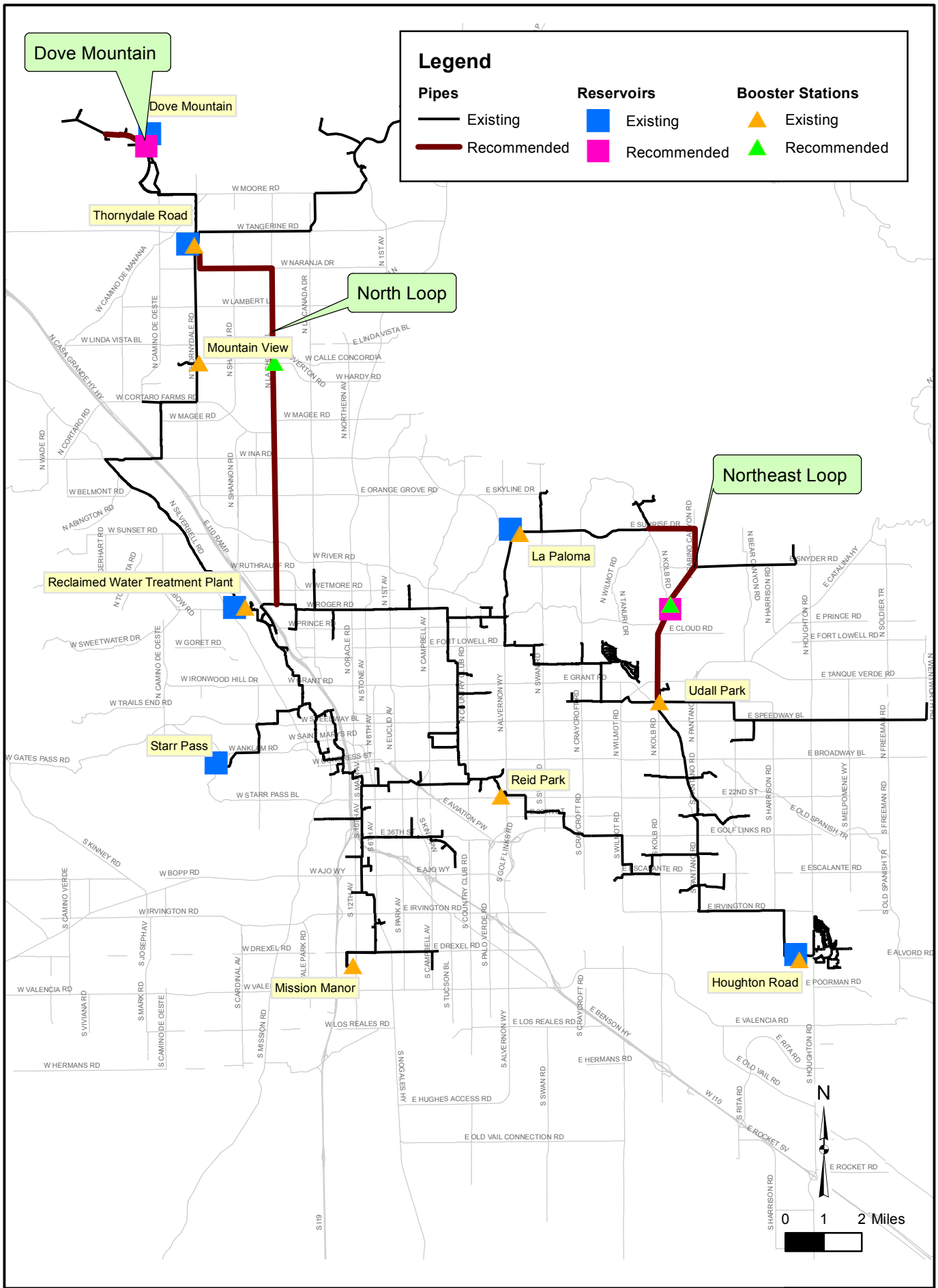
Figure 3-5

All system improvement alternatives were evaluated to identify the most suitable improvements to address the existing system deficiencies. The evaluation process was iterative and involved verification of pressures, velocities, headlosses, and storage tank levels to meet all system performance criteria. The alternatives with the minimum required improvements and minimum disruptions to current operational strategies were selected as preferred improvements. Based on the EPS modeling analyses, Figure 3-6 presents the preferred improvements to address the existing system deficiencies.

The recommended system improvements were presented to and discussed with Tucson Water staff, including priorities based primarily on customer demands impacted. Based on the discussions, Tucson Water staff helped to prioritize the recommended system improvements as discussed in the following subsections.



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Recommended System Improvements to Correct Existing Deficiencies

Figure 3-6

3.6.1 North Loop Improvements

The North Loop improvements are considered the highest priority to address existing system deficiencies, as the area represents the highest volume of reclaimed water deliveries, approximately 10 MGD of the 35.8 MGD total peak day demand. Deliveries to the north area (Dove Mountain and Oro Valley) represent the largest source of reclaimed water revenues to Tucson Water. This loop would also improve service to Oro Valley, prepare the system for future additional service to MDWID, and relieve stress on the existing 24-inch diameter pipeline along Thornydale Road. The North Loop would add redundancy and improve reliability for reclaimed water customers in the area. The North Loop improvements include:

- 11 miles of 24-inch diameter pipeline along La Cholla Boulevard from Roger Road to El Camino del Norte Road,
- A 14 MGD booster station near the intersection of Overton Road and La Cholla Road.

3.6.2 Dove Mountain Area Improvements

The Dove Mountain Area improvements are considered second highest priority as these improvements improve service to a group of high-demand customers (6.25 MGD). Also, the primary improvement is a new storage reservoir which will also contribute to improving service in the entire north area. The improvements will address storage deficiencies and would help to improve the ability to meet contractual agreements with golf courses in this area during peak day demand periods. The Dove Mountain Area improvements include:

- A 6 MG reservoir co-located with an existing potable reservoir (the existing 0.1 MG stand pipe serving as existing storage in the area will be decommissioned). This new storage is part of the required additional system storage to provide hydraulic equalization under peak day demand conditions.
- 2,000 feet of new 16-inch diameter pipe paralleling existing pipes.
- 1 mile of new 12-inch diameter pipe paralleling existing pipes.

3.6.3 Northeast Loop Improvements

The Northeast Loop is considered the third priority improvements to address existing system deficiencies. The improvements would connect the pipeline along Tanque Verde Road to the

pipeline along Synder Road east of the La Paloma reservoir. The improvements are needed to supplement booster pumping and storage at the La Paloma reservoir, and to address high velocities and headlosses identified in existing pipelines near the La Paloma Reservoir and along Snyder Road. The improvements will improve reliability and the ability to meet contractual agreements with golf courses in the La Paloma area during peak day demand periods. The Northeast Loop improvements include:

- 3.5 miles of 24-inch diameter pipeline along Sabino Canyon Road from Tanque Verde Road to Snyder Road.
- 1 mile of new 16-inch diameter pipe paralleling an existing pipe along Sabino Canyon Road from Snyder Road to Surprise Drive.
- 1 mile of new 16-inch diameter pipe paralleling an existing pipe along Surprise Drive from Sabino Canyon Road to Kolb Road.
- A 7.3-MG storage tank and 5 MGD booster station located near the intersection of Cloud Road and Sabino Canyon Road. The new storage is part of the required additional system storage to provide hydraulic equalization under peak day demand conditions.

4 Evaluation of Future System

This chapter presents future system analyses which examined the impacts of future Tucson Water reclaimed water demands (including existing Pima County and Oro Valley demands) to determine additional future system improvements that will be required to maintain reliable service to Tucson Water customers. A separate analysis was also conducted to determine if the RWS could supply up to 4,000 acre-feet per year (AFY) to the proposed Tucson Water/Pima County Southeast Houghton Area Recharge Project (SHARP).

Chapter 5 of this technical memorandum presents additional future system analyses that examine the impact of other future demands from Pima County, Oro Valley, MDWID, FWID and Spanish Trails to determine the magnitude of improvements that may be required should Tucson Water choose to supply these future demands.

4.1 Southeast Houghton Area Recharge Project Analysis

SHARP is a proposed joint Tucson Water and Pima County recycled water recharge project. The potential SHARP site is shown on Figure 4-1. The project concept involves recharging up to 4,000 AFY at the SHARP facility, with each entity contributing up to 2,000 AFY, to develop long-term storage credits. The project concept assumes that reclaimed water would be sent to SHARP only during periods of low reclaimed water demands in the RWS.

An analysis was performed to evaluate the ability of the existing RWS, without any improvements, to deliver reclaimed water to the SHARP site. The current limiting factor in providing reclaimed water to the SHARP site is the production capacity during peak demand days as discussed in Section 3.2. However, for demonstration purposes, the analysis was based on delivering the 4,000 AF uniformly throughout the year. The modeling analysis demonstrated that the required deliveries to SHARP could be made even under peak day demand conditions. That is, if the reclaimed water was available, the Udall (8.4 MGD) and Reid Park (3.2 MGD) booster stations have sufficient pumping capacity to deliver the required reclaimed water to the SHARP site on a peak day demand condition, without imposing undesirable stresses on the southeast portion of the RWS. This analysis demonstrates that the existing RWS would also be capable of delivering sufficient reclaimed water to SHARP during the low demand periods as intended.

Additionally, Tucson Water staff conducted a field test during a period of low demand to determine how much reclaimed water could actually be pumped to the Houghton Road Reservoir. The field

test showed that the Reid Park and Udall booster stations could deliver 4,000 AFY to SHARP via the existing distribution system, further confirming the hydraulic analysis results.

4.2 Analysis of Future Tucson Water Reclaimed Water Demands

The following additional analyses of future system and demand conditions were all conducted assuming that the recommended improvements described in Chapter 3 of this technical memorandum are constructed and are operational. Tucson Water's reclaimed water demand projections are discussed in Chapter 5 of the *Recycled Water Master Plan* as follows:

- A demand increase of 560 AFY by 2016 which is based on fiscal year 2012 financial and rate projections provided by Tucson Water Financial Services.
- Between 2016 and 2020, the demand would increase by 800 AFY to account for a proposed University of Arizona Bio5 Institute golf course (also included in the Tucson Water Financial Services projections).
- Beyond 2020, reclaimed water demands are assumed to increase by 500 AFY every five years, based on historic new connections to the RWS.

In providing the above reclaimed water demand projections, Tucson Water indicated that there was a significant amount of uncertainty in identifying where the additional demands would occur (other than the University of Arizona Bio5 golf course). In consultation with Tucson Water staff, the future demands were allocated uniformly as described below. Figure 4-1 shows the allocation of Tucson Water's future reclaimed water demands.

- For 2015, the 560 AFY increase in demand was distributed uniformly to the central area of the RWS to represent potential future infill customers.
- For 2020, the 800 AFY increase in demand was applied downstream of the Houghton Road booster station to represent a new connection for the planned University of Arizona Bio5 Institute golf course.
- For 2025, the 500 AFY increase in demand was again distributed uniformly to the central area of the reclaimed water distribution system and to the Starr Pass pipeline.
- For 2030, the 500 AFY increase in demand was also applied downstream of the Houghton Road booster station to represent the projected growth in the Southeast region.

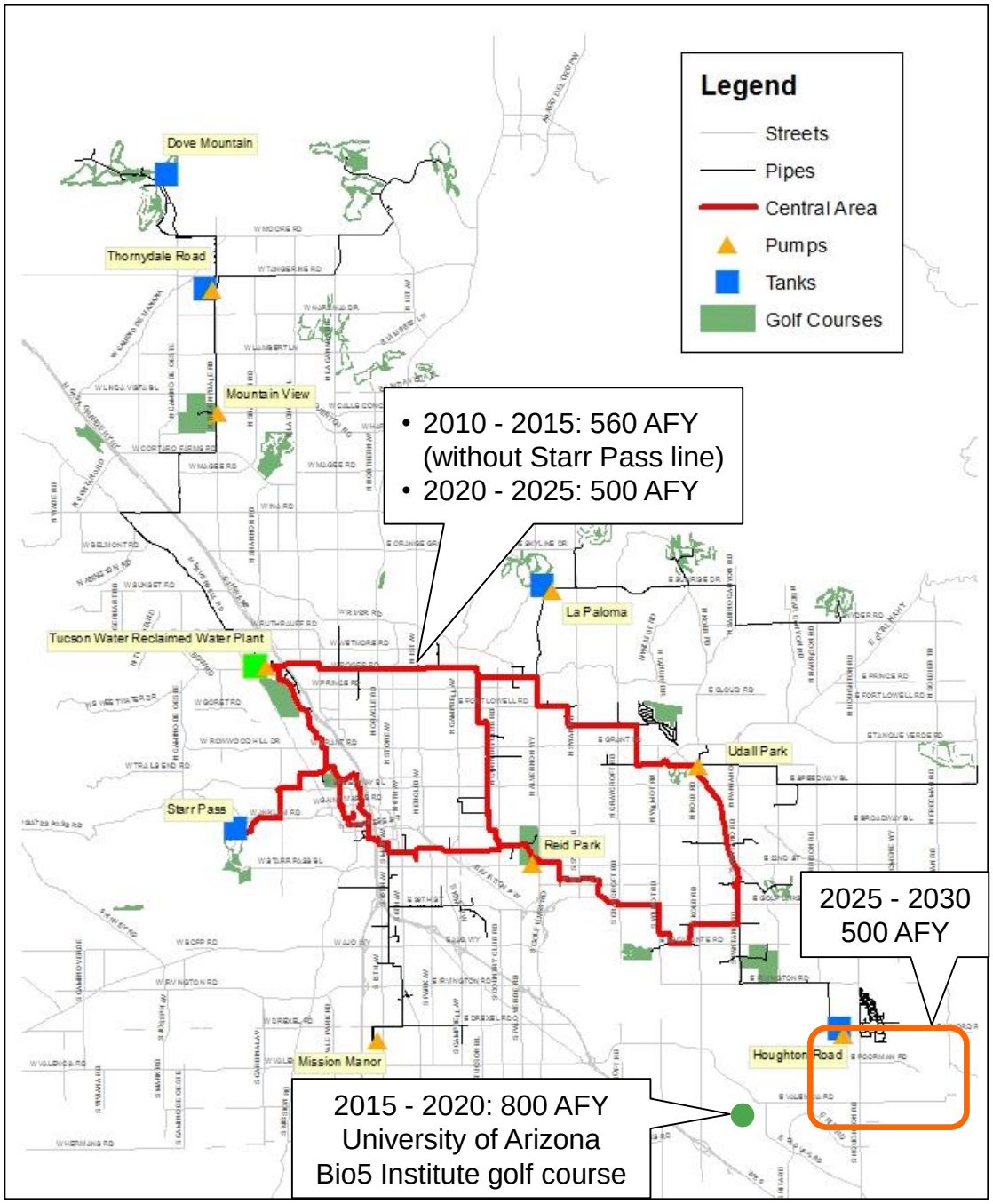


Figure 4-1. Future Tucson Water Reclaimed Water Demands

Table 4-1 summarizes the projected increases in Tucson Water customer reclaimed water demands.

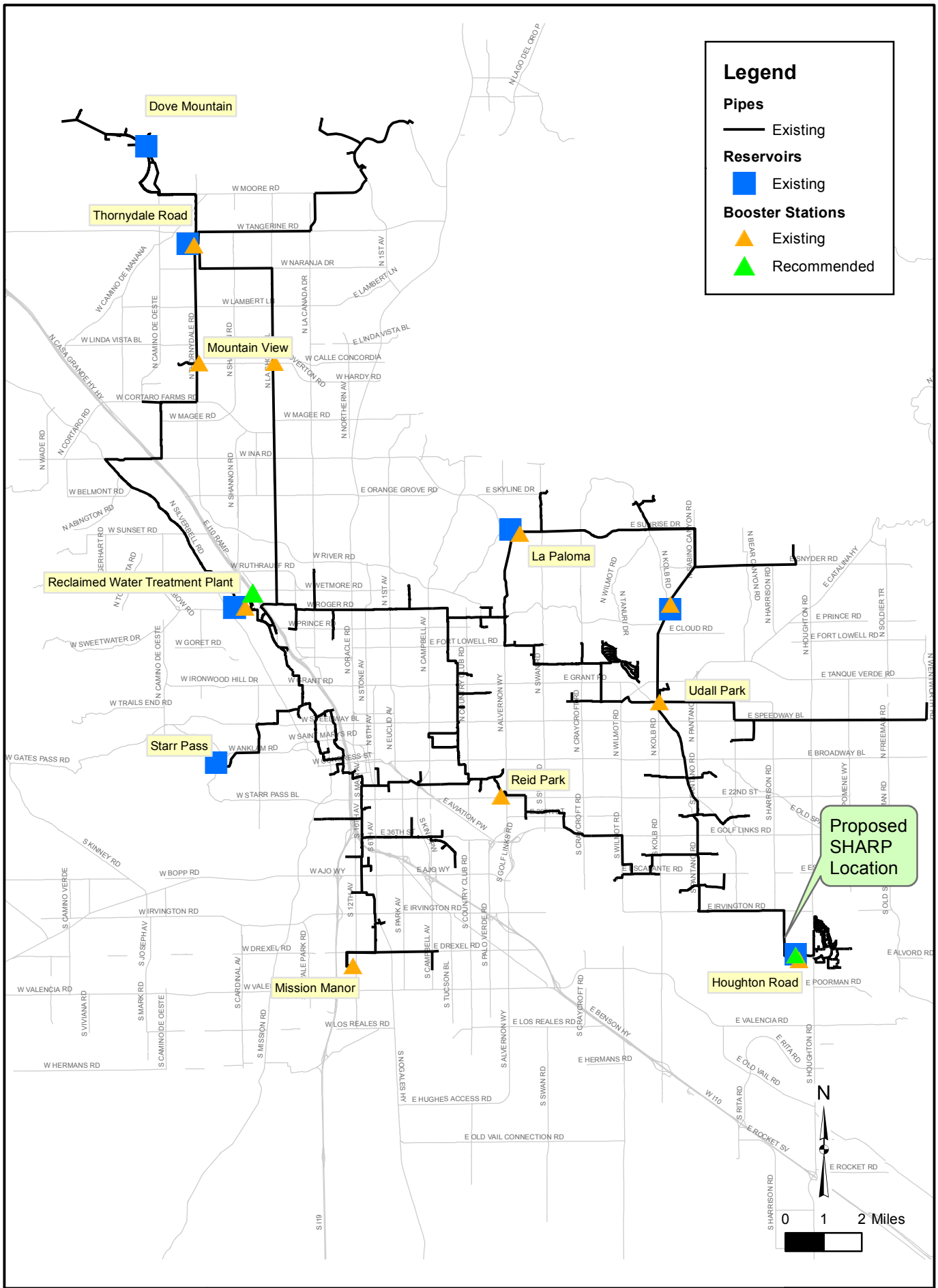
Table 4-1. Comparison of Existing Reclaimed Water Production and Peak Day Demands

Year	Increase in Average Day Demand (AFY)	Increase in Peak Day Demand (MGD)[1]	Peak Day Demand (MGD)[2]
2010	--	--	35.8
2015	560	1.2	37.0
2020	800	1.6	38.6
2025	500	1.0	39.6
2030	500	1.0	40.6

[1]*Based on a peaking factor of 2.31 for increases in demand*

[2]*Includes existing Pima County and Oro Valley demands*

Analysis of the RWS under future Tucson Water demands did not reveal any additional deficiencies in the 2015 and 2025 time periods. For 2020, an 8 MGD booster station expansion at the Tucson Water RWTP is required to meet projected peak day demands. This project is already in the Tucson Water reclaimed water CIP. For 2030 peak day demands, a 1.5 MGD booster station upgrade at the Houghton Reservoir is required. Figure 4-2 shows the required RWS upgrades to supply the projected Tucson Water reclaimed water demands.



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Recommended Improvements
for Future Tucson Water Demands

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Figure 4-2

5 Evaluation of Impacts of Other Entity Future Reclaimed Water Demands

This chapter presents future system analyses that examine the impacts to the required existing and future system improvements identified in Chapter 3 and 4 of this technical memorandum if Tucson Water serves additional future demands of first, other water providers (Oro Valley, MDWID, FWID and Spanish Trail Water Company); and second, Pima County. These analyses determine the types and magnitude of improvements that may be required to serve these additional future demands.

5.1 Other Entity Reclaimed Water Demand Projections

Figure 2-2 showed the locations of existing and future connections to the RWS of other water providers, including Oro Valley, MDWID, FWID, and Spanish Trail Water Company. Table 5-1 presents a summary of the future reclaimed water demands projected by each water provider.

Table 5-1. Other Water Providers Projected Additional Reclaimed Water Demands

Year	Increase in Demand (MGD)				
	Oro Valley[1]	MDWID	FWID	Spanish Trail	Total
Existing	-	-	-	-	-
2015	1.1	0.7	0.08	0.01	1.9
2020	1.3	0.3	0.03	0.002	1.6
2025	0.9	0.4	0.02	0.002	1.3
2030	0.9	0.5	0.05	0.003	1.5

[1] *In addition to use of its own effluent entitlement, demand includes agreed upon use of 200 AFY of Tucson Water's entitlement for ten years (2012 to 2021)*

Figure 5-1 shows the locations of Pima County's projected future reclaimed water demands which total 3,267 AFY (2.92 MGD) of additional demand by 2030 (the County does not have projected demands for intermediate time periods), which includes 2,000 AFY for the SHARP project. Attachment B contains Pima County's existing and projected future reclaimed water demands.

5.2 Analysis of Future Other Water Provider Reclaimed Water Demands

An initial modeling analysis was conducted to identify the impacts of the future reclaimed water demands of Oro Valley, MDWID, FWID, and Spanish Trail Water Company. For the analysis of peak day demand conditions, a peaking factor of 2.31 was assumed for all demands, except

MDWID demands. Tucson Water staff indicated that MDWID would be served their reclaimed water entitlements on an “as available basis.”

The initial analysis indicated that if Tucson Water decides to serve the other water provider future demands, booster station upgrades would be required at the Thornydale Booster Station to satisfy the future Oro Valley demands as summarized on Table 5-2 and shown on Figure 5-2. The existing peak day demand for Oro Valley included in the hydraulic model is approximately 3.8 MGD and the existing Thornydale Booster Station capacity for Oro Valley demands is 4.4 MGD. The peak day demand for Oro Valley is projected to increase to about 6.3 MGD in 2015 and 13.5 MGD in 2030.

At the direction of Tucson Water, the recommended Thornydale Booster Station upgrades are included in the recommended system improvements in Chapter 6 of this technical memorandum. It is assumed that Oro Valley will make the necessary improvement in their reclaimed water system to accept the additional water.

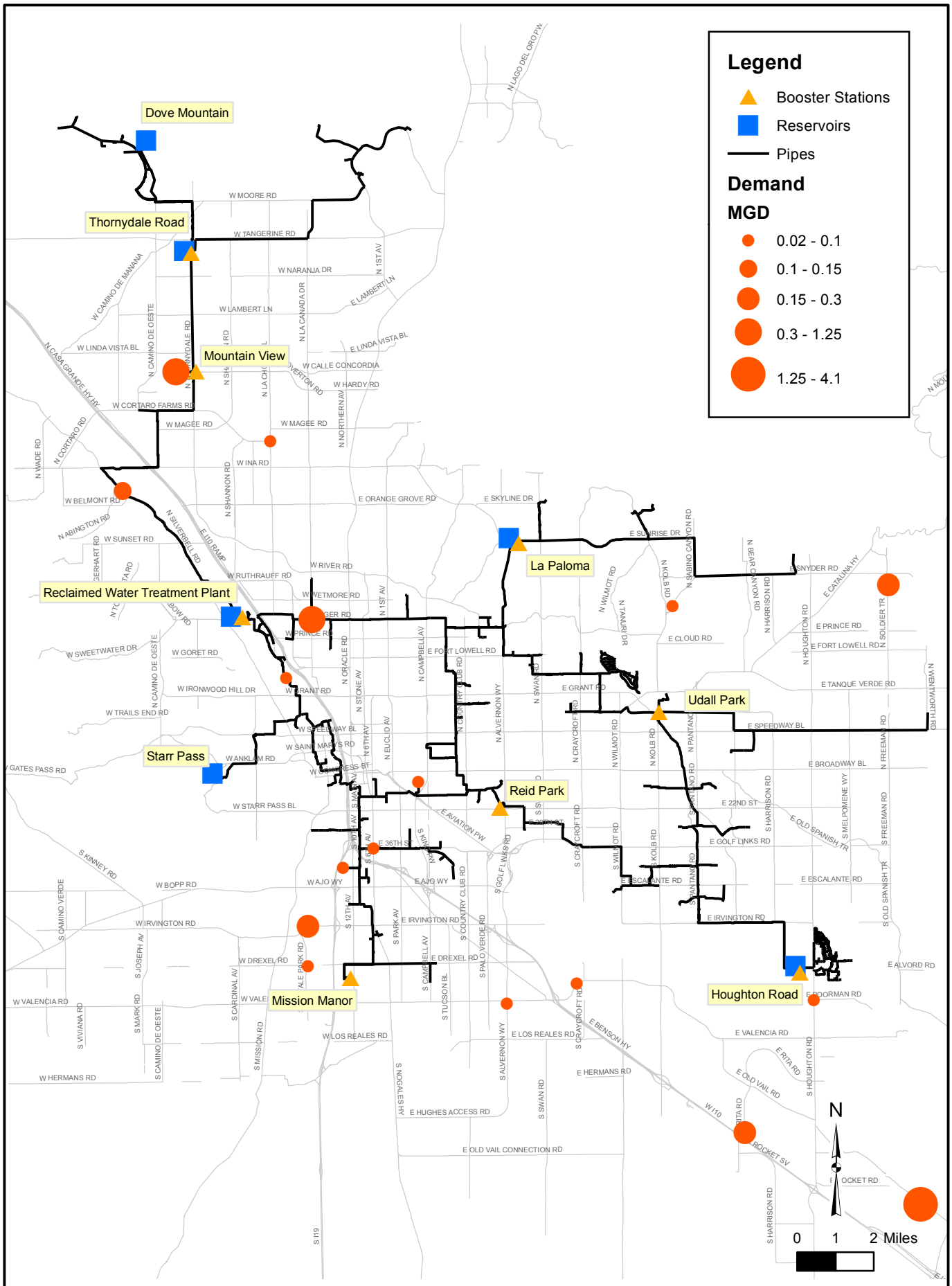
Table 5-2. Thornydale Booster Station Upgrades for Future Oro Valley Reclaimed Water Demands

Year	Booster Station Upgrades
2015	4.4 MGD at 270 feet Total Dynamic Head
2025	4.4 MGD at 270 feet Total Dynamic Head
2030	1 MGD at 270 feet Total Dynamic Head

5.3 Analysis of Future Pima County Reclaimed Water Demands

The additional analysis of future Pima County reclaimed water demands included addition of all their projected irrigation demands in 2030 (the 2,000 AFY SHARP demand was not included as that demand would be met during off peak conditions). For the peak day analysis, a peaking factor of 2.31 was used for all Pima County irrigation demands. The analysis indicated that if Tucson Water decides to serve future Pima County demands, additional system improvements may be needed. The additional system improvements to meet future Pima County demands in 2030 include a 1 MGD booster station upgrade at Sabino Canyon Road, a 1.5 MGD booster station upgrade at Udall Park, and 1.5 miles of 8-inch diameter pipeline along Snyder Road (also shown on Figure 5-2).

The potential additional system improvements to serve future Pima County demands are not included in the recommended system improvements in Chapter 6 of this technical memorandum.



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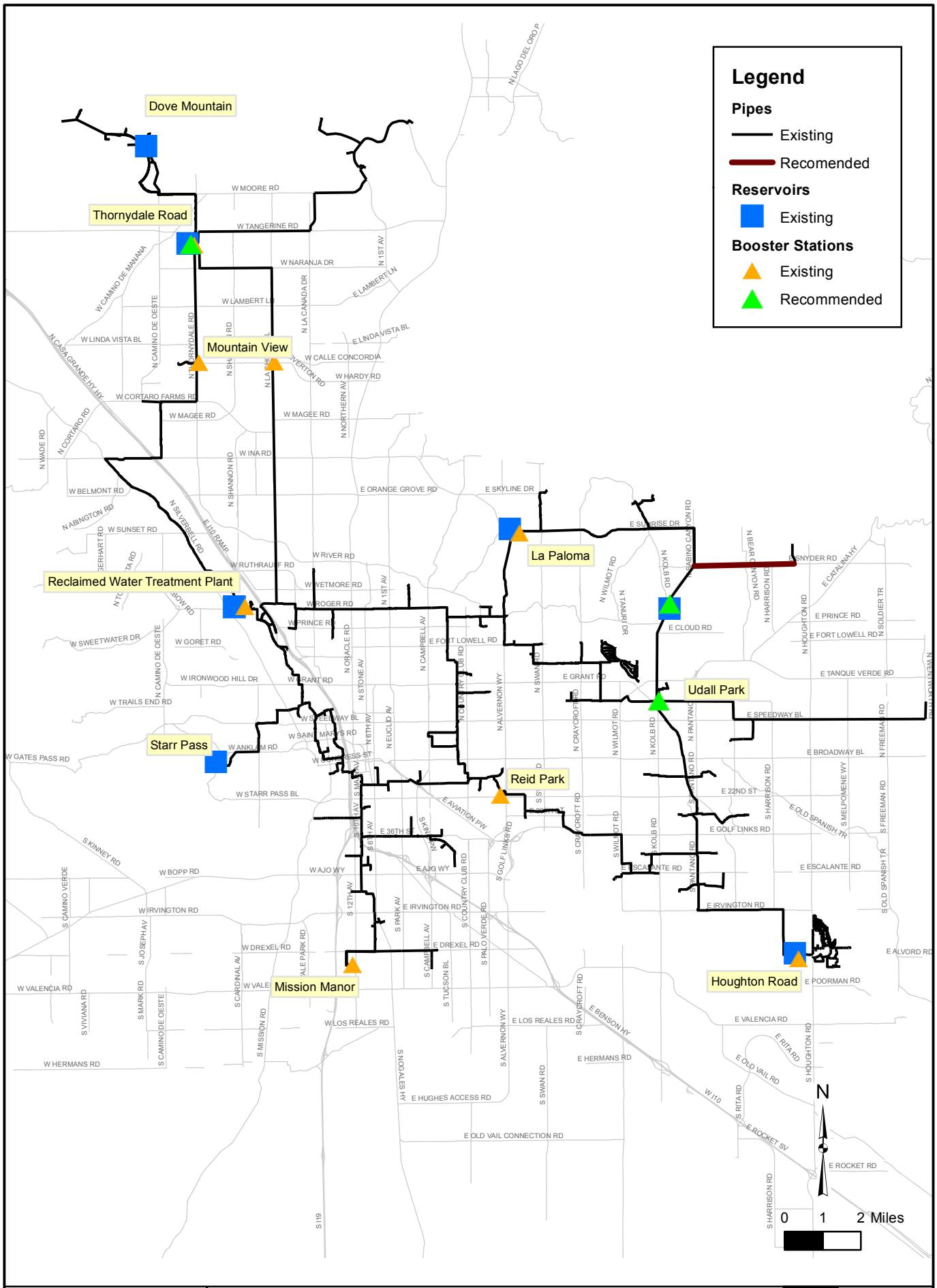
Potential Future Pima County Reclaimed Demands

Figure 5-1



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Potential Improvements to Serve
Future Pima County and Other Water Providers

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Figure 5-2

6 Recommended Schedule of System Improvements and Costs

This chapter presents the recommended RWS system improvements identified in Chapter 3 to address existing system deficiencies (which includes serving existing Pima County and Oro Valley demands), and Chapter 4 to serve future Tucson Water reclaimed water customers and Oro Valley only. The recommended improvements do not include providing service to future Pima County, MDWID, FWID and Spanish Trail Water Company demands described in Chapter 5.

6.1 Basis of Capital Cost Opinions

The capital cost opinions developed herein are based on available existing studies, recent projects with similar components, manufacturers' budget estimates, standard construction cost estimating manuals, and engineering judgment. The level of accuracy for the cost opinions corresponds to Class 5 as defined by the Association for the Advancement of Cost Engineering (AACE) International. Class 4 estimates are generally prepared based on limited information and have a typical accuracy range of -30 percent to +50 percent. This level of cost estimating is typically done for feasibility studies and concept evaluation.

Attachment C contains the unit cost information and other assumptions used for developing cost opinions for new RWS infrastructure. Unit capital costs include engineering and design, materials of construction, installation, and contractor overhead and profit. Different unit cost values were used for pipes that were located in developed and undeveloped areas. Pipes located in developed areas have higher unit costs to account for additional costs associated with pavement resurfacing and traffic management. All costs also include a 25 percent factor for engineering and construction administration, and a 30 percent factor for project contingencies. All costs are in January 2012 dollars referenced to an Engineering News Record Construction Cost Index (ENR CCI) of 9,176.

6.2 Recommended Schedule of System Improvements and Costs

The recommendations resulting from the hydraulic modeling analyses of the RWS are summarized in Table 6-1 and illustrated on Figure 6-1. Tucson Water should incorporate the recommended system improvements and costs in the reclaimed water CIP to continue its commitment to providing reliable reclaimed water service.

Table 6-1. Schedule of Recommended RWS Improvements and Cost Opinions

Project No.	Improvement	Projected Capital Costs ($1,000) [1,2,3]			
		FY 2013-2017	FY 2018-2022	FY 2023-Build Out	Total
IMPROVEMENTS TO ADDRESS EXISTING SYSTEM DEFICIENCIES					
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					
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**

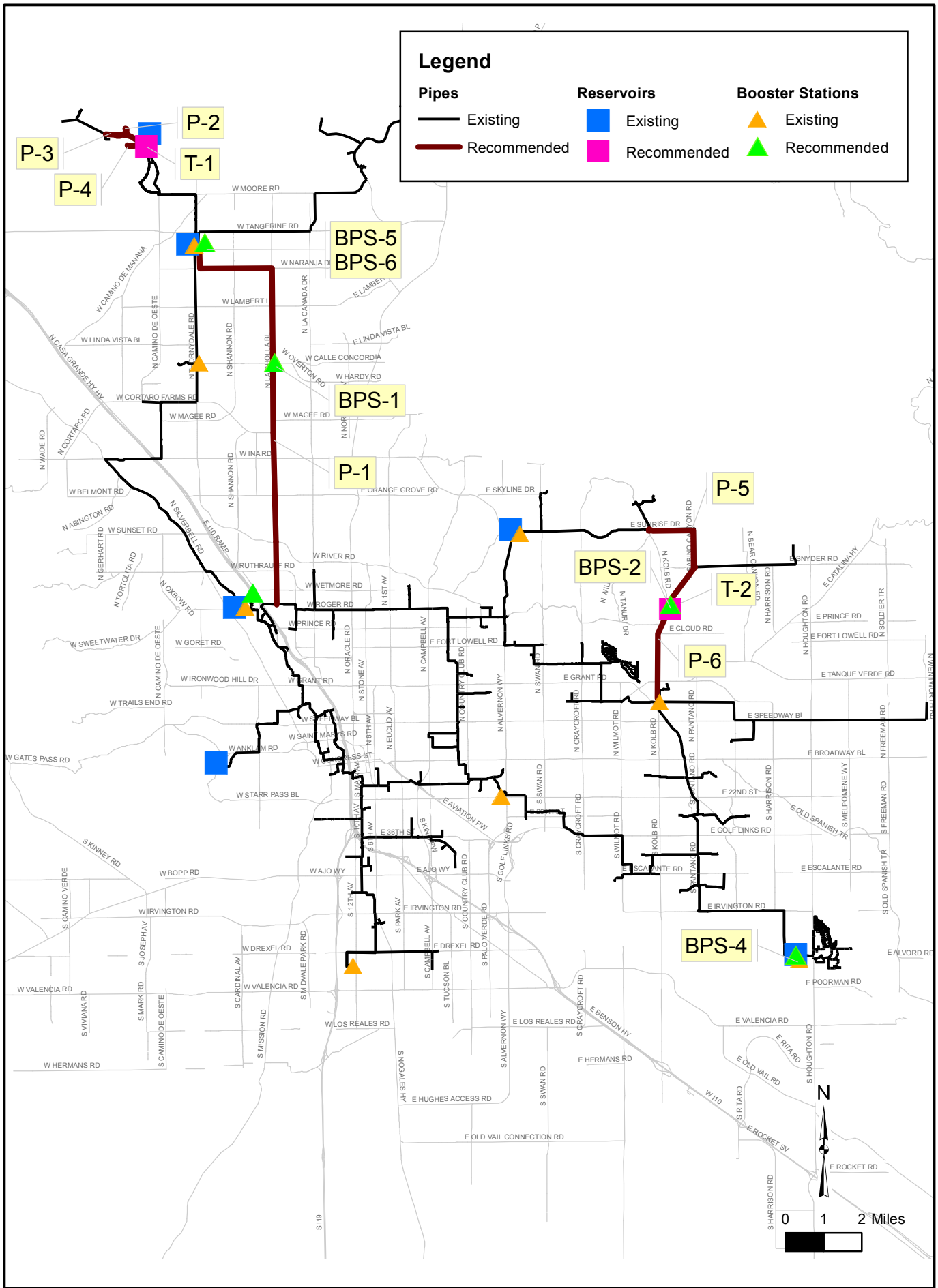
[1]January 2012 (ENR CCI = 9176)

[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.



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Recommended Reclaimed Water System Improvements

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Figure 6-1

7 References

Malcolm Pirnie, Inc. Reclaimed Water System Master Plan for Tucson Water. December, 1999.

CH2M Hill. Tucson Water Reclaimed Water System, Recovery, Disinfection and Booster Capacity: Baseline Analysis, Revised Final Technical Memorandum No. 1. May 7, 2007.

ATTACHMENT A

GOLF COURSE RECLAIMED WATER USAGE PATTERNS

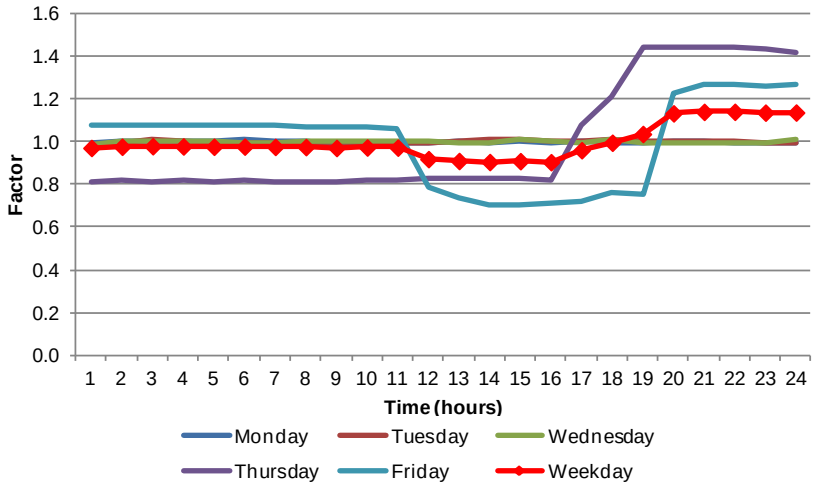

Figure 1: Gallery North Weekday Pattern

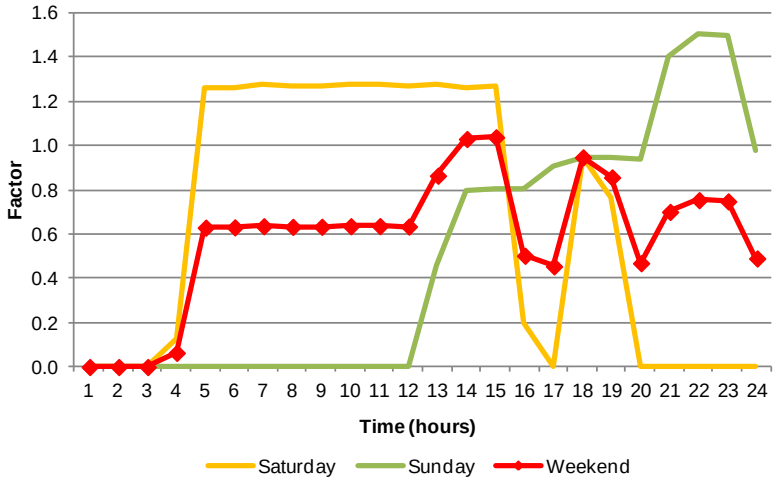

Figure 2: Gallery North Weekend Pattern

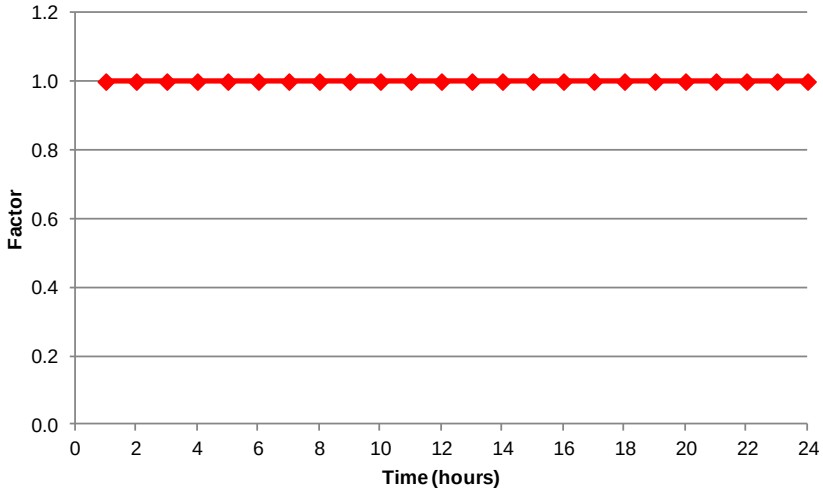

Figure 3: Gallery North Final Peak Demand Pattern

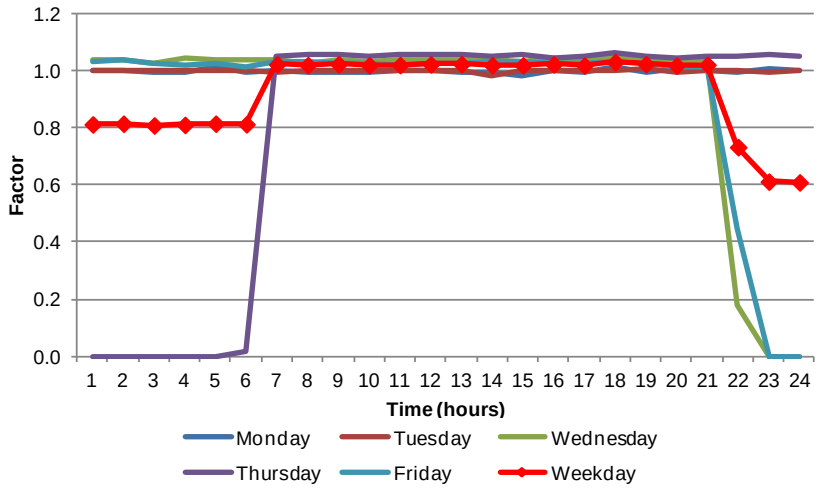

Figure 4: Gallery South Weekday Pattern

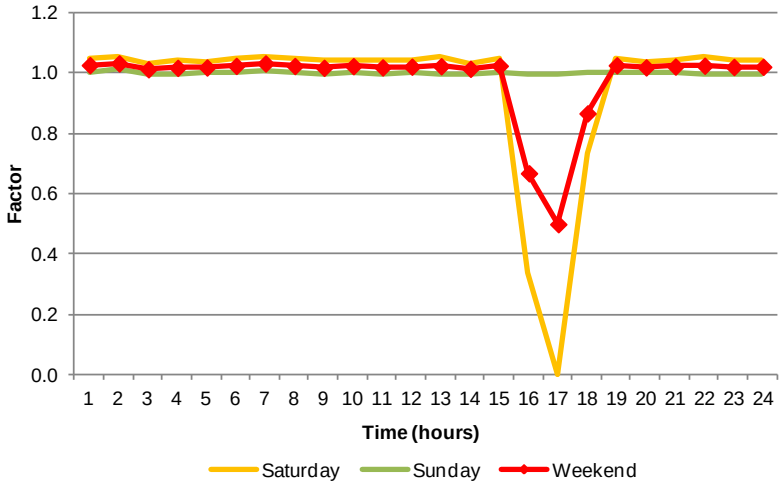

Figure 5: Gallery South Weekend Pattern

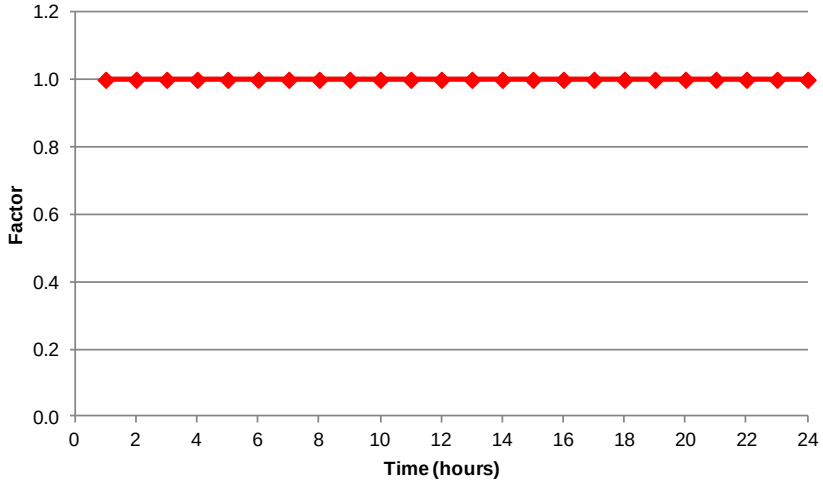

Figure 6: Gallery South Final Peak Demand Pattern

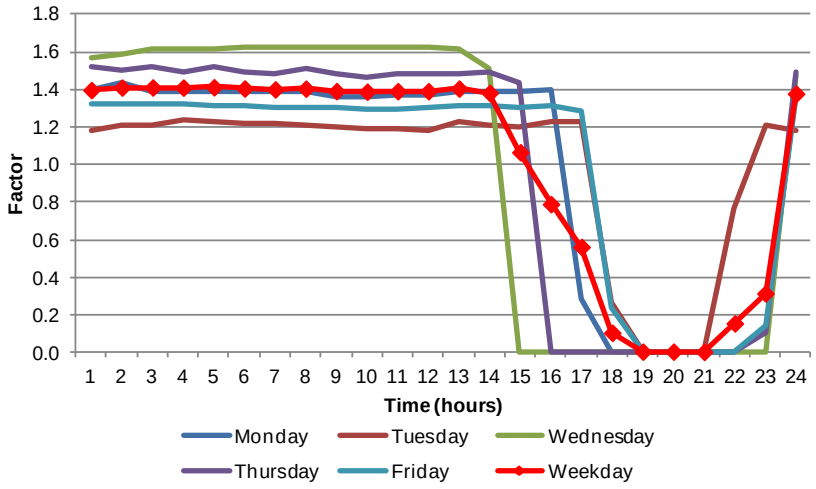

Figure 7: Heritage Weekday Pattern

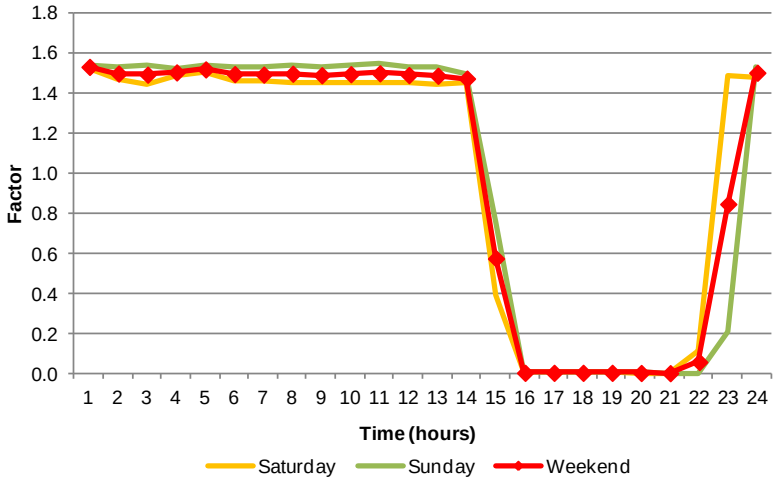

Figure 8: Heritage Weekend Pattern

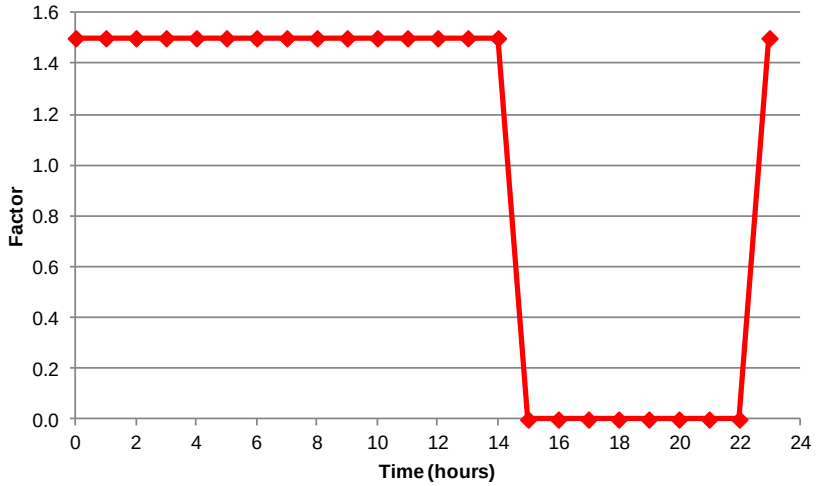

Figure 9: Heritage Final Peak Demand Pattern

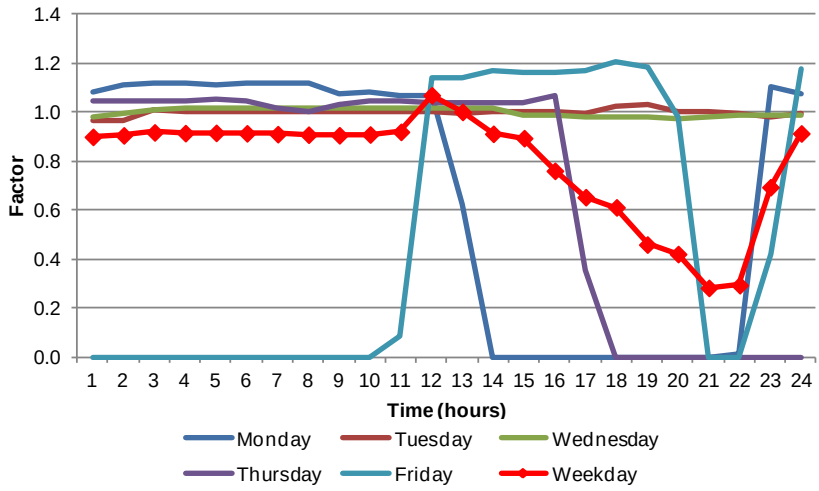

Figure 10: Dove Mountain 1 Weekday Pattern

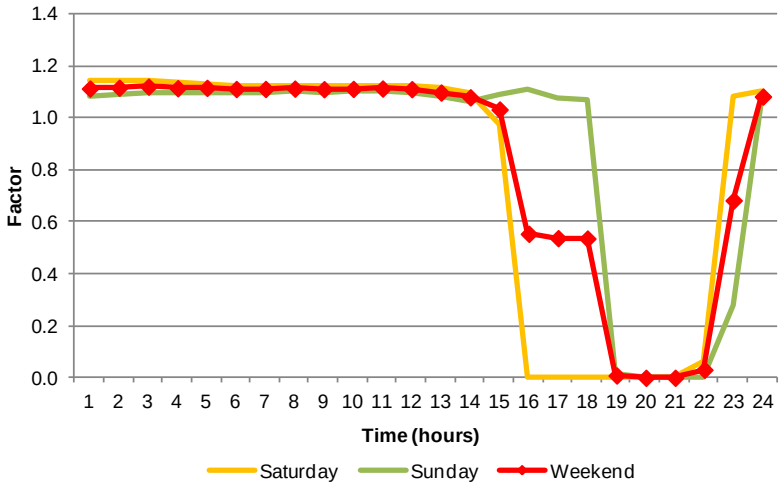

Figure 11: Dove Mountain 1 Weekend Pattern

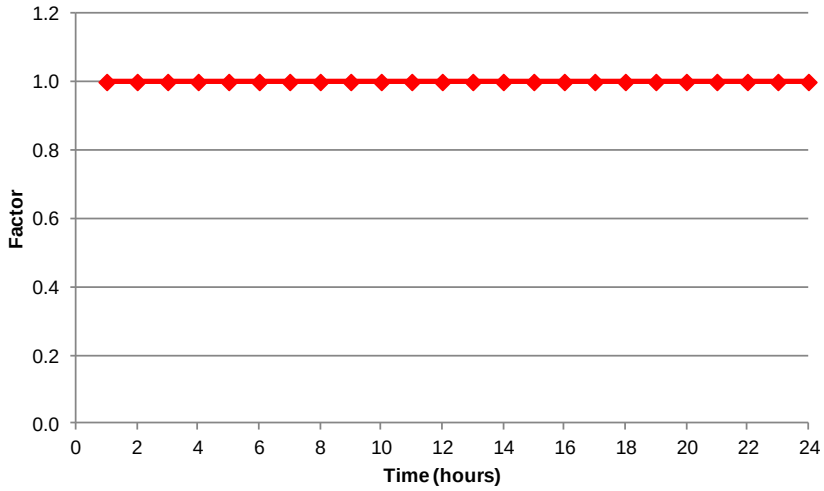

Figure 12: Dove Mountain 1 Final Peak Demand Pattern

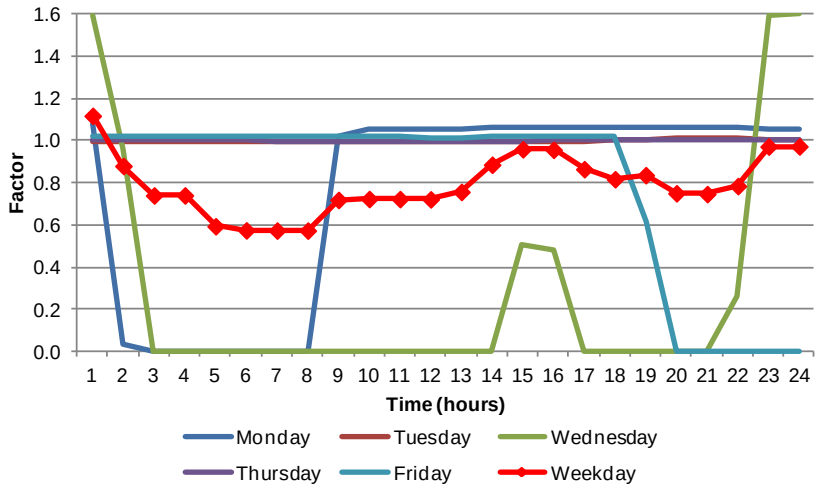

Figure 13: Dove Mountain 2 Weekday Pattern

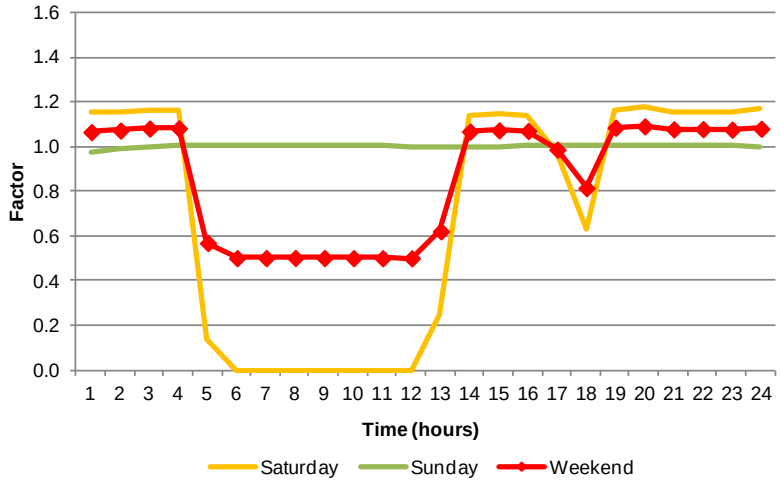

Figure 14: Dove Mountain 2 Weekend Pattern

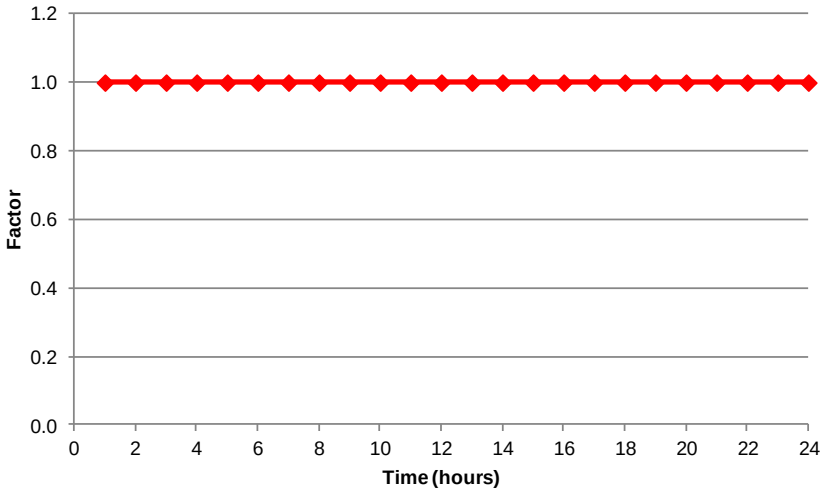

Figure 15: Dove Mountain 2 Final Peak Demand Pattern

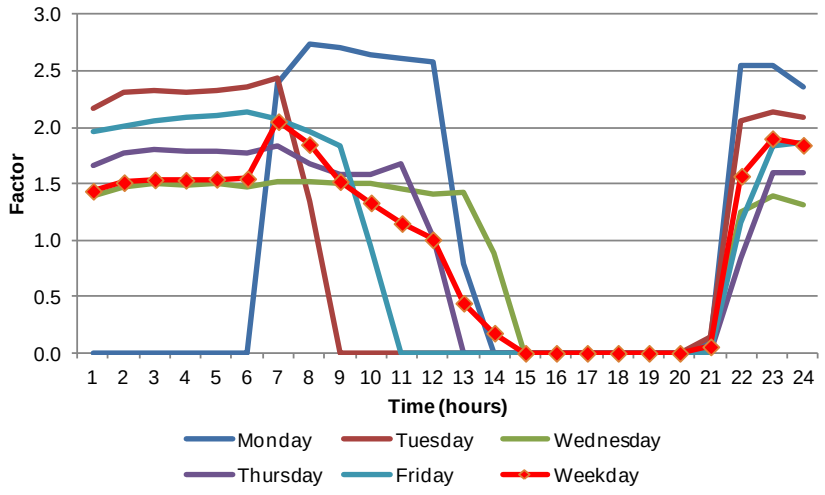

Figure 16: Randolph Park Weekday Pattern

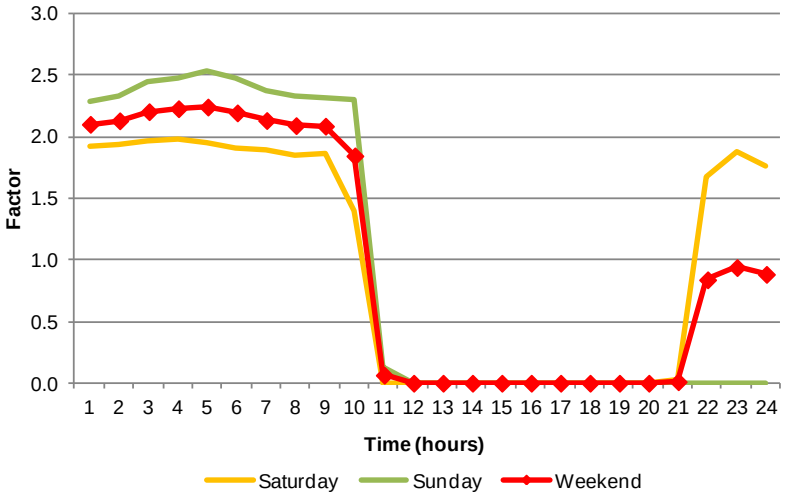

Figure 17: Randolph Park Weekend Pattern

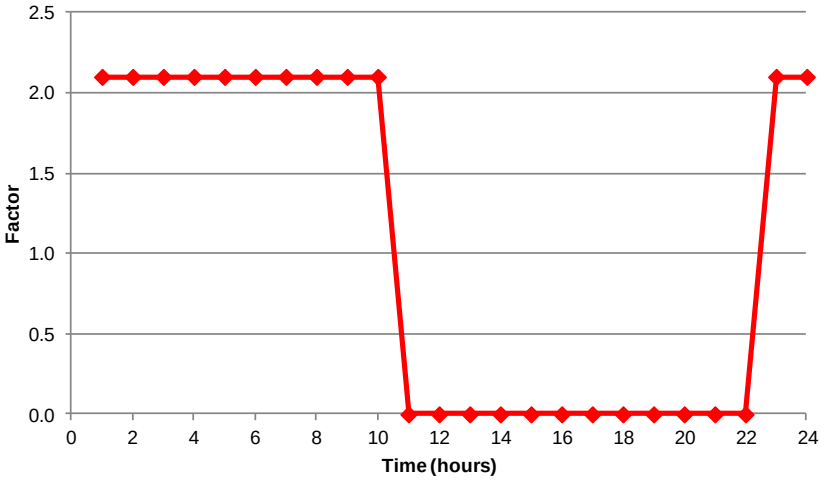

Figure 18: Randolph Park Final Peak Demand Pattern

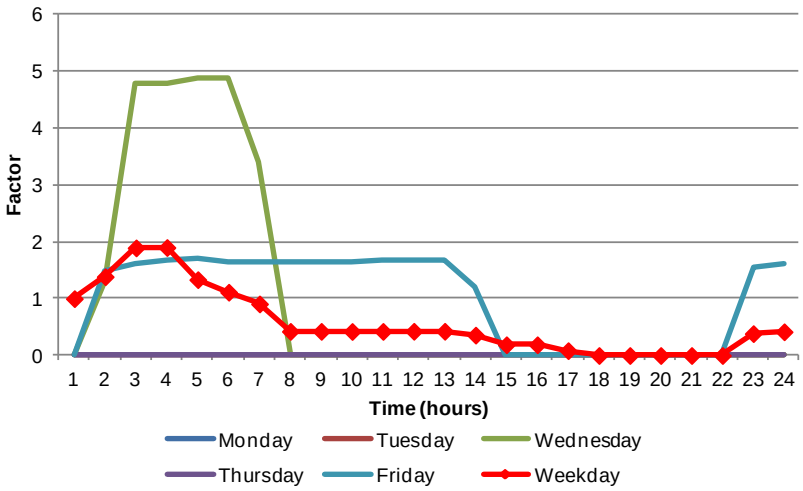

Figure 19: Davis Monthan Weekday Pattern

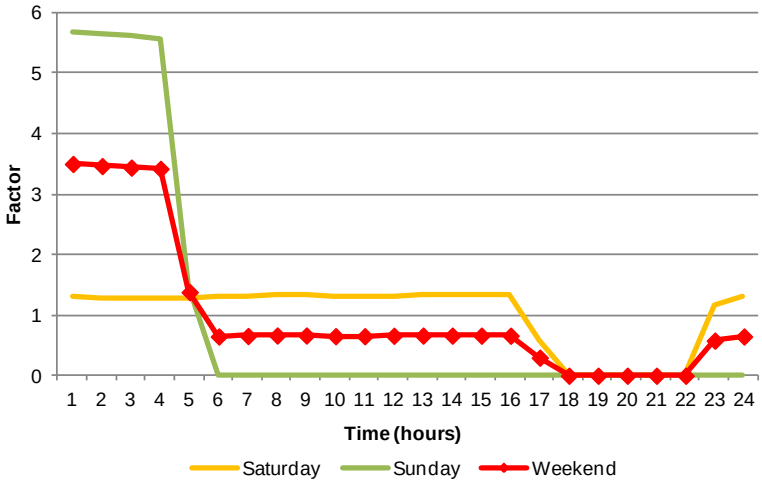

Figure 20: Davis Monthan Weekend Pattern

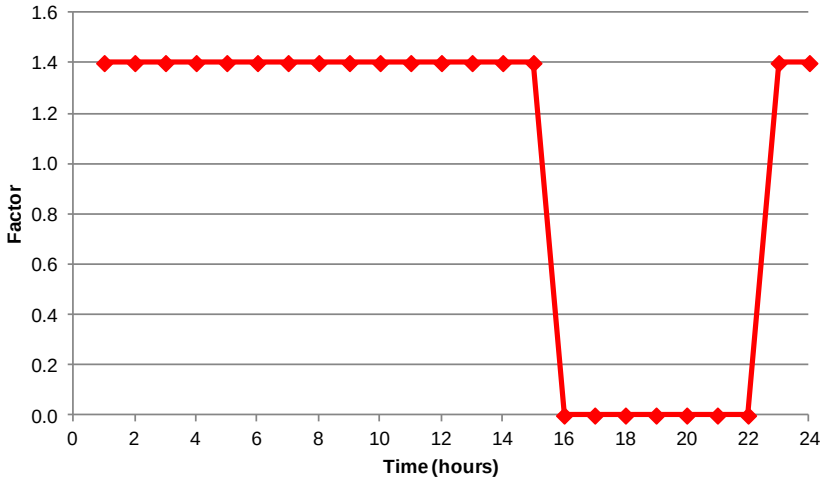

Figure 21: Davis Monthan Final Peak Demand Pattern

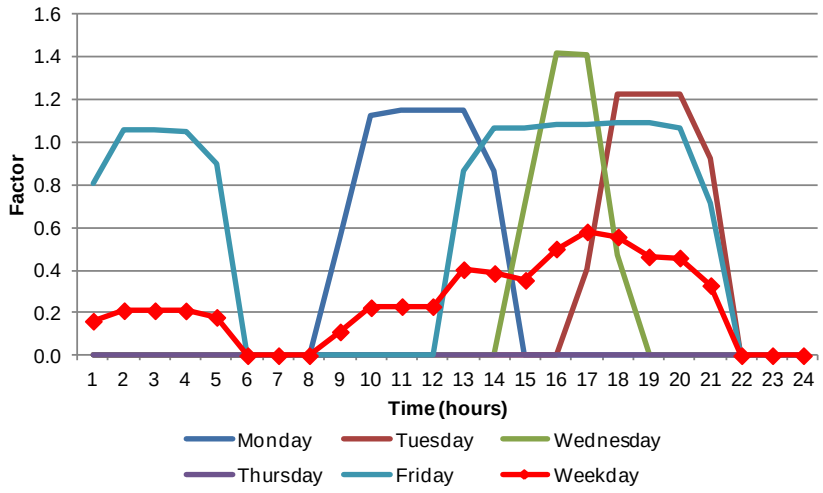

Figure 22: 49ers Weekday Pattern

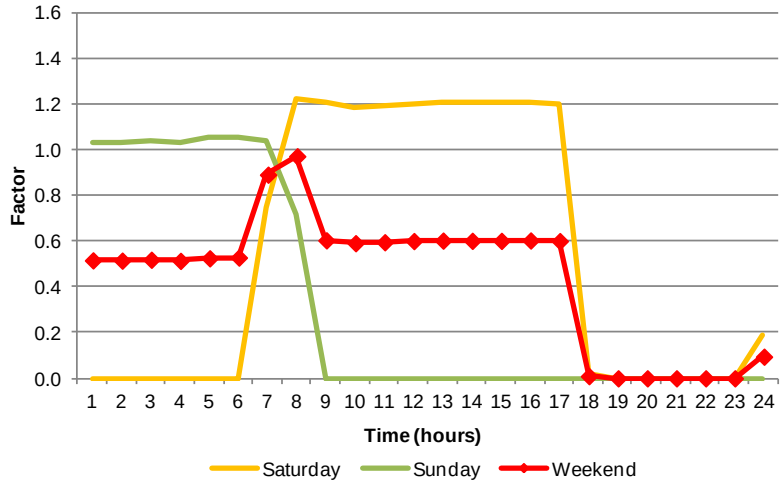

Figure 23: 49ers Weekend Pattern

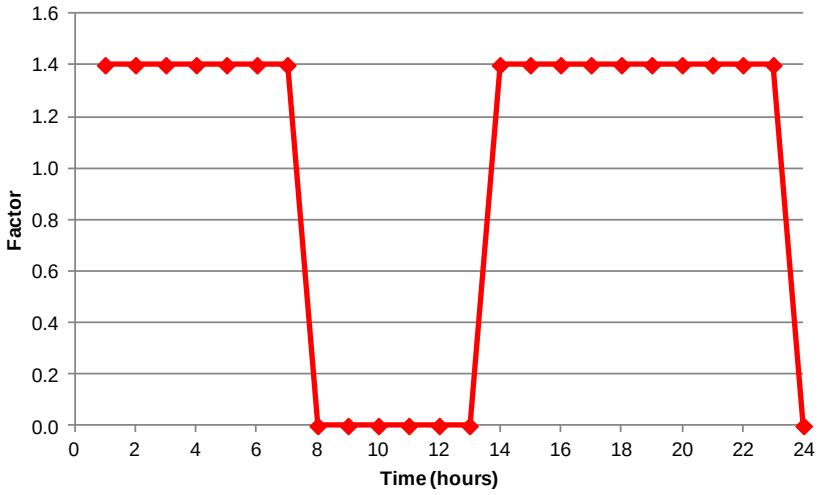

Figure 24: 49ers Final Peak Demand Pattern

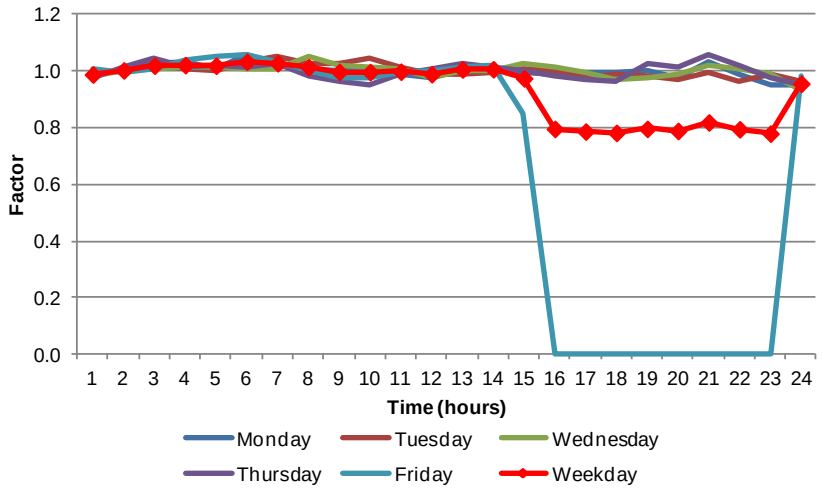

Figure 25: Reid Park Weekday Pattern

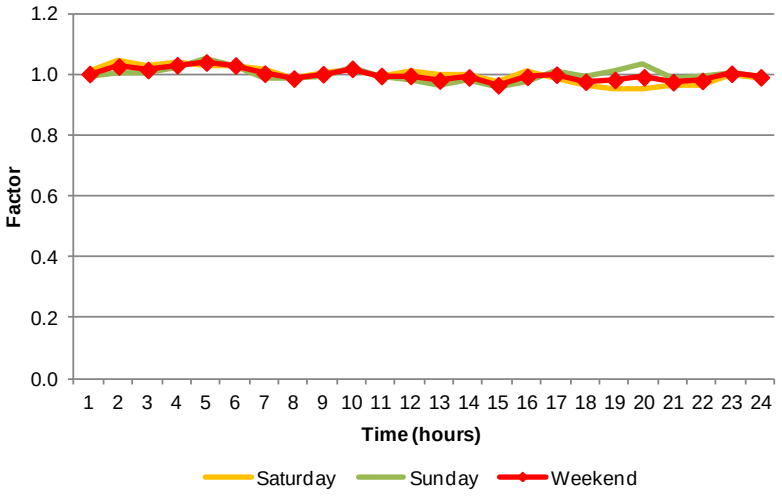

Figure 26: Reid Park Weekend Pattern

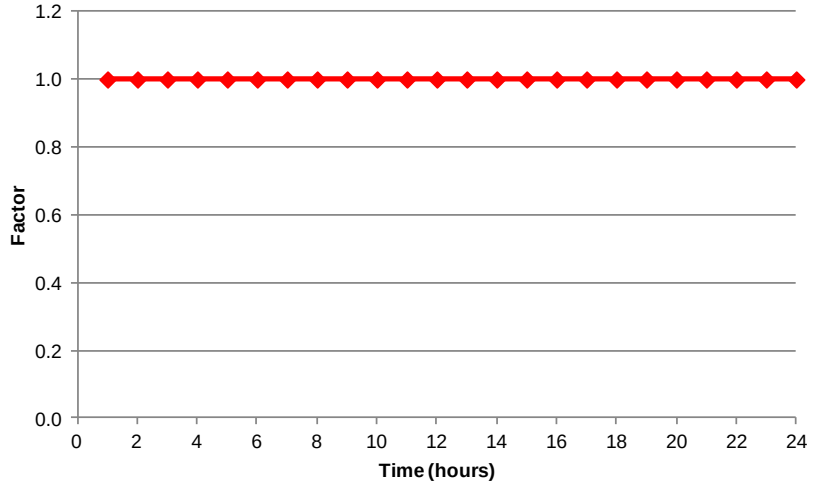

Figure 27: Reid Park Final Peak Demand Pattern

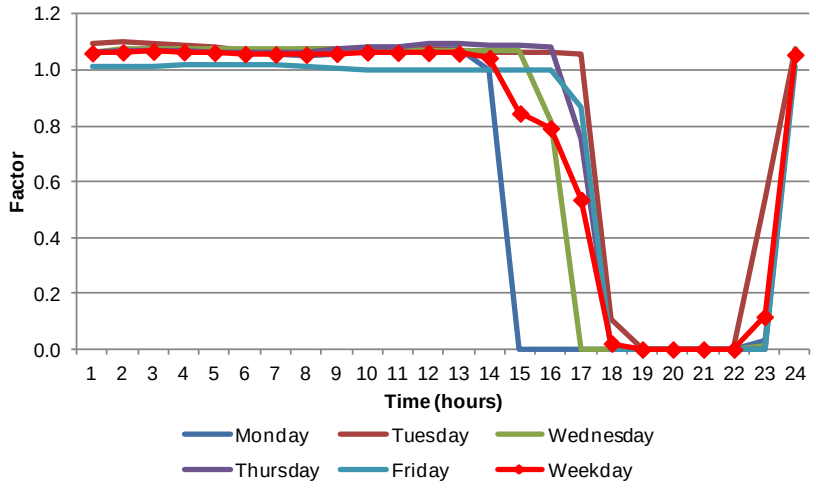

Figure 28: Starr Pass Weekday Pattern

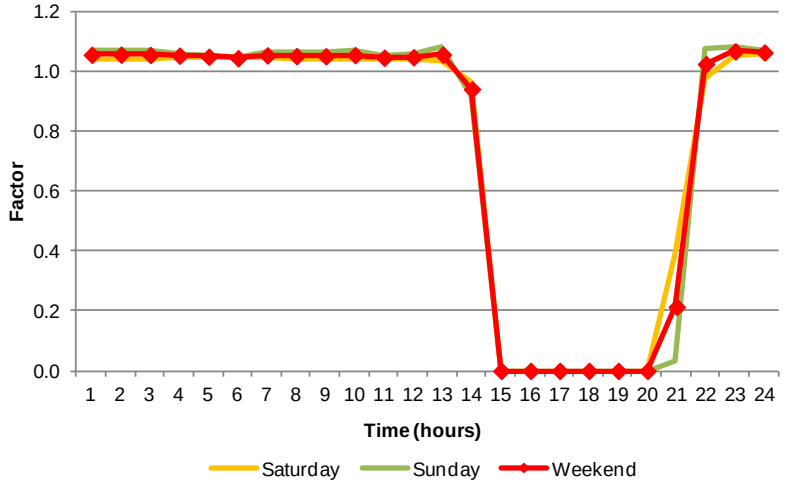

Figure 29: Starr Pass Weekend Pattern

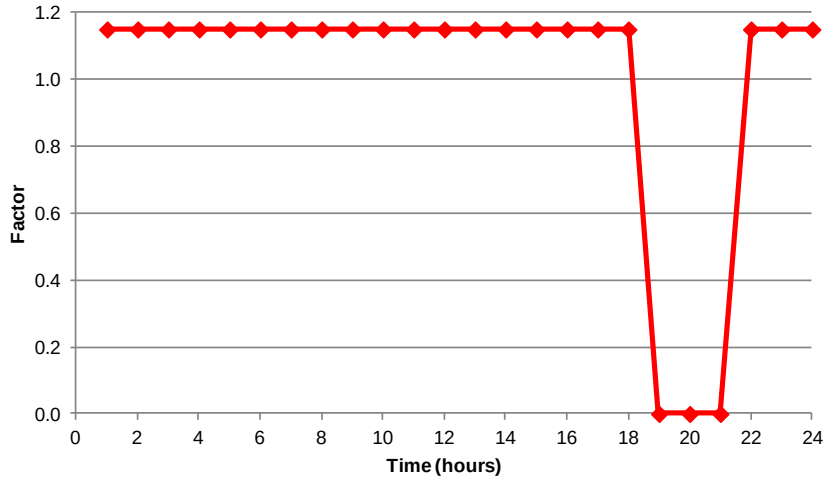

Figure 30: Starr Pass Final Peak Demand Pattern

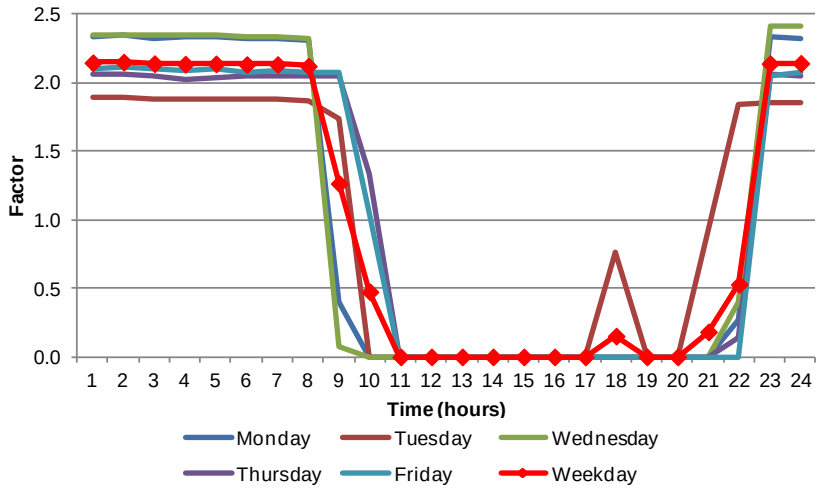

Figure 31: El Rio Weekday Pattern

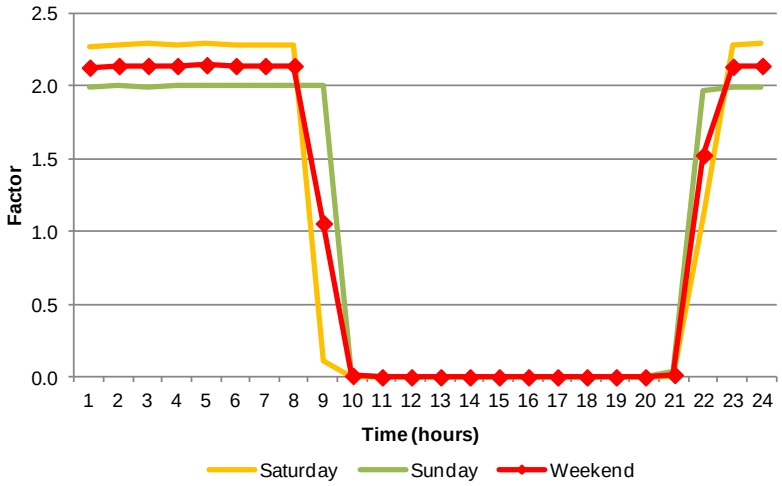

Figure 32: El Rio Weekend Pattern

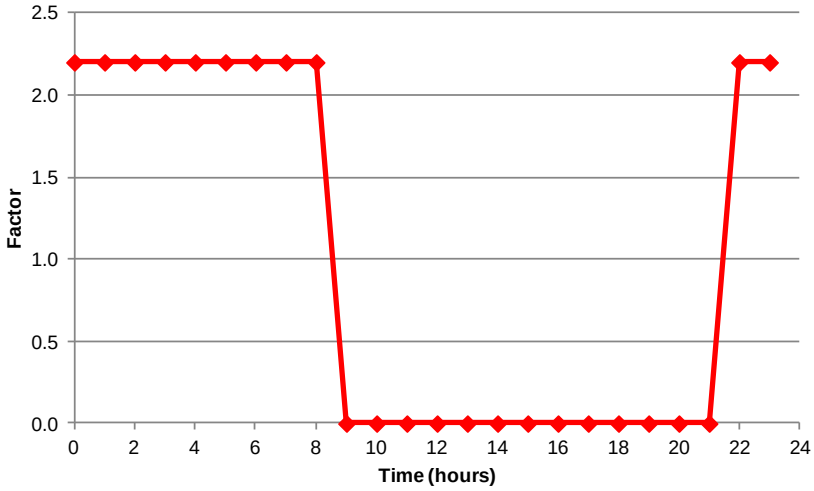

Figure 33: El Rio Final Peak Demand Pattern

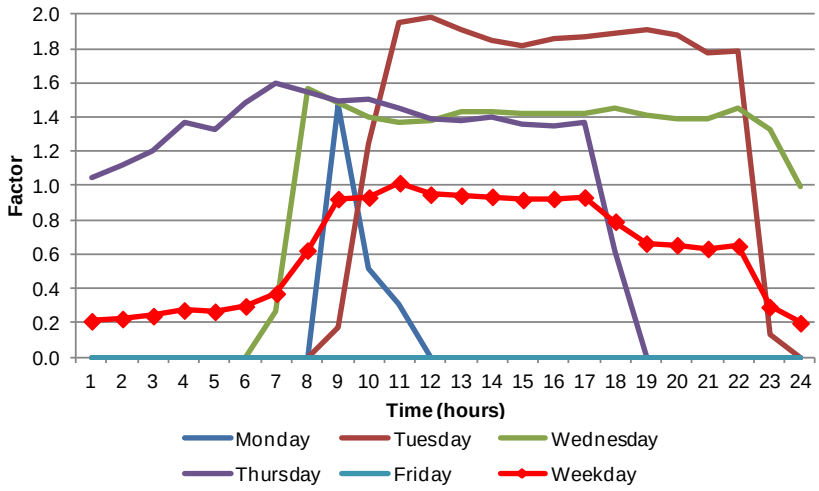

Figure 34: Kino Park Weekday Pattern

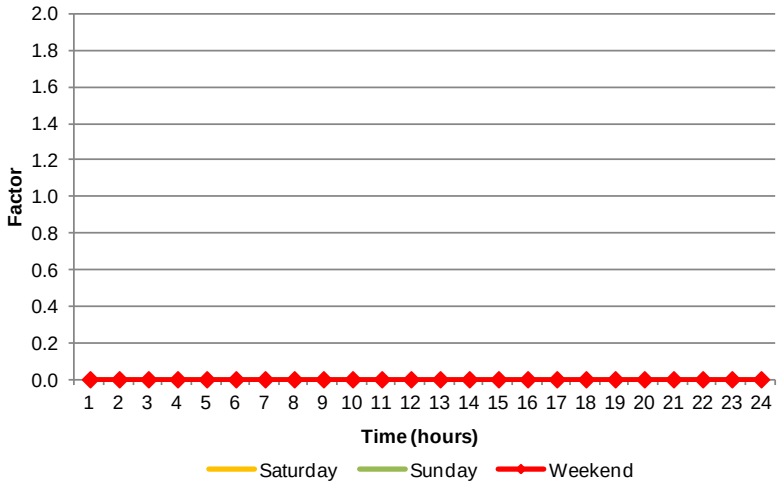

Figure 35: Kino Park Weekend Pattern

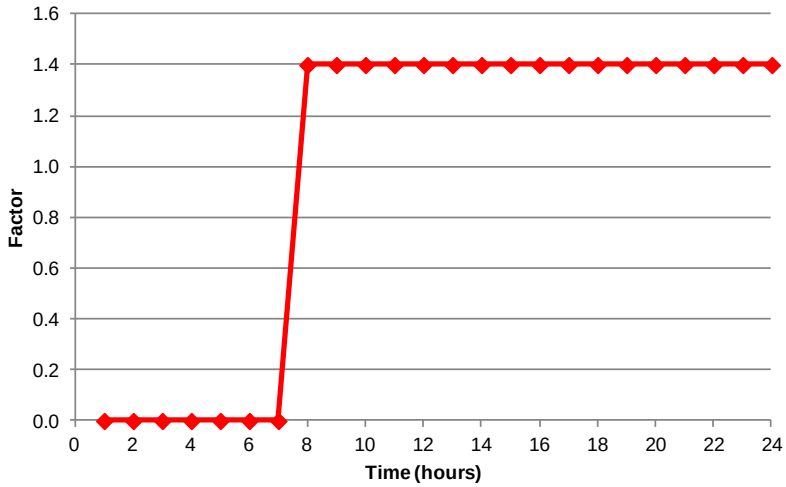

Figure 36: Kino Park Final Peak Demand Pattern

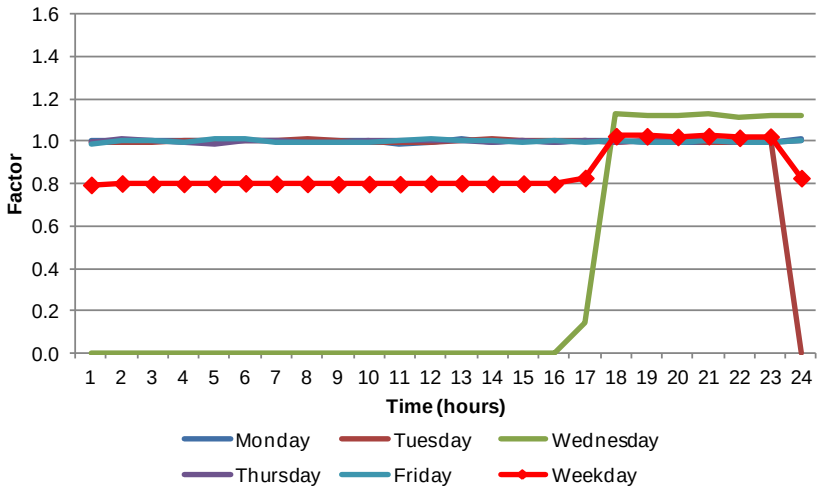

Figure 37: Arthur Pack Weekday Pattern

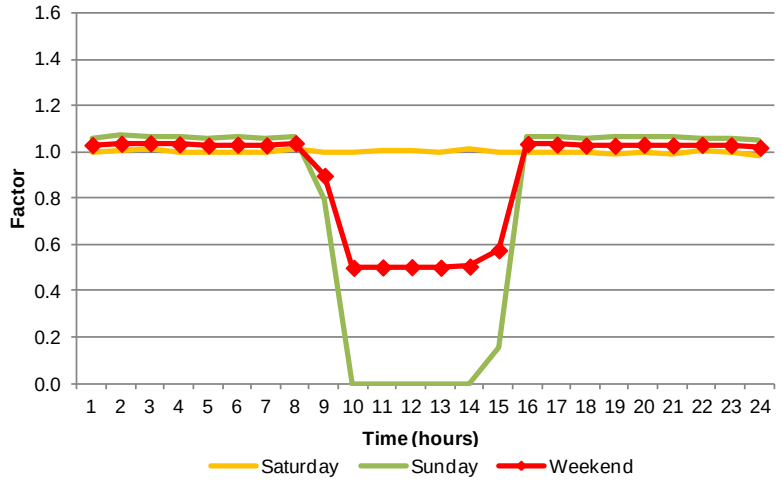

Figure 38: Arthur Pack Weekend Pattern

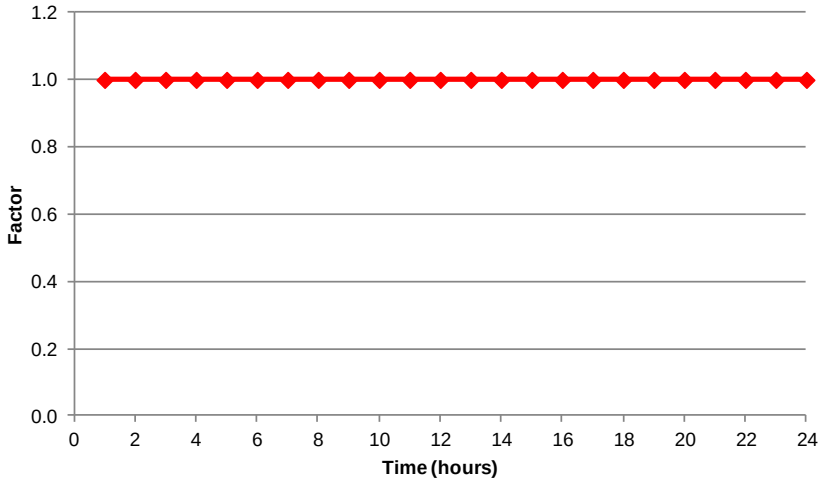

Figure 39: Arthur Pack Final Peak Demand Pattern

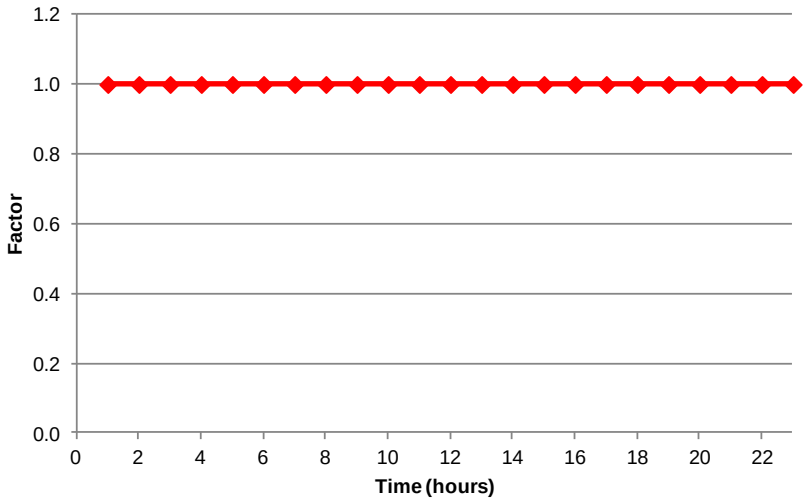

Figure 40: Other Golf Courses Final Peak Demand Pattern

ATTACHMENT B

PIMA COUNTY RECLAIMED WATER DEMAND PROJECTIONS

Location	2010 (acre-ft/yr)	2030 (acre-ft/yr)
Restoration Sites - Currently using Reclaimed Water from County's Share of Effluent		
Kino Environmenal Restoration Project	15	15
West Branch SCR	1	3
Swan Wetlands (metered off of RRP & included with Rillito RP)	16	-
Subtotal	**32**	**18**
Restoration Sites - Possible Future Sites and Expansion of Existing Sites		
Reclaimed Water to protect Cienega Creek	-	700
Southeast Houghton Area Recharge Project	-	2,000
Arroyo Chico - Park Ave Basins	-	9
Paseo de las Iglesias	-	15
Kolb Rd. Detention Basins	-	-
Cortaro Bosque (currently on non-potable water)	-	-
Subtotal	**0**	**2,724**
Pima County NRPR, PC DOT, and Stadium District Existing Sites		
PC DOT medians and right-of-ways	40	50
Alamo Wash	-	-
Arthur Pack Golf Course	660	700
Riverbend Park / Brandi Fenton	-	25
Children's Memorial Park	20	20
Curtis Park (Metered with Rillito River Park)	-	-
Flowing Wells District Park (Metered with Rillito River Park)	-	-
George Mehl District Park	36	35
Rillito Park	54	55
Rillito River Park	110	180
Santa Cruz River Park	16	50
Sam Lena Park (Metered with Kino Sports Complex)	-	-
Hildago - Willie Blake Park (Metered with Kino Sports Complex)	-	-
Kino Sports Complex (does not include KERP; 15 af in 2010 and 20 af in 2030)	114	330
Subtotal	**1,050**	**1,445**
Pima County NRPR, PC DOT, and Stadium District Future Sites		
CDO River Park - (Wheeled through Metro Water Line extension)	-	40
NW/YMCA - (Wheeled through Metro Water Line extension)	-	15
Arthur Pack (Hardy Rd Fields)	-	15
Arthur Pack Regional Park ballfields 1-7	-	25
Rillito Park - (future fields)	-	75
Santa Cruz River Park - north of Grant & south of Broadway not including COT maintained sections	-	75
Corazon de los Rios del Norte (Includes new athletic fields and riparian restoration)	-	200
Manzanita Park (existing and future fields) and Manzanita/Drexal Greenway	-	75
Lawrence Park (existing and future fields)	-	30
Rillito River Park (west of La Cholla)	-	25
Dan Felix Park (existing & future fields) - currently on non-potable	-	30
NRPR Main Office & Prickly Pear Park (3500 W. River Rd)	-	5
Chicken Ranch - Mesquite Bosque Restoration - Camino de La Tierra @ south bank of Rillito River	-	25
Ted Walker Park (future and existing fields at Mike Jacob Sports park) - currently on non-potable	-	75
Thomas Jay (Littletown Park)	-	50
Los Ninos/Augie Acuna Park	-	15
Julian Wash (not including COT & S. Tucson maintained sections)	-	75
Tucson Diversion Channel	-	30
Harrison Greenway	-	40
Tanque Verde River Park	-	40
Pantano River Park (COT maintained at this time)	-	0
Agua Caliente Park & Ponds	-	120
Subtotal	**0**	**1,080**
Total Pima County Effluent Wheeled Through TW Reclaimed System	**1,082**	**5,267**

ATTACHMENT C

BASIS OF COST OPINIONS

Summary of Capital Unit Costs[1,2]					
Item	**Units**	**Cost (Jan. 2012)**	**Engineering and Admin[3] (Jan. 2012)**	**Contingency[4] (Jan. 2012)**	**Total (Jan. 2012)**
Pipelines					
Ductile Iron Pipe (inches)[5]					
6	$/LF	$74	$18	$28	$120
8	$/LF	$91	$23	$34	$148
10	$/LF	$108	$27	$40	$175
12	$/LF	$125	$31	$47	$203
14	$/LF	$142	$36	$53	$231
16	$/LF	$160	$40	$60	$260
18	$/LF	$176	$44	$66	$287
20	$/LF	$193	$48	$72	$314
24	$/LF	$228	$57	$85	$370
30	$/LF	$279	$70	$105	$453
36	$/LF	$294	$74	$110	$478
Reservoirs[6]					
0.0 to < 2.5 MG	$/MG	$1,426,741	$356,685	$535,028	$2,318,453
2.5 to < 4.0 MG	$/MG	$1,156,826	$289,207	$433,810	$1,879,842
4.0 to < 7.5 MG	$/MG	$886,911	$221,728	$332,592	$1,441,231
7.5 to < 12.5 MG	$/MG	$616,997	$154,249	$231,374	$1,002,620
Booster Pump Stations[6]					
0 to < 7 mgd	$/MGD	$378,270	$94,567	$141,851	$614,688
7 to < 13 mgd	$/MGD	$215,213	$53,803	$80,705	$349,722
13 to < 17 mgd	$/MGD	$130,451	$32,613	$48,919	$211,983

NOTES:

(1) January 2012 Costs (ENR CCI = 9,176).

(2) Unit capital costs include engineering/design, materials of construction, installation and contractor overhead and profit.

(3) Engineering & Administration Cost - 25 percent.

(4) Contingency - 30 percent.

(5) Ductile iron pipe with excavation, five feet of cover, backfill, and bedding.

(6) Includes fencing and access gates, site paving, landscaping, earth and concrete work, electrical, mechanical, instrumentation, and SCADA.

APPENDIX E

NEW RECYCLED WATER PROGRAM EVALUATION

Recycled Water Master Plan

Appendix E:
New Recycled Water Program Evaluation

December 2013

The Water Division of ARCADIS

Imagine the result

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B. Criterium DecisionPlus Attributes and Scoring Results

C. Design Criteria and Cost Estimates for the Recycled Water Program Alternatives

1 Introduction

This technical memorandum summarizes the identification and evaluation of recycled water programs that could put Tucson Water's unutilized recycled water to beneficial use. Chapter 4 of the Recycled Water Master Plan presents projections of Tucson Water's total "effluent entitlements" and Chapter 5 describes the recycled water (treated effluent entitlements) that is unutilized after demands in the reclaimed water system (RWS) are satisfied. In concept, the unutilized recycled water could be used to replenish groundwater and, after additional advanced treatment, could be used to supplement future drinking water supplies.

Alternatives for potential future recycled water programs are identified by revisiting Tucson Water's previous scenario planning effort for water reuse. Advanced treatment processes are identified, evaluated, and prioritized for the recycled water program alternatives. Finally, the alternatives are developed to allow concept cost evaluations, including conveyance, pumping, recharge and recovery, advanced treatment, and finished water transmission facilities. The evaluations result in the identification of preferred recycled water program strategies that are recommended to be taken forward for detailed evaluations and demonstration testing.

2 Process for Identifying Recycled Water Program Alternatives

Tucson Water initially developed the impetus for the Recycled Water Master Plan, in part, by revisiting the Utility's scenario planning assumptions and uncertainties for recycled water reuse originally developed in *Water Plan: 2000-2050*. By extending the scenario planning process specifically for water reuse, Tucson Water utilized the best available information and planning assumptions to address many possible views of the future related to a potential water recycling program. The process identified the two most significant uncertainties which will influence the development of a new recycled water program:

1. Will the public accept indirect potable reuse of recycled water supplies?

2. Will the City treat recycled water beyond potable regulatory standards?

Recycled water program alternatives were identified which would cover the range of possibilities imposed by the above uncertainties. The recycled water program alternatives were identified and evaluated using the following process.

- Step 1: Identify concepts for strategic sources of recycled water and recharge and recovery locations. These concepts are described in Chapter 3 of this technical memorandum.

- Step 2: Identify additional concepts for recycled water conveyance, treatment locations (pre-recharge and post-recovery), brine and treatment residuals management, recovery, and purified water transmission elements. These concepts are described in Chapter 4.

- Step 3: Based on alternative treatment locations (pre-recharge and post-recovery), identify and evaluate options for advanced treatment processes to identify preferred treatment processes. The treatment process evaluations are described in Chapter 5.

- Step 4: Combine all elements of the recycled water program alternatives for a complete evaluation of program alternatives. The program evaluations are described in Chapter 6.

3 Identification of Concepts for Recycled Water Program Alternatives

The concepts for recycled water program alternatives involve strategic sources of recycled water and recharge and recovery locations.

3.1 Recycled Water Sources

The most obvious sources of recycled water are from the metropolitan area treatment facilities: the future Water Reclamation Campus (WRC) at Roger Road, Ina Road Wastewater Reclamation Facility (WRF), and Randolph Park WRF. The metropolitan area facilities are where most of the region's wastewater is collected. Of these locations, Tucson Water is to receive its recycled water at the Water Reclamation Campus according to current City/County intergovernmental agreements (IGAs). Thus, for purposes of the evaluation, it is assumed that the primary source of recycled water from the metropolitan area will be the Water Reclamation Campus under all alternatives.

Another existing source of recycled water could be the Reclaimed Water System (RWS); however, the RWS is dedicated to serving existing and future reclaimed water customers. The RWS could also deliver recycled water (up to 4,000 acre-feet per year, AFY) to the proposed Southeast Haughton Area Recharge Project (SHARP) site within the constraints of service to other RWS customers.

Finally, the non-metropolitan treatment facilities including the Avra Valley WRF, the future Southeast (SE) Area WRF, and the future Southlands WRF could be sources of recycled water. However, the current supplies are non-existent or are insignificant compared to supplies from the metropolitan area facilities. Thus, the evaluations herein are focused on recycled water supplies from the metropolitan area treatment facilities.

3.2 Recharge Locations

Preferred locations for recycled water recharge would depend on whether Tucson Water decides to pursue an indirect potable reuse (IPR) project or if it elects just to recharge the water for long-term storage credits.

3.2.1 Recharge Locations for IPR Purposes

If indirect potable reuse is pursued, recharge would be conducted with purposeful augmentation of the potable supply. To reduce costs, recharge should occur where there is existing infrastructure to recover the water and to get it to locations meant for distribution of large volumes of potable

water supply. Because of the potential volume of recycled water supply, recharge should also occur where large tracts of land are available. Possible recharge locations would therefore include the Central Avra Valley Storage and Recovery Project (CAVSARP), the Southern Avra Valley Storage and Recovery Project (SAVSARP), and potentially SHARP.

Recharge within the Central Wellfield and/or close to the existing metropolitan water reclamation facilities (Roger Road and Ina Road Water Reclamation Facilities) were considered but were not considered viable:

- There are no more large tracts of vacant land available within the Central Wellfield and the area is distant from the existing major potable water distribution infrastructure associated with the Clearwater Program (delivery of CAP water through the CAVSARP and SAVARP facilities). Any potential cost savings would be offset by the need to convey large volumes of water to the existing primary potable water distribution infrastructure.
- Similarly, there are no large tracts of land available near the metropolitan water reclamation facilities (all available land is being used for water reclamation, recharge and recovery, and other RWS facilities).
- Groundwater in the vicinity of the Roger and Ina Road WRFs has elevated levels of many wastewater and industrial contaminants.
- The area in the vicinity of the metropolitan water reclamation facilities is surrounded by three significant Arizona Water Quality Assurance Revolving Fund (WQARF) sites. Additional significant local recharge and recovery activities would be highly constrained by the water quality remediation objectives of these sites.

The CAVSARP and SAVSARP locations could accommodate the full unutilized Tucson Water recycled water supplies, whereas the SHARP site could only accept up to 4,000 AFY until it is fully demonstrated and a new agreement is developed with the County. SHARP is a joint City of Tucson and Pima County recycled water recharge project to develop long-term water storage credits. Thus, there is no large-scale recovery currently planned. Because recycled water conveyance, recharge, and recovery capacities for the SHARP alternative are limited, the SHARP alternative is considered complementary to other recycled water program alternatives and is not included in the subsequent evaluations. The SHARP alternative could provide an opportunity for a demonstration project that could transition to a permanent first phase of a full-scale project.

Of the CAVSARP and SAVSARP locations, the CAVSARP location has the best potential because 1) the City has property just to the north of the CAVSARP basins, 2) it is closer to the recycled water source, and 3) the opportunity to extend another major conveyance facility through

existing rights-of-way to SAVSARP are very limited. Thus, two categories of IPR alternatives were identified:

- The CAVSARP Alternatives would utilize the existing CAVSARP basins for recycled water recharge (mixing with CAP water prior to recharge)
- The North CAVSARP Alternatives would utilize new basins constructed north of the CAVSARP basins.

3.2.2 Recharge Locations for Non-IPR Purposes

If IPR is not pursued, recharge would have to be conducted at substantial distance from, or hydrologically separated from, the potable water supply. The intent would be to avoid mixing of recharged water with native groundwater used for potable purposes. In order to maximize the benefits to local groundwater resources, recharge should occur within the Tucson Active Management Area (AMA) boundaries. Recharging recycled water outside of the Tucson AMA will not contribute to Tucson Water's long-term planning goal of achieving hydrologic sustainability. It would also not contribute to long-term storage credits for Tucson Water. The extreme southern boundaries of the Central Wellfield and Avra Valley basins would be the most acceptable recharge location as vacant land is still available in these areas.

Recharge in areas to the north of Tucson Water's service area and other developed areas were also considered but were not considered acceptable because of jurisdictional concerns associated with large-scale recharge facilities being located within the service/planning areas of others. In addition, this area is downgradient of the Tucson Water service area, and the recharged water would flow out of the drainage basin without contributing to Tucson Water's long-term planning goal of achieving hydrologic sustainability.

To represent the case where IPR is not pursued, a third category of alternatives was identified, the Southeast (SE) Tucson Alternatives. The SE Tucson recharge location can be planned to recharge the entire unutilized recycled water supplies.

3.3 Recovery Locations

For both CAVSARP and North CAVSARP Alternatives, existing infrastructure could be used to recover and convey the recovered water to the CAVSARP reservoir and booster station. However, since the existing recovery capacity at CAVSARP is limited, both categories of alternatives would require that some recharge of CAP water (in an amount equal to recycled water that is recharged) be shifted to an expanded SAVSARP.

The SE Tucson Alternative does not include any purposeful recovery. However, over many years the recharged water is expected to eventually migrate and blend with the Central Wellfield water.

3.4 Summary of Concepts for Recycled Water Programs

Table 3-1 provides a summary of the concepts for potential recycled water program alternatives. Figure 3-1 shows the locations of the concepts summarized in Table 3-1.

Table 3-1. Summary of Concepts for Recycled Water Program Alternatives

Alternative Category	Recharge Location	Recovery Location	Recharge Capacity
CAVSARP	Existing CAVSARP basins	Existing CAVSARP recovery facilities	All unutilized recycled water
North CAVSARP	New basins North of CAVSARP	Existing and new recovery facilities north of CAVSARP	All unutilized recycled water
SE Tucson	New recharge basins Southeast of Tucson	No purposeful recovery	All unutilized recycled water

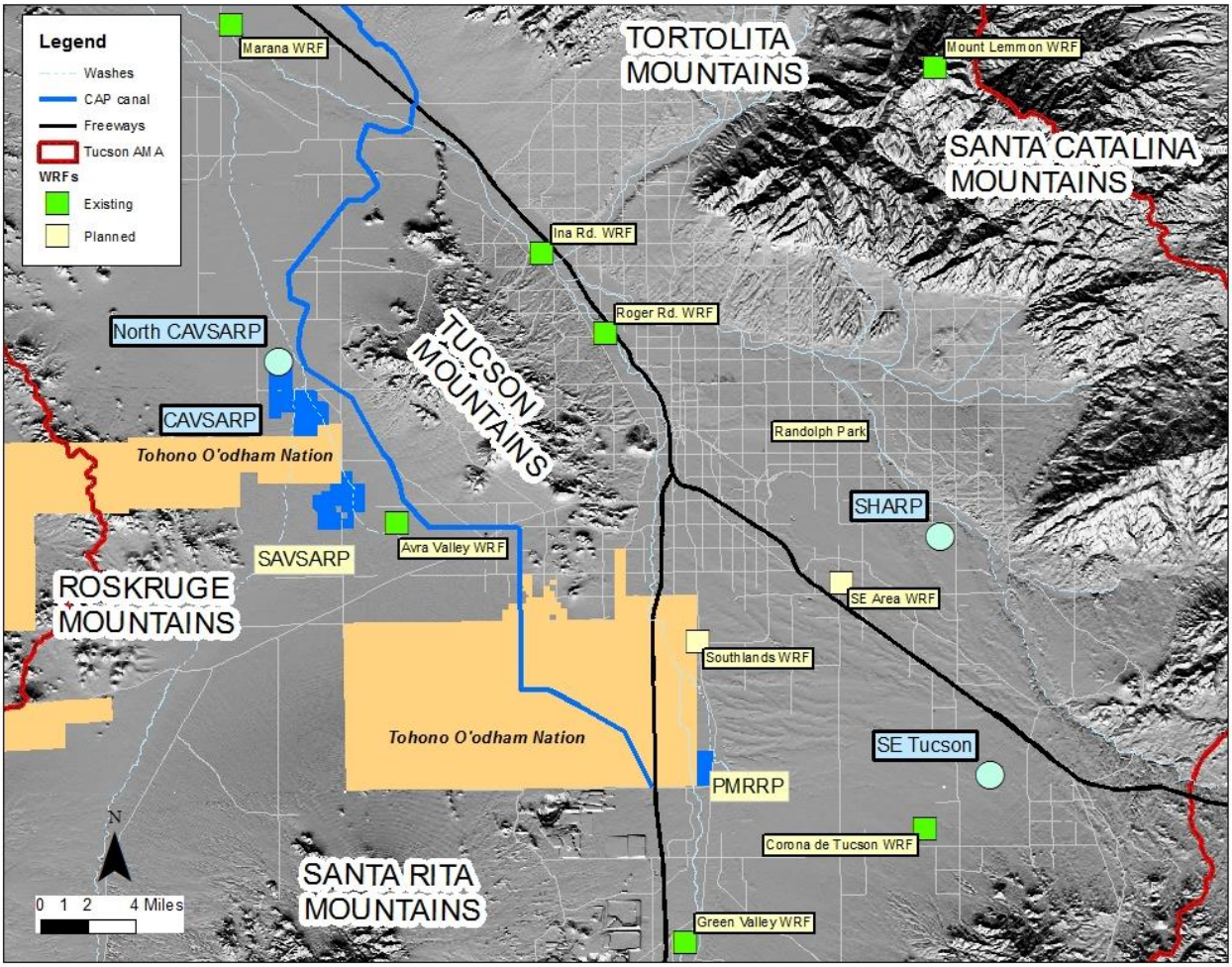

Figure 3-1. Concepts for Recycled Water Program Alternatives

4 Additional Facility Concepts for Recycled Water Programs

Based on the framework for recycled water sources and recharge and recovery locations, additional concepts for recycled water conveyance, locations for treatment (pre-recharge and post-recovery), brine and treatment residuals management, recovery, and purified water transmission elements were identified for the recycled water program alternatives.

4.1 Recycled Water Conveyance Concepts

Both the CAVSARP and North CAVSARP alternatives would involve recycled water conveyance from the metropolitan area treatment facilities (assumed location at the Water Reclamation Campus per existing agreements) to these recharge locations. Figure 4-1 shows the potential conveyance route from the metropolitan area treatment facilities to the CAVSARP and North CAVSARP recharge areas. The conveyance alignment is approximately 25 miles long and would require a total lift of 100 feet. The conveyance alignment is based on the proposed conceptual alignments for conveyance facilities from the 1995 Regional Effluent Utilization Plan Phase B (Malcolm Pirnie, June 1995), which considered existing rights-of-way and optimizing gravity flow.

The SE Tucson alternative would also involve recycled water conveyance from the metropolitan area treatment facilities to the recharge location. Figure 4-2 shows a potential conveyance route from the metropolitan area treatment facilities to the assumed location of the SE Tucson recharge facility. The conveyance alignment is approximately 35 miles long and would require a total lift of 1,200 feet. The conveyance alignment to the SE Tucson alternative was based on conceptual routing that considered open space and availability of existing rights-of-way.

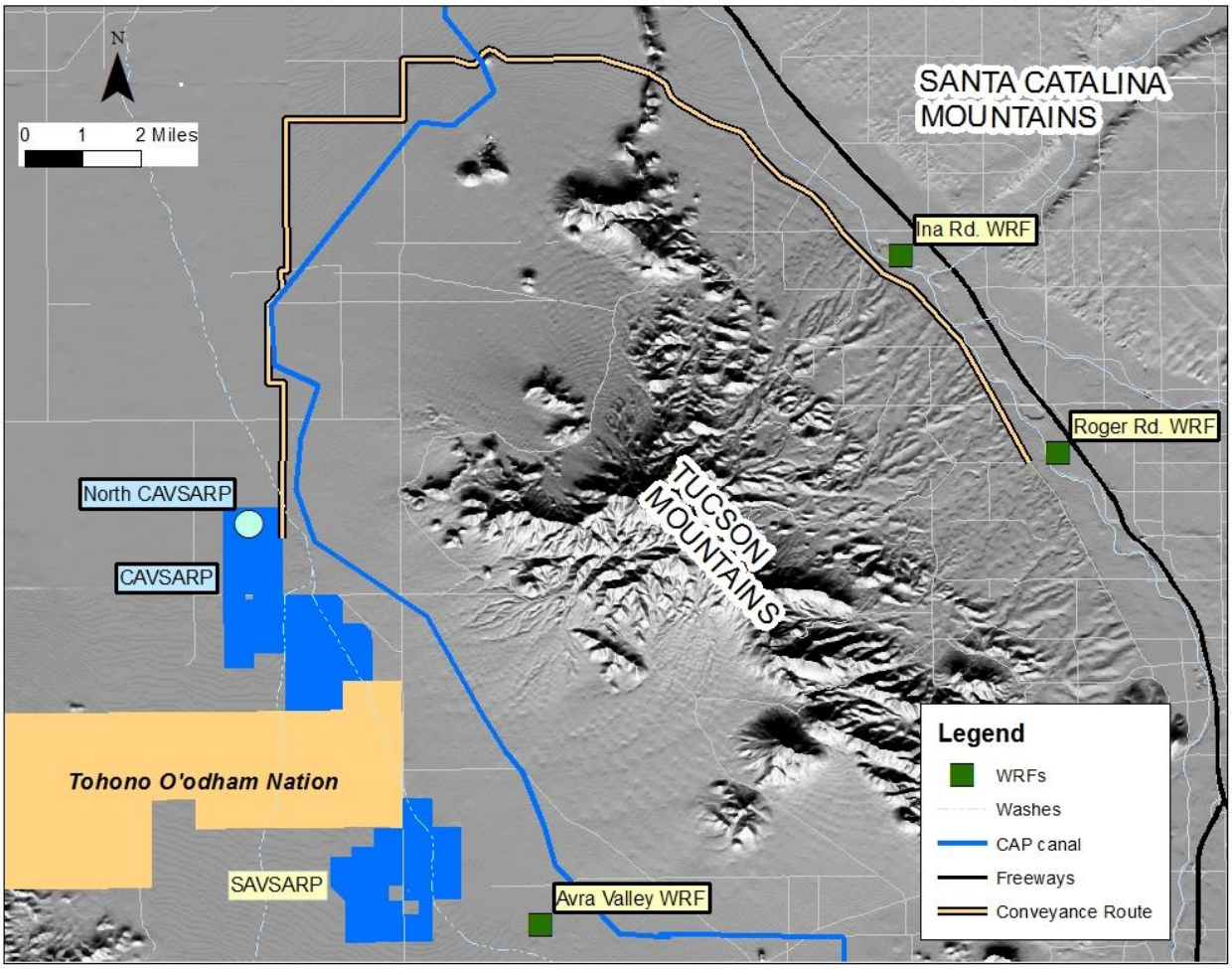

Figure 4-1. Conveyance Route from Metropolitan Area Treatment Facilities to CAVSARP Area

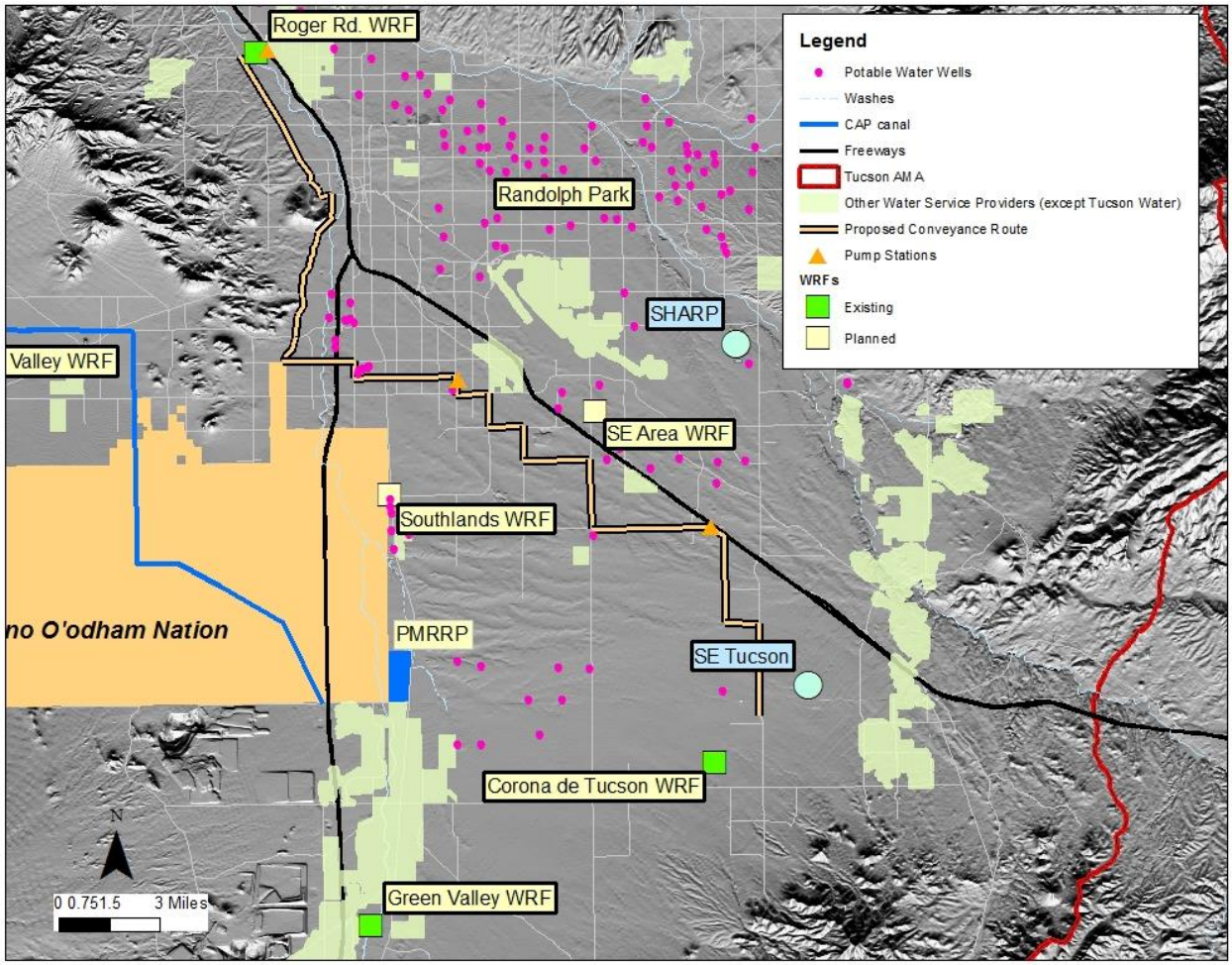

Figure 4-2. Conveyance Route from Metropolitan Area Facilities to SE Tucson Recharge Location

4.2 Recharge and Recovery Facilities

The CAVSARP alternatives would use existing CAVSARP infrastructure for recharge and recovery of recycled water. Recycled water would be recharged in the same basins as CAP water which has implications from a regulatory perspective because modifications to the Aquifer Protection Permit (APP) may be required for the CAVSARP alternatives. Another consideration for the CAVSARP alternatives is that recycled water will displace some CAP water that would normally be recharged at CAVSARP, resulting in the need to expand SAVSARP facilities to accommodate the displaced CAP recharge. Expansion of SAVSARP would be the best option

as there is sufficient capacity to deliver additional CAP water to SAVSARP, space is available for new recharge basins, and recovery capacity is available at SAVSARP.

The North CAVSARP alternatives would use new basins north of the existing CAVSARP facilities for recharge. Existing infrastructure could be used to recover and convey the recovered water to the CAVSARP reservoir and booster station, thus the recovery capacity would not need to be expanded. However, since the recovered water transmission, reservoir and booster station are limited in capacity, the North CAVSARP alternatives would also require that some CAP water be shifted to an expanded SAVSARP.

The SE Tucson recharge location was chosen because of its substantial distance from the current potable water supply. Figure 4-2 also illustrates the proximity of the SE Tucson recharge location to existing potable water wells, other water providers, and the Tucson AMA boundary. It is improbable to move the location of the SE Tucson alternative to a location further away from the Central Wellfield because of the AMA boundary to the East and the Santa Rita mountains to the South. The SE Tucson alternatives would include construction of new recharge basins, and there would be no purposeful recovery of recharged water.

4.3 Location of Advanced Treatment

Potential locations for advanced water treatment in the indirect potable reuse (IPR) application for Tucson Water include prior to recharge (pre-recharge) and after recovery (post-recovery). Factors that impact the location for treatment include public perception, energy consumption, and cost.

Pre-recharge treatment may reduce the perception of degrading the receiving groundwater, but the process is potentially more costly and energy intensive as the treatment facilities would have to be sized to accommodate the significant variations in unutilized recycled water. Examples of treatment prior to recharge include the Orange County, CA Groundwater Replenishment System and the West Basin Municipal Water District, CA facilities, which utilize microfiltration (MF), reverse osmosis (RO), and UV hydrogen peroxide advanced oxidation process (AOP) to purify recycled water prior to injection into the groundwater.

Post-recovery treatment provides the opportunity for soil aquifer treatment (SAT) as a natural process for removal or reduction of many contaminants. It also provides pre-treatment that benefits downstream advanced treatment steps, such as eliminating filtration prior to membrane treatment and reducing treatment residuals production. Post-recovery treatment has the potential to be less costly because of pre-treatment provided naturally by SAT, and because the aquifer serves as storage and buffers the large seasonal variations in unutilized recycled water

(i.e., the treatment facilities can be sized for a smaller and constant flow rate). Thus, it might be viewed as a more sustainable process. An example of post-recovery treatment is the Prairie Waters Project in Aurora, CO, which uses river bank filtration, softening, UV-AOP, granular media filtration, and GAC.

5 Evaluation of Advanced Treatment Process Options

This chapter summarizes the identification and evaluation of treatment process options for pre-recharge and post-recovery treatment locations for the recycled water program alternatives. The existing recycled water quality is reviewed and future water quality is projected based on planned changes in the regional water reclamation facilities and operations. Water quality goals are then established to provide a framework for identification of advanced treatment processes. Finally, the preferred advanced treatment processes are identified based on cost comparisons and a systematic application of decision criteria scoring and weighting. The preferred advanced treatment processes are then included in Chapter 6 in the evaluation of overall recycled water programs.

The identification and evaluation of advanced water treatment options were completed with input and review by 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). 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. NWRI specializes in working with researchers across the country, such as laboratories at universities and water agencies, and are guided by a Research Advisory Board (representing national expertise in water, wastewater, and water reuse) and a six-member Board of Directors (representing water and wastewater agencies in Southern California).

Through its research program, NWRI supports multi-disciplinary research projects with partners and collaborators that pertain to treatment and monitoring, water quality assessment, knowledge management, and exploratory research. NWRI also provides third-party expertise and scientific advice in reviewing projects or policies for local and state agencies through their Independent Advisory Panel Program.

The NRWI panel reviewed the work to identify recycled water program alternatives and helped to shortlist advanced treatment process options for detailed evaluations (NWRI, July 2011; NWRI, March 2012; NWRI, April 2013). The Panel evaluated topics related to: public health and safety; public outreach and advocacy; groundwater; advanced treatment technologies (such as use of advanced treatment technologies to reduce mineral content, attenuate contaminants of emerging concern, etc.); and, other topics related to IPR. The Panel members for this effort were selected to represent a broad range of disciplines and experience relevant to potable reuse (e.g., engineering, water reuse criteria, groundwater hydrology, chemistry, and risk assessment), and included the following:

- Panel Chair: Shane Snyder, Ph.D., University of Arizona (Tucson, AZ)
- Jörg E. Drewes, Dr.-Ing., Colorado School of Mines (Golden, CO)
- Ian Pepper, Ph.D., University of Arizona (Tucson, AZ)
- Anne Browning-Aiken, University of Arizona, Udall Center for Studies in Public Policy (Tucson, AZ)
- Michele Robertson, P.G., Montgomery & Associates (Scottsdale, AZ)
- Robert Hultquist, California Department of Public Health (El Cerrito, CA)
- Ron Wildermuth, West Basin Municipal Water District (Carson, CA)

5.1 Existing Recycled Water Quality

Current recycled water quality characteristics were developed using available data from Pima County Regional Wastewater Reclamation Department (PCRWRD) and Tucson Water. Secondary effluent water quality characteristics were determined for the existing Roger Road WRF and the Ina Road WRF. Water quality characteristics were also determined for the recovered water from the Sweetwater Underground Storage and Recovery (US&R) Facility and the RWS. Reclaimed water in the RWS is a blend of the Tucson Water Reclaimed Water Plant (RWP) tertiary filter effluent and recovered water from the Sweetwater US&R Facility extraction wells. Table 5-1 summarizes the 90th percentile concentrations of water quality parameters for secondary effluent from the Roger Road and Ina Road WRFs, recovered water from the Sweetwater US&R Facility extraction wells, and RWS reclaimed water based on data from 2005 to 2010.

Table 5-1. Summary of 90th Percentile Concentrations of Water Quality Parameters

	Ina Road WRF Secondary Effluent	Roger Road WRF Secondary Effluent	Sweetwater US&R Facility Extraction Wells	Reclaimed Water in RWS
Traditional Wastewater Parameters				
Ammonia, mg/L as N	33	26	NS	16
TKN, mg/L as N	43	30	<0.2	17
Nitrate, mg/L as N	8	5	11	6
Nitrite, mg/L as N	1	3	<0.1	2
Total Nitrogen, mg/L as N	44	33	NS	23
BOD, mg/L	22	14	NS	5
Total Phosphorus, mg/L as P	5	4	NS	NS
E. coli, MPN/100mL	NA	120	<1	<1
Total coliform, MPN/100mL	NA	2420	<1	7.5
Additional Parameters Important for Water Reuse				
pH	7	7	7	8
Alkalinity, mg/L as $CaCO_3$	302	237	265	238
Total Dissolved Solids, mg/L	647	721	724	750
TSS, mg/L	22	12	NS	3
Turbidity, NTU	3	12	2	4
Total Silica, mg/L	NS	18	26	21
Arsenic, µg/L	3	6	7	6
Major Cations and Anions				
Calcium, mg/L	61	66	90	85
Magnesium, mg/L	7	12	16	15
Sodium, mg/L	124	157	133	153
Potassium, mg/L	21	18	4	12
Barium, mg/L	59	0	0	0
Total Iron, mg/L	NS	0	NS	0
Manganese, mg/L	13	<0.02	NS	<0.02
Chloride, mg/L	140	153	119	147
Fluoride, mg/L	0.5	0.7	0.9	0.8
Sulfate, mg/L	131	159	166	160
DBPs and DBP Precursors				
Total THMs, µg/L	22	2	2	5
TOC, mg/L	14	18	1	10
Bromide, mg/L	NS	0.4	0.4	0.4

NS = Not Sampled, NA = Not Available during data collection period.

5.2 Projected Recycled Water Quality

The Regional Optimization Master Plan (ROMP) was developed by PCRWRD in conjunction with community partners, including the City of Tucson, the Town of Oro Valley, and others. ROMP outlines the long-term plan to meet new environmental regulatory requirements mandated by the Arizona Department of Environmental Quality (ADEQ). The new environmental regulations require PCRWRD to decrease the amount of nitrogen and ammonia in wastewater effluent discharged to the Santa Cruz River. The Ina Road WRF will be upgraded and expanded, while a new water reclamation facility will be constructed at the Water Reclamation Campus in the vicinity of the existing Roger Road WRF. The existing Roger Road WRF will be decommissioned after the Water Reclamation Campus is completed. The Ina Road WRF and Water Reclamation Campus will both include nitrification and dentrification treatment processes.

The new treatment facilities at the Ina Road WRF and Water Reclamation Campus will ultimately determine the future water quality for use in new recycled water programs. Current and projected recycled water quality for the Ina Road WRF and Water Reclamation Campus are shown on Figure 5-1. Projected water qualities were provided by the Compliance and Regulatory Affairs Office of PCRWRD. The projected concentrations for nitrogen, BOD, and TSS were estimated using removal efficiencies from existing Pima County facilities that utilize biological nitrogen removal (BNR) and actual influent concentrations from 2010. The projected concentration for phosphorus was estimated from the Ina Road WRF Capacity and Effluent Quality Upgrade Final Design Report (PCRWRD, January 2011).

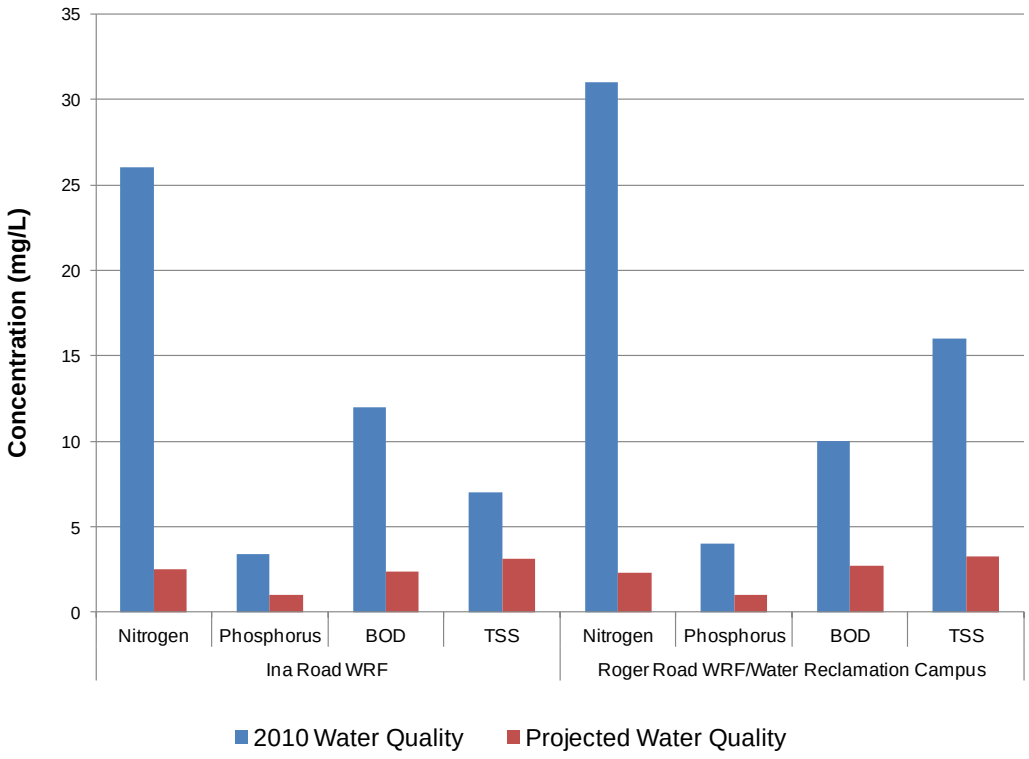

Figure 5-1. Current and Projected Recycled Water Quality

5.3 Emerging Contaminants

The presence of emerging contaminants in the recycled water used for IPR is important to the planning and evaluation of advanced treatment processes. Tucson Water and the County do not currently monitor for emerging contaminants in wastewater or recycled water. However, as part of its Microconstituent Sampling program, Tucson Water monitors for the presence of several pharmaceuticals, personal care products (PPCPs) and endocrine disrupting compounds (EDCs) in drinking water sources. Established in 2008, the program monitors for PPCPs and EDCs on an annual basis. The program water quality sampling locations are shown on Figure 5-2. Sampling is conducted at four wells near the Santa Cruz River, which may be influenced from the secondary treated effluent discharged to the river: W-001B, Y-001A, Y-004A, and Z-013A on Figure 5-2. Sampling is also conducted at three combined well field locations: EPDS 129 (CAVSARP), EPDS 124 (SAVSARP), and EPDS 125 (Santa Cruz Wellfield). The results of the Microconstituent Sampling program are presented in Table 5-2.

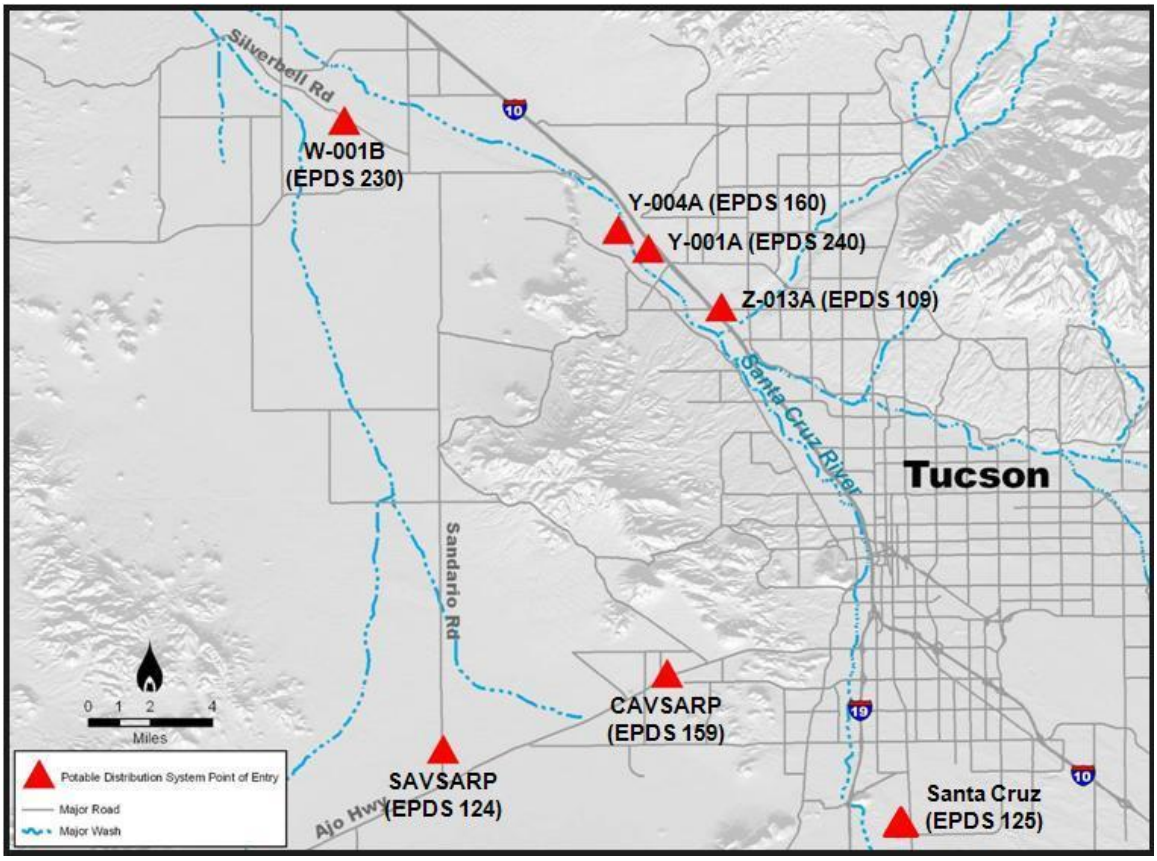

Figure 5-2. Tucson Water Microconstituent Sampling Program Locations

Table 5-2. Tucson Water Microconstituent Sampling Program Results

Sample Point	Detected Compound[1]	2010 Results (ng/L)	2009 Results (ng/L)	2008 Results[2] (ng/L)	2002 Results[2] (ng/L)
Well W-001B	Caffeine	3.3			
	Carbamazepine		11		
	PFOS	3.1	3.9		
Well Y-001A	Carbamazepine		11	79	47
	Dyhydronifedipine				0.5
	Fluoxetine		1.2		
	Iopromide			5.9	
	PFOS	38	42		
	PFOSA	79			
	PFOA	21			
	Sulfamethoxazole			8.1	11
	Triclosan			7.9	
Well Y-004A	Carbamazepine	75	65		
	PFOS	16	48		
	PFOSA	86			
	PFOA	20			
Well Z-013A	Carbamazepine	130	120		
	Ibuprofen	1.3			
	PFOS	27	65		
	PFOSA	120			
	PFOA	29			
	Sulfamethoxazole	1.6	1.4		
CAVSARP	PFOS	0.98	0.21		
SAVSARP		*No Constituents Detected*	*No Constituents Detected*		
Santa Cruz	PFOS	1.1			
	Sulfamethoxazole	2.9			

[1] *The analyte list for each year may not be the same and is subject to change based on results from the previous year.*
[2] *For 2008 and 2002, only Well Y-001A was monitored.*

5.4 Water Quality Goals for Indirect Potable Reuse

Advanced water treatment will apply only to recycled water program alternatives involving IPR. Water quality goals for advanced water treatment were developed for the point where recycled

water is introduced into the Clearwater blend produced by the CAVSARP and SAVSARP facilities. SAT provided during the recharge step is considered part of the advanced treatment trains. Water quality required for recycled water recharge will be provided by the County water reclamation facilities in compliance with State Aquifer Protection Permit (APP) requirements.

Table 5-3 presents the water quality parameters, rationale, and numeric goals for advanced water treatment that were developed from state and federal drinking water standards, quality of existing supplies, desired quality improvements for existing supplies, and from practices of other leaders in IPR (i.e., California). The water quality goals were also established with the assistance of the NWRI Independent Advisory Panel, which brought to bear the experiences and lessons learned from similar indirect potable reuse projects across the country and the world.

Table 5-3. Advanced Water Treatment Water Quality Goals

Parameter	Rationale	Numeric Goals
Particulate	Comply with federal/state drinking water standard	0.3 NTU (95%, 1 NTU max)
Total Organic Carbon (TOC)[1]	Comparable to Clearwater blend	~0.5 mg/L
Mineral content (hardness)	1. Partial stream treatment 2. Full flow treatment	1. ~250 mg/L 2. ~100 mg/L
Mineral content (TDS)	1. Partial stream treatment (meet CAP concentration) 2. Full flow treatment	1. ~650 mg/L 2. ~250 mg/L
Nutrients	Comply with federal/state drinking water standard (70% of MCLs)	Nitrate < 7 mg/L as N Nitrite < 0.7 mg/L as N
Viruses	California draft regulations (2011)[2]	12 log reduction value (LRV)
Cryptosporidium	California draft regulations (2011)	10 LRV
Total Coliform, Fecal Coliform, *E. coli*	Meet LT2[3] requirements	Non-detect
Giardia	California draft regulations (2011)	10 LRV
Contaminant Candidate List 3 Pathogens	Meeting LT2 requirements will comply with CCL3 Pathogens	
Microconstituents	Removal consistent with water treatment industry practice	
Nitrosamines	Potential 10 ng/L future standard	
Refractory Chemicals	Removal consistent with water treatment industry practice	

[1] *The concentration of TOC in the Clearwater blend may change over time, and the numeric goal for TOC may be adjusted in the future to be comparable to the Clearwater blend*
[2] *Draft Regulations for Groundwater Replenishment Reuse projects under Title 22 California Code of Regulations, Div. 4 Environmental Heath, Ch. 3 Recycling Criteria (CA Dept. of Public Health 11/21/2011)*
[3] *Long Term 2 Enhanced Surface Water Treatment Rule (LT2)*

According to the Groundwater Replenishment Reuse Draft Regulation (California Department of Public Health, November 2011), a Groundwater Replenishment Reuse Project (GRRP) must be designed and operated such that the recycled municipal wastewater used as recharge water be treated by at least three separate treatment processes. For each pathogen, a separate treatment process may be credited with no more than 6-log reduction and shall achieve at least 1-log reduction. A portion of the total required pathogen log reduction value may be achieved using SAT, including underground retention. For each month retained underground, the recycled municipal wastewater or recharge water will be credited with 1-log virus reduction. A GRRP meeting either the definition of filtered wastewater, or the definition of disinfected tertiary recycled water, or providing advanced treatment complying with the regulation, that also demonstrates at least six months retention underground, will be credited with 10-log Giardia cyst reduction and 10-log Cryptosporidium oocyst reduction (Title 22 California Code of Regulations, Div. 4 Environmental Health, Ch. 3 Recycling Criteria, Article 1 Definitions).

5.5 Advanced Water Treatment Technologies

Advanced water treatment processes can be employed to meet the water quality goals of a particular water reuse program by providing multiple barriers for pathogens and diverse barriers for trace organic contaminants. Several factors may impact the selection of a treatment technology, including source water quality, treatment goals, operational complexity, residuals management, operations and maintenance, and energy and chemical requirements. The following sections summarize key treatment processes for mainstream treatment and concentrate (brine) treatment. Table 5-4 provides an overview of the advanced water treatment technologies and the classes of contaminants removed.

5.5.1 Mainstream Treatment Technologies

Several key treatment processes for the purification of recycled water were considered:

- **Microfiltration (MF) and Ultrafiltration (UF)**: Pressure-driven membrane processes used to remove particulate matter, including turbidity and microorganisms. MF and UF are effective pre-treatment processes for reverse osmosis and nanofiltration.

- **Reverse Osmosis (RO) and Nanofiltration (NF)**: Pressure driven membrane processes in which hydraulic pressure in excess of a membrane's osmotic pressure is applied to push water through a dense membrane. Removal is not solely based on size exclusion, but also on diffusive and electrostatic properties. The key difference between NF and RO is that NF does not remove monovalent ions (i.e., sodium and chloride). RO usually requires higher operating pressures than NF.

- **Soil Aquifer Treatment (SAT)**: A natural treatment process in which the water to be treated is recharged in basins allowing water to percolate through the soil column where it undergoes physical, biological, and chemical transformation. The soil column acts as a natural filter, microorganisms break down the biodegradable organic matter, and there is additional purification through neutralization, oxidation, precipitation, and adsorption reactions. SAT is also effective for degradation of microconstituents. Ozonation can be employed prior to SAT to increase the dissolved oxygen concentration and break down organic carbon, which could improve biological reactions.

- **Granular Activated Carbon (GAC)**: GAC offers large available surface area via its porous pore structure which contaminants can diffuse into and adsorb onto. GAC is effective for removal of broad classes of microconstituents and also provides other water quality benefits, such as removing taste and odor compounds. GAC is often utilized after ozonation, which is called Biologically Activated Carbon (BAC).

- **Ultraviolet/Hydrogen Peroxide Advanced Oxidation Process (UV-AOP)**: UV photolysis of hydrogen peroxide generates hydroxyl radicals ($^{\bullet}OH$) that have an oxidation potential greater than other strong oxidants. Hydroxyl radicals are non-selective and have fast reaction rates with organic and inorganic species present in natural waters. UV-AOP is effective for disinfection and destruction of broad classes of microconstituents. GAC can also be used for hydrogen peroxide quenching after UV-AOP.

5.5.2 Concentrate Treatment Technologies

Several key treatment processes for concentrate treatment were considered:

- **Ozone**: Ozone is an unstable gas that is slightly soluble in water and is a very powerful oxidant. During ozonation, the two main oxidants ozone and hydroxyl radicals are formed during the decomposition of ozone. Ozone is very reactive with a number of common constituents, including natural organic matter (NOM). During concentrate treatment, ozone is an effective pre-treatment process for oxidation of TOC.

- **Biologically Activated Carbon (BAC)**: As mentioned in Section 5.5.1, GAC is often utilized after ozonation, which is called BAC. During concentrate treatment, BAC is an effective pre-treatment process for removal of particulates and TOC.

- **Ion Exchange (IX)**: Contaminant cations and anions can be removed from water using IX with resins or adsorption onto granular metal oxides/hydroxides. For concentrate treatment, IX is primarily used for the removal of nutrients and hardness.

- **Electrodialysis Reversal (EDR)**: Membrane process driven by electric potential in which ions are transferred through ion exchange membranes by means of a direct current voltage. EDR also has a low scaling potential and is more appropriate for concentrate treatment since EDR does not concentrate silica.

- **Granular Activated Carbon (GAC)**: As mentioned in Section 5.5.1, GAC is effective for removal of broad classes of microconstituents and also provides other water quality benefits through adsorption. During concentrate treatment, GAC is used to remove particulates, TOC, and microconstituents.

Table 5-4. Summary of Advanced Water Treatment Technologies

Advanced Treatment Process	Classes of Contaminants Removed	
	As a Primary Removal Mechanism	As a Secondary/ Potential Removal Mechanism
Main Stream Treatment Technologies		
MF/UF	Particulates	Pathogens, Viruses
RO/NF	Particulates, TOC, Mineral Content, Microconstituents	Nutrients, Pathogens, Viruses
SAT	TOC, Nutrients, Pathogens	Particulates, Microconstituents, Viruses
GAC	Particulates, TOC, Microconstituents	--
UV-AOP	Microconstituents, Pathogens, Viruses	--
Concentrate Treatment Technologies		
Ozone	--	TOC, Microconstituents, Pathogens, Viruses
BAC	Particulates, TOC	Pathogens, Viruses
IX	Nutrients, Mineral Content	--
EDR	--	Mineral Content
GAC	Particulates, TOC, Microconstituents	--

5.6 Selection of Advanced Water Treatment Processes

The project team identified advanced treatment processes for each category of recycled water program alternatives by holding workshops with several recycled water experts, including Dr. Shane Snyder (University of Arizona), Dr. Paul Westerhoff (Arizona State University), and Dr. Gary Amy (King Abdullah University of Science and Technology). These experts brought to bear not only the experiences of successful IPR programs across the county, but also the state-of-the-art in water treatment research. The workshops focused on emerging trends in treatment for IPR, including different perspectives for inland versus coastal IPR projects since concentrate management is more difficult for inland IPR projects. Several treatment train concepts and

strategies for concentrate management were also developed with input from the experts. Based on recent research and experience, several of the experts advocated post-recovery treatment for inland IPR projects due to the potential for flow equalization, lower costs, and lower energy requirements. Based on the results of the workshops, a long list of alternative advanced treatment process trains was narrowed down to a list of ten candidate treatment train alternatives. The treatment trains are presented in Table 5-5 and include pre-recharge, post-recovery, and concentrate treatment processes. All of the treatment train alternatives use chlorine disinfection prior to blending with the Clearwater blend.

Table 5-5. Summary of Treatment Train Alternatives

Alternative	Pre-Recharge Treatment	SAT	Post-Recovery Treatment	Concentrate Treatment
CAVSARP-1	MF, NF, UV-AOP	SAT	Disinfection	O_3, BAC, IX, EDR
CAVSARP-2	MF, RO, UV-AOP	SAT	Disinfection	O_3, BAC, IX, EDR
CAVSARP-3	MF, RO	SAT	Disinfection	O_3, BAC, IX, EDR
CAVSARP-4	MF, RO (partial), UV-AOP	SAT	Disinfection	O_3, BAC, IX, EDR
CAVSARP-5	MF, RO (partial), O_3	SAT	Disinfection	O_3, BAC, IX, EDR
North CAVSARP-1	MF, NF, UV-AOP	SAT	Disinfection	O_3, BAC, IX, EDR
North CAVSARP-2	MF, RO, UV-AOP	SAT	Disinfection	O_3, BAC, IX, EDR
North CAVSARP-3	-	SAT	RO, UV-AOP, GAC (for H_2O_2 quenching), Disinfection	EDR
North CAVSARP-4	O_3	SAT	RO, Disinfection	EDR, GAC
North CAVSARP-5	O_3	SAT	RO (partial), UV-AOP (partial), GAC (for H_2O_2 quenching), Disinfection	EDR, GAC

As indicated previously, recycled water from the CAVSARP category of alternatives would be recharged with CAP water in existing recharge basins at CAVSARP. Thus, all of the CAVSARP alternatives utilize pre-recharge advanced treatment of the recycled water. Post-recovery treatment would require treatment of recovered recycled water and CAP water, which would dramatically increase the required design capacity.

The CAVSARP-1 and 2 treatment trains closely follow the treatment approach used at the Orange County, CA Groundwater Replenishment System and the West Basin Municipal Water District, CA facilities. The CAVSARP-1, 2 and 3 treatment trains include full stream membrane treatment to provide maximum salinity control. The CAVSARP-4 and 5 treatment trains were included to assess partial stream membrane treatment to match the mineral content of the CAP surface water.

The North CAVSARP category of alternatives considers both pre-recharge and post-recovery treatment since they present the opportunity to isolate the recharge and recovery operations for recycled water. Pre-recharge treatment would be sized to accommodate the variations in unutilized recycled water, while post-recovery treatment could be sized to take advantage of the storage and buffering benefit of the aquifer.

5.7 Advanced Treatment Processes and Treatment Effectiveness

Process flow diagrams and treatment effectiveness tables were developed for each treatment train alternative to graphically illustrate the treatment components and the relative effectiveness of each component at removing classes of contaminants of concern. The graphical illustrations also show the potential multiple barriers to each class of contaminant.

Figure 5-3 presents the legend for the treatment effectiveness tables, which illustrate the redundant and diverse barrier treatment approach that could be used to meet water quality goals. The primary removal mechanism is indicated with a green dot, while a potential removal mechanism is indicated with a yellow dot. Partial removal is indicated with quarter, half, and three quarter full circles depending on removal effectiveness. No removal is indicated with an empty circle. Water quality parameters considered include particulates, TOC, nutrients, mineral content (hardness and TDS), microconstituents, pathogens, and viruses.

Figures 5-4 through 5-13 illustrate the treatment trains and treatment effectiveness tables for the advanced treatment train alternatives listed in Table 5-5. Figures 5-14 through 5-16 illustrate the treatment trains and treatment effectiveness tables for the concentrate treatment train alternatives listed in Table 5-5.

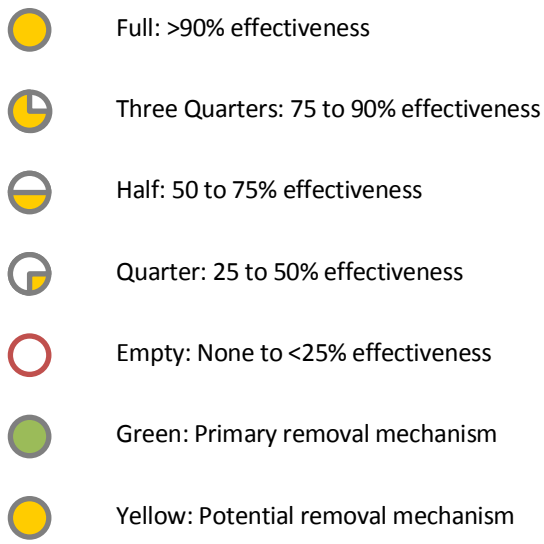

Figure 5-3. Legend for Treatment Effectiveness Diagrams

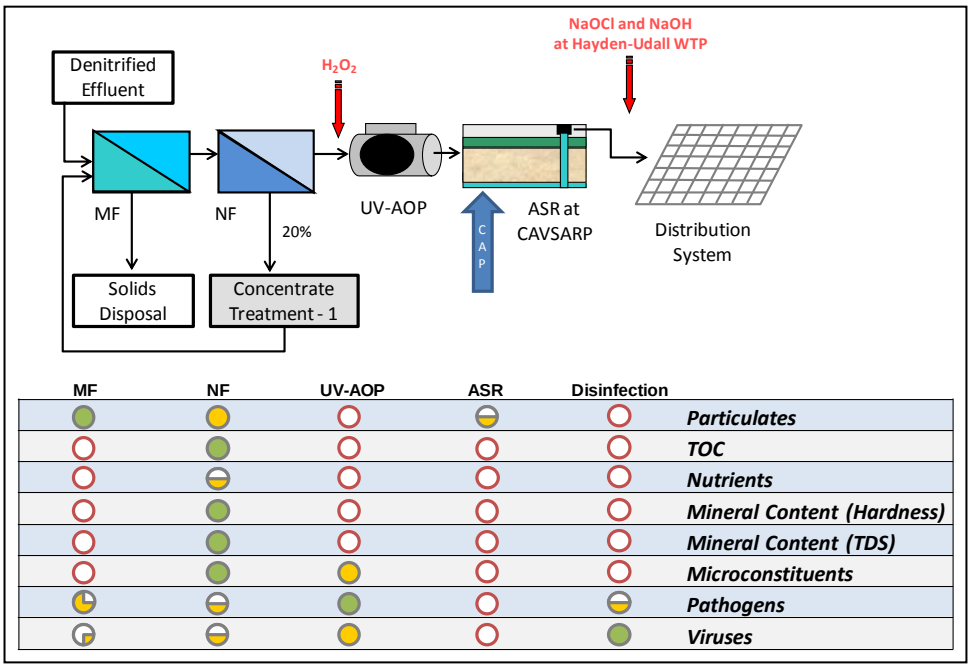

Figure 5-4. CAVSARP-1 Process Flow Diagram and Treatment Effectiveness Table

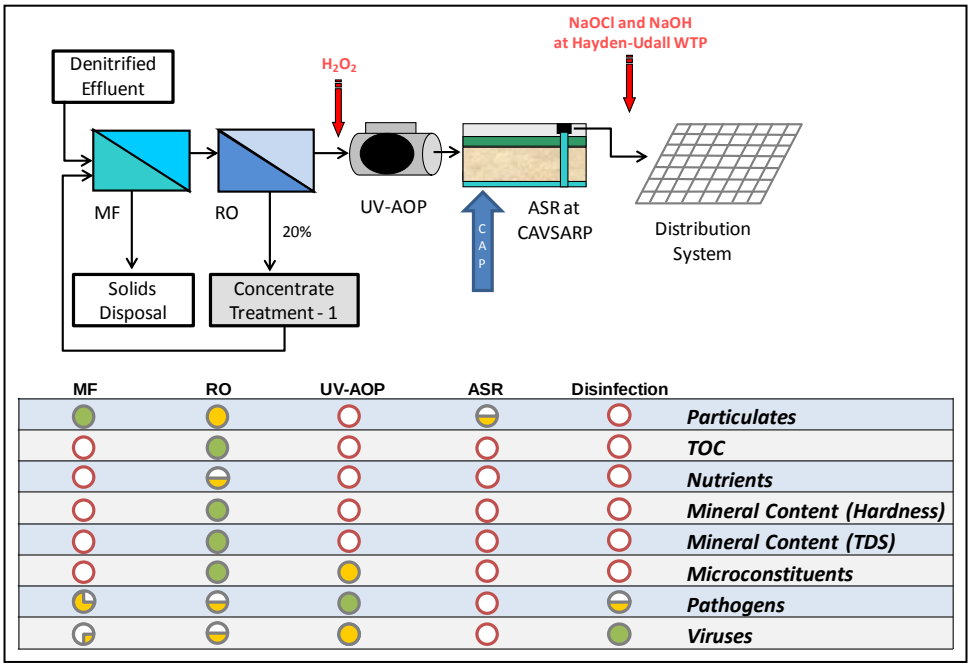

Figure 5-5. CAVSARP-2 Process Flow Diagram and Treatment Effectiveness Table

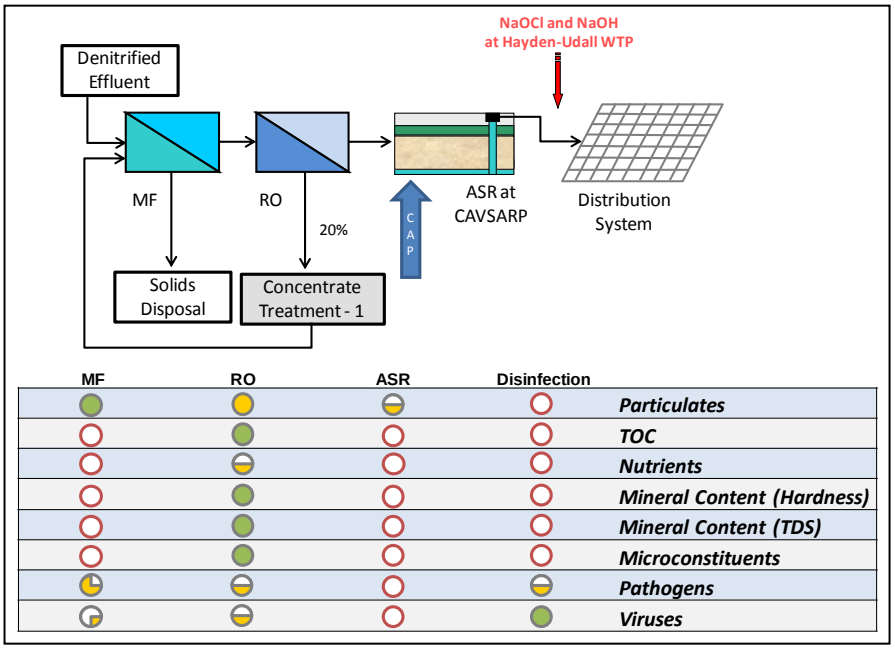

Figure 5-6. CAVSARP-3 Process Flow Diagram and Treatment Effectiveness Table

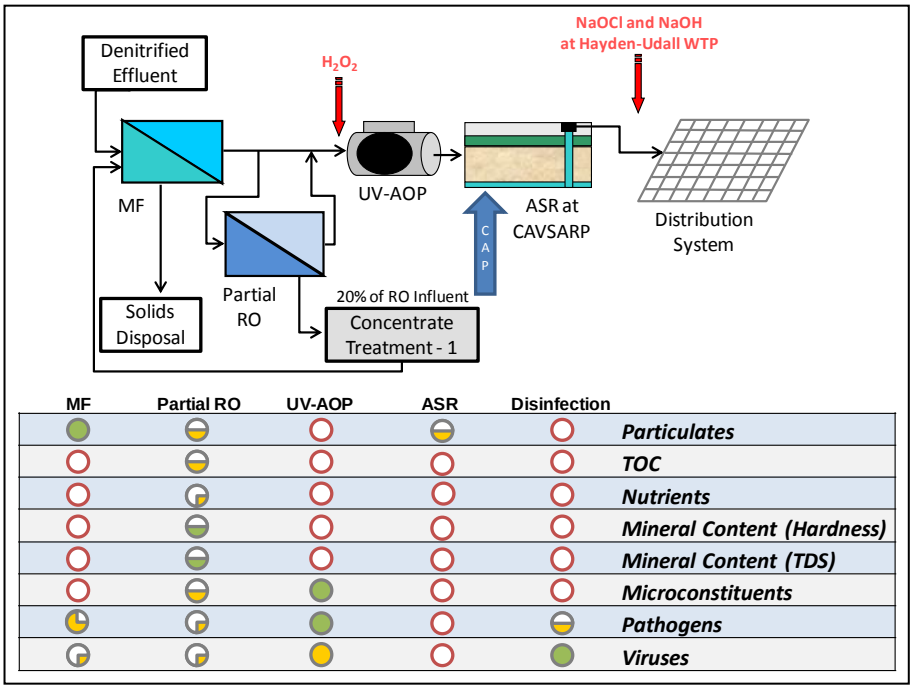

Figure 5-7. CAVSARP-4 Process Flow Diagram and Treatment Effectiveness Table

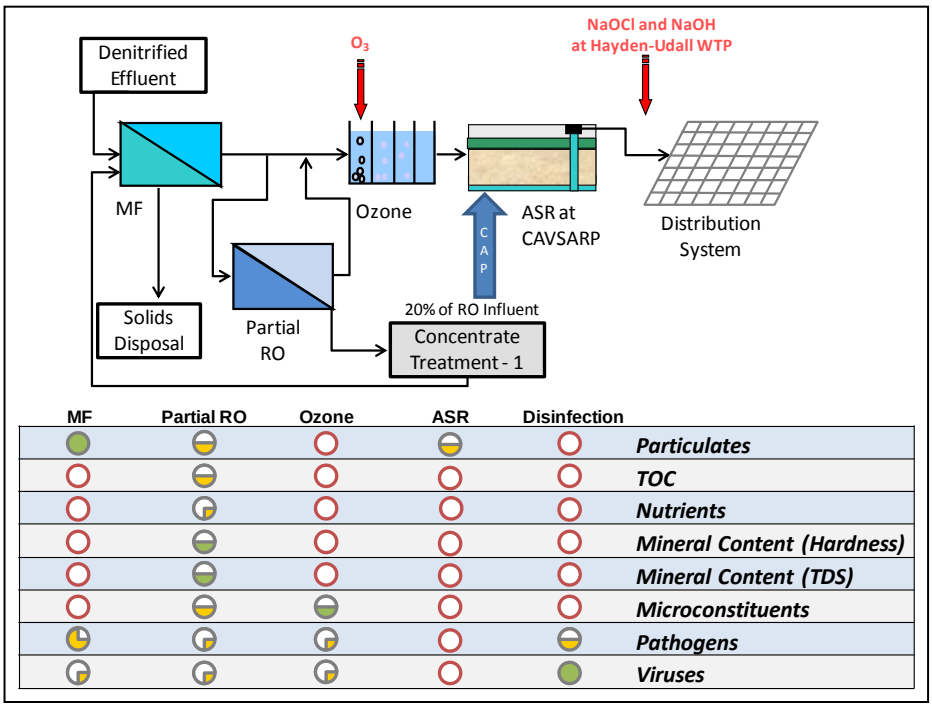

Figure 5-8. CAVSARP-5 Process Flow Diagram and Treatment Effectiveness Table

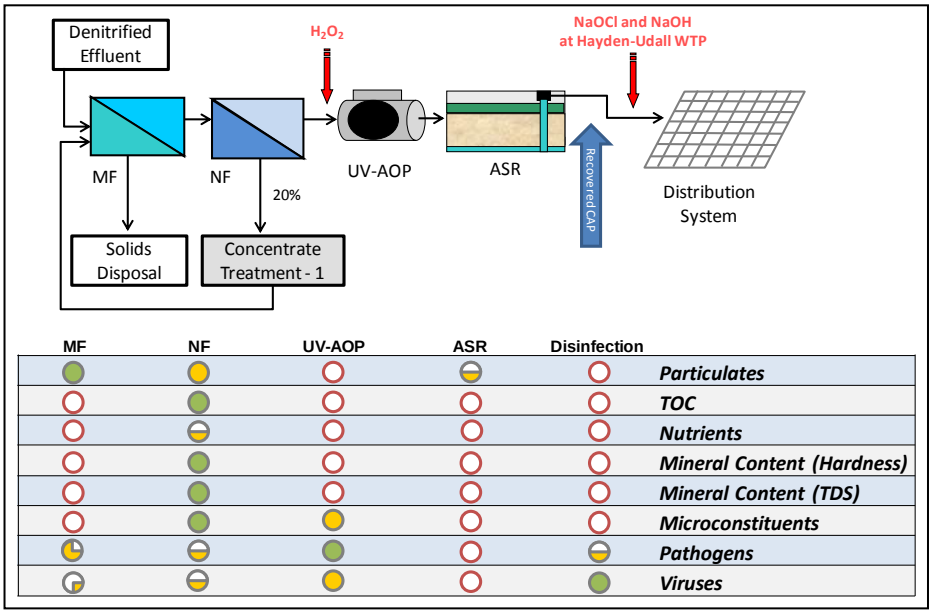

Figure 5-9. North CAVSARP-1 Process Flow Diagram and Treatment Effectiveness Table

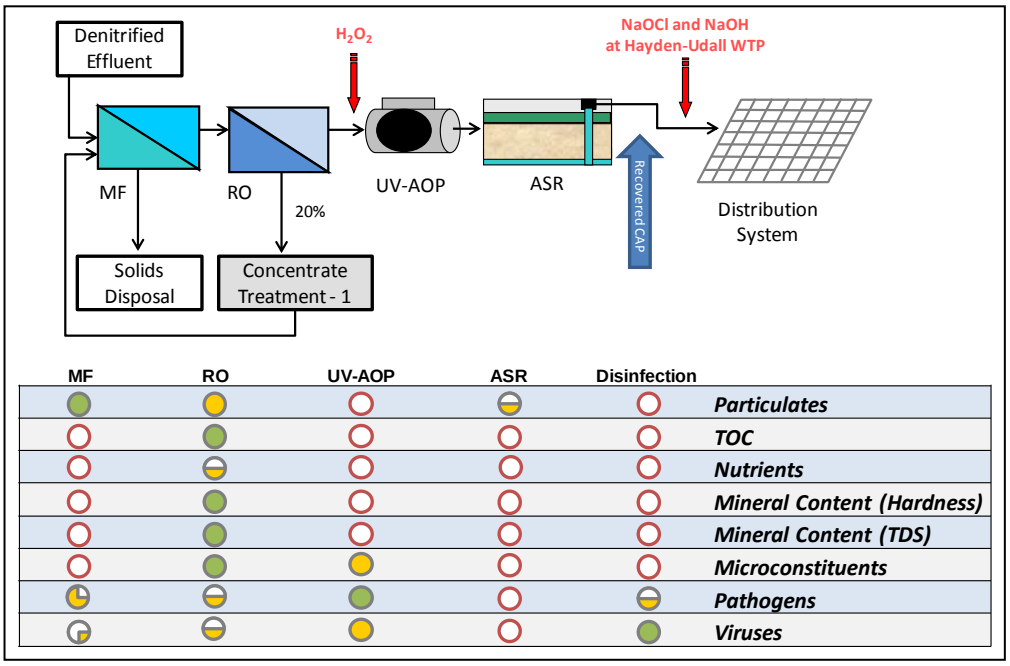

Figure 5-10. North CAVSARP-2 Process Flow Diagram and Treatment Effectiveness Table

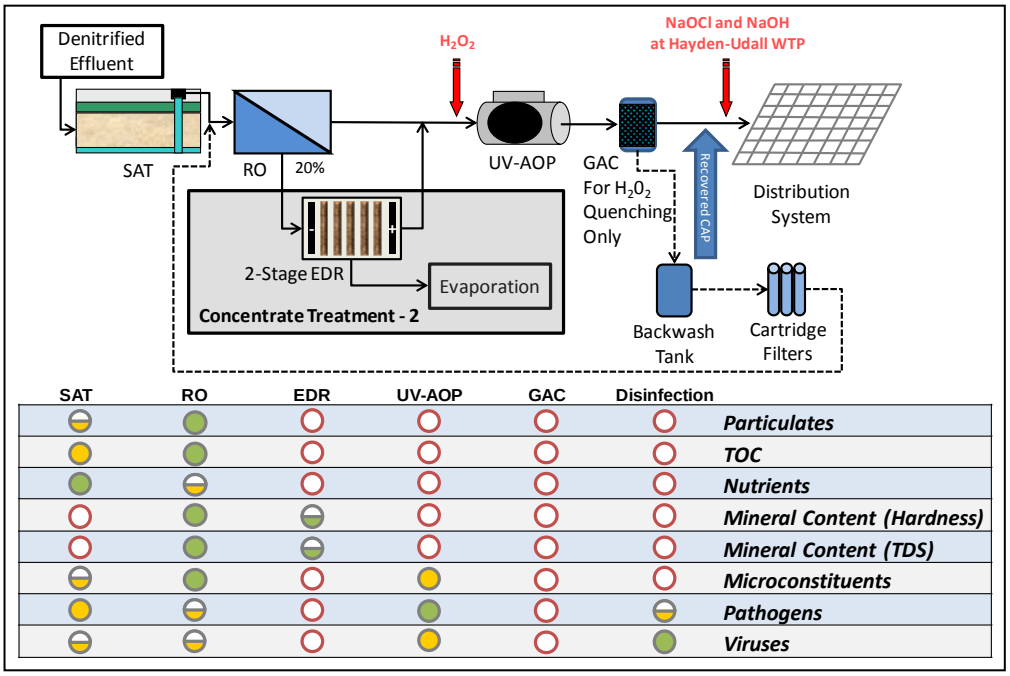

Figure 5-11. North CAVSARP-3 Process Flow Diagram and Treatment Effectiveness Table

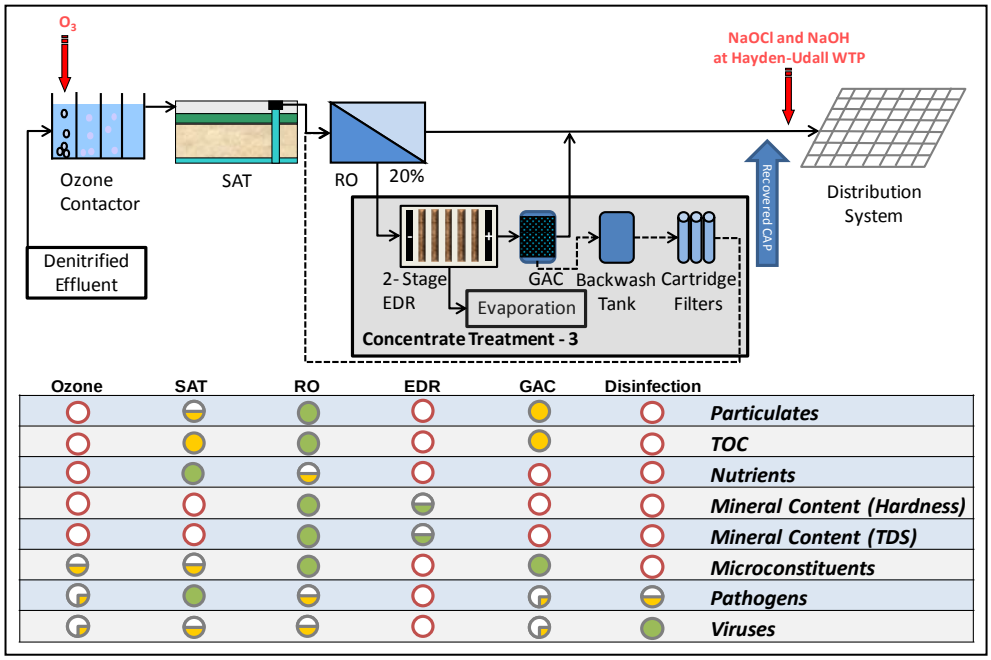

Figure 5-12. North CAVSARP-4 Process Flow Diagram and Treatment Effectiveness Table

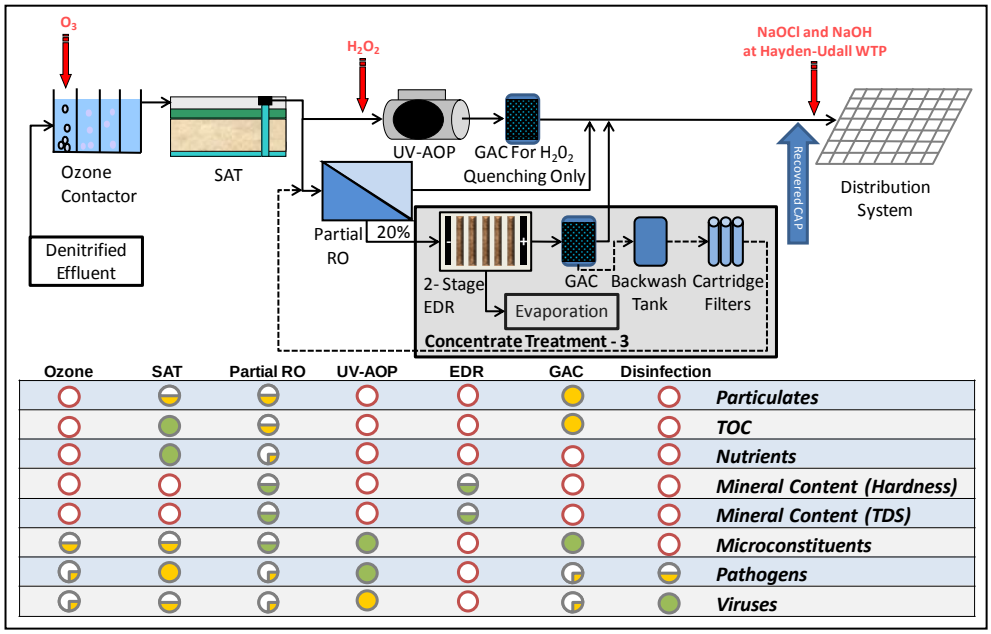

Figure 5-13. North CAVSARP-5 Process Flow Diagram and Treatment Effectiveness Table

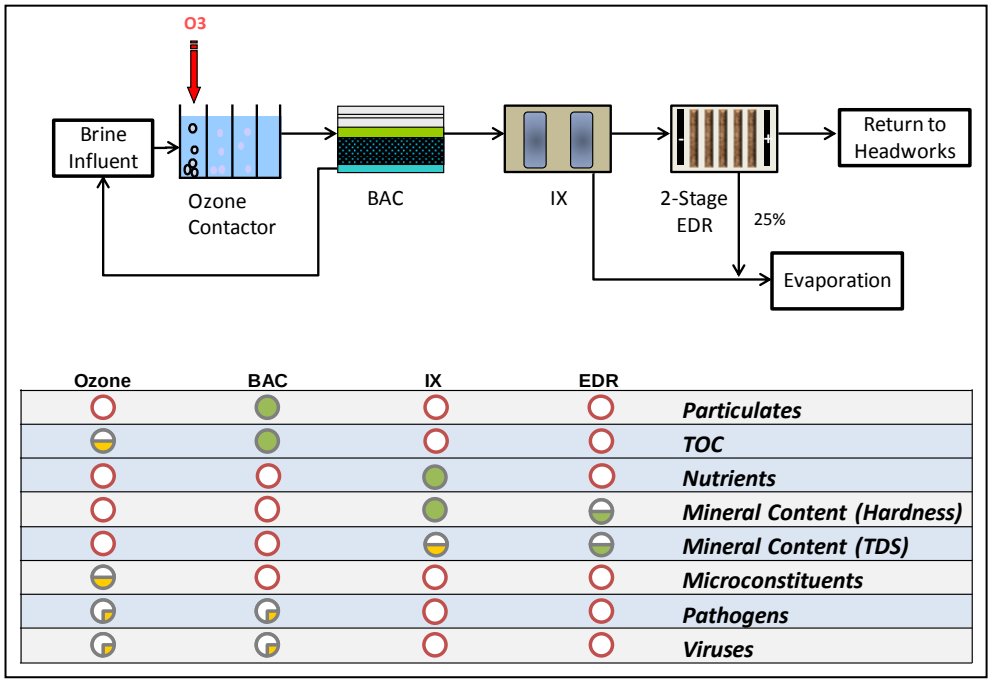

Figure 5-14. Concentrate Treatment-1 Process Flow Diagram and Treatment Effectiveness Table

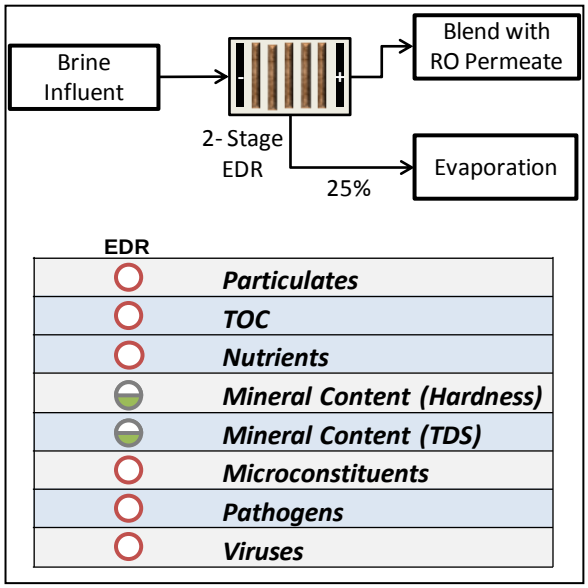

Figure 5-15. Concentrate Treatment-2 Process Flow Diagram and Treatment Effectiveness Table

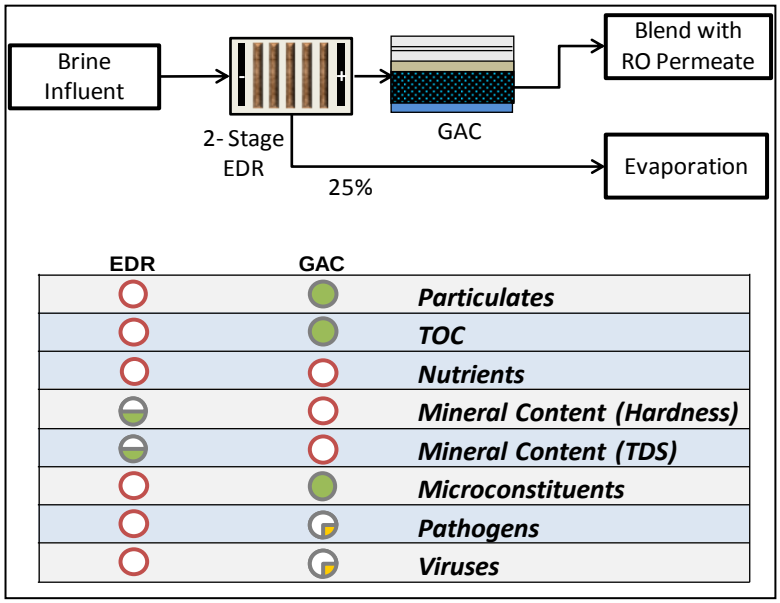

Figure 5-16. Concentrate Treatment-3 Process Flow Diagram and Treatment Effectiveness Table

5.8 Cost Evaluation of Treatment Process Alternatives

The treatment process trains identified in the previous section were defined in enough detail for development of conceptual costs. Conceptual design flows, based on the seasonal availability of unutilized recycled water described in Chapter 5 of the Recycled Water Master Plan, and conceptual advanced water treatment design criteria were used to size treatment component facilities and to estimate operational requirements. This information was then used to develop conceptual opinions of capital costs, annual operations and maintenance (O&M) costs, and total 20-year present worth for each treatment process train.

5.8.1 Conceptual Design Flows

Chapter 5 of the Recycled Water Master Plan provided projections of future unutilized Tucson Water recycled water based on the most recent wastewater flow projections, allocation of effluent entitlements, and projections of the seasonal usage of reclaimed water. A range of unutilized recycled water supplies were projected:

- A “High Range” based on the most recent regional wastewater flow projections and assuming that the Conservation Effluent Pool (CEP) allotment was not being utilized (the allotment would revert back to the contributing entities).
- 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 5-6 summarizes the analysis provided in the Recycled Water Master Plan.

Table 5-6. Summary of Unutilized Recycled Water Available for New Recycled Water Programs

Available	2020		2030		2050	
	Low Range	High Range	Low Range	High Range	Low Range	High Range
Minimum Month	0 AF (0 MGD)	732 AF (8 MGD)	88 AF (1 MGD)	1,310 AF (14 MGD)	416 AF (5 MGD)	1,860 AF (20 MGD)
Maximum Month	1,630 AF (19 MGD)	2,770 AF (32 MGD)	2,270 AF (26 MGD)	3,490 AF (41 MGD)	2,740 AF (32 MGD)	4,190 AF (49 MGD)
Annual Average	7,890 AF/YR (7 MGD)	21,600 AF/YR (19 MGD)	14,700 AF/YR (13 MGD)	29,300 AF/YR (26 MGD)	19,500 AF/YR (17 MGD)	36,900 AF/YR (33 MGD)

The information in Table 5-6 was used to develop concept design flows for sizing of advanced treatment component facilities. The pre-recharge alternatives would have to treat the peak recycled water availability and operate to accept the wide fluctuations throughout the year. The post-recovery alternatives could treat the annual average availability and operate at near constant flows throughout the year. Table 5-7 summarizes the concept design flows that were used to size treatment processes.

Table 5-7. Summary of Design Flows

Infrastructure	2020		2030		2050
	Low Range (MGD)	High Range (MGD)	Low Range (MGD)	High Range (MGD)	Low Range (MGD)
Pre-recharge Treatment Equipment	19	32	26	41	N/A
Post-recovery Treatment Equipment	7	19	13	26	N/A

5.8.2 Conceptual Design Criteria

Table 5-8 summarizes the conceptual design criteria that were utilized to size treatment component facilities and to estimate operational requirements for the treatment train alternatives.

Table 5-8. Design Criteria for Conceptual Cost Opinions for Treatment Train Alternatives

Microfiltration	Recovery	90%
Nanofiltration and Reverse Osmosis	Recovery	80%
UV-AOP	Target Contaminant (Photolysis)	NDMA
	Log Reduction of NDMA	1.2
	Target Contaminant (Oxidation)	1,4-dioxane
	Log Reduction of 1,4-dioxane	0.5
	Lamp Fouling Factor	0.9 to 1
	UVT	95%
	Peroxide dose	4 mg/L
Ozone	Target Ozone: TOC Ratio (mg O_3: mg TOC)	0.5
	Contact Time	10 minutes
Soil Aquifer Treatment	Infiltration Rate	1.5 ft/day
GAC (Hydrogen Peroxide Quenching)	Contactor Type	Pressure Contactors (ASME Rated)
	Contactor Configuration	Parallel
	Contactor Diameter	12 ft
	Carbon Type	Catalytic Coconut
	Empty Bed Contact Time	6 minutes
	Liquid Loading Rate	9 gpm/sf
	GAC Changeout Frequency	2 years
GAC (Adsorption)	Contactor Type	Pressure Contactors (ASME Rated)
	Contactor Configuration	Parallel
	Contactor Diameter	12 ft
	Carbon Type	Coconut Shell
	Empty Bed Contact Time	30 minutes
	Liquid Loading Rate	4 gpm/sf
	GAC Changeout Frequency	0.5 years
BAC	Contactor Type	Pressure Contactors (ASME Rated)
	Contactor Configuration	Series
	Contactor Diameter	12 ft
	Carbon Type	Coconut Shell
	Empty Bed Contact Time	20 minutes
	Liquid Loading Rate	4 gpm/sf
	GAC Changeout Frequency	4 years
Ion Exchange	Recovery	98%
Electrodialysis Reversal	Recovery / Stage	50%
	Salt Removal	75%
	Overall Water Recovery	75%
Evaporation Ponds	Pan Evaporation Rate	107 inches
	Average Precipitation	11.1 inches
Pipelines	Maximum Velocity	5 feet per second

5.8.3 Basis for Conceptual Cost Opinions

The conceptual cost opinions presented in this section are for the purposes of comparing treatment process trains and were conducted early in the project. All conceptual cost opinions presented are for January 2012 (20 Cities Average Engineering News Record Construction Cost Index = 9176). The level of accuracy for the cost opinions corresponds to Class 5 as defined by the Association for the Advancement of Cost Engineering (AACE) International. Class 5 estimates are generally prepared based on limited information and have a typical accuracy range of 30 percent to +50 percent. This level of cost estimating is typically done for project screening, feasibility studies, and concept evaluation. The cost opinions include 25 percent for engineering and administration and 30 percent for project contingencies. The present worth analyses are based on a term of 20 years and an interest rate of 6 percent.

Additional cost evaluations for recycled water program alternatives in Chapter 6 were completed after the treatment train evaluations and may have a different basis of cost as described above.

5.8.4 Conceptual Cost Opinions for Treatment Train Alternatives

Conceptual cost opinions for the treatment train alternatives were developed to provide relative comparison of treatment costs, and for use in a matrix evaluation of treatment train alternatives. To facilitate the comparisons, the conceptual cost opinions were based on the 2020 low range projection of unutilized recycled water in Table 5-6.

The detailed conceptual cost opinions for treatment train alternatives are presented in Attachment A to this technical memorandum and are summarized on Figures 5-17, 5-18 and 5-19 (capital costs, O&M costs, and total present worth, respectively). The figures illustrate that the post-recovery treatment trains, North CAVSARP-3, 4 and 5, have the lowest total present worth and are approximately 65 percent less than the pre-recharge treatment train alternatives. The alternatives with partial stream membrane treatment, CAVSARP-4 and 5, have the median total present worth. The alternatives with pre-recharge treatment and full flow membrane treatment, CAVSARP-1, 2, and 3 and North CAVSARP-1 and 2, had the highest total present worth.

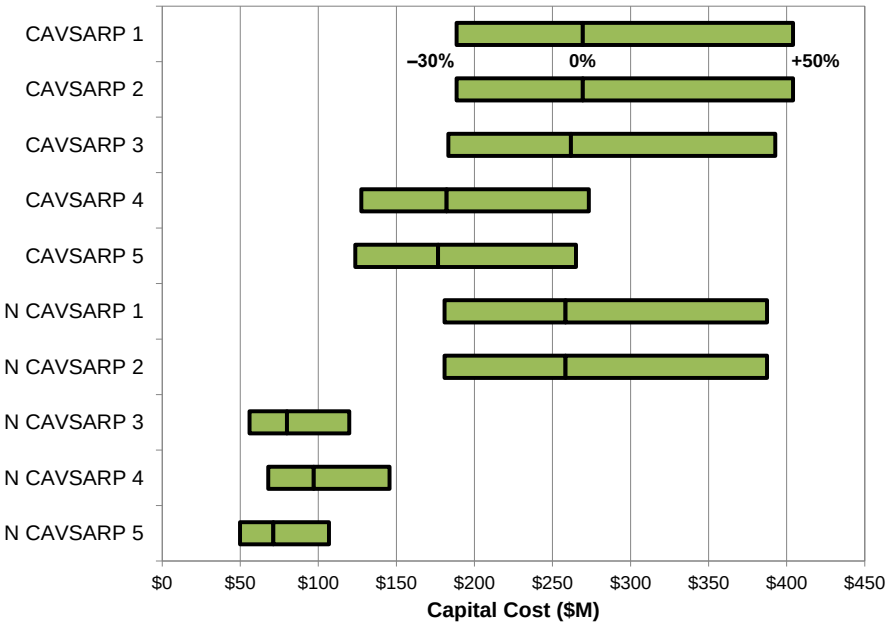

Figure 5-17. Conceptual Opinion of Capital Costs for Treatment Train Alternatives

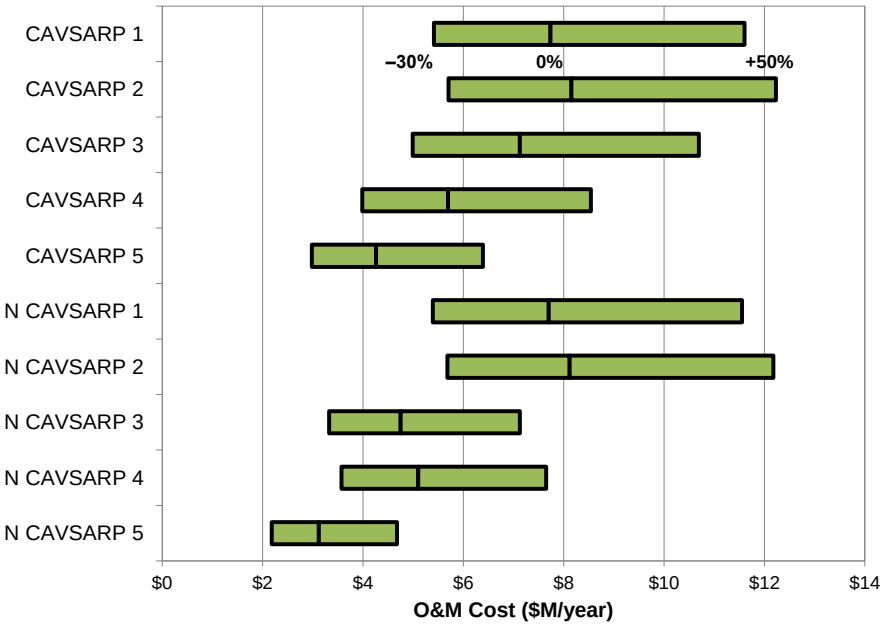

Figure 5-18. Conceptual Opinion of O&M Costs for Treatment Train Alternatives

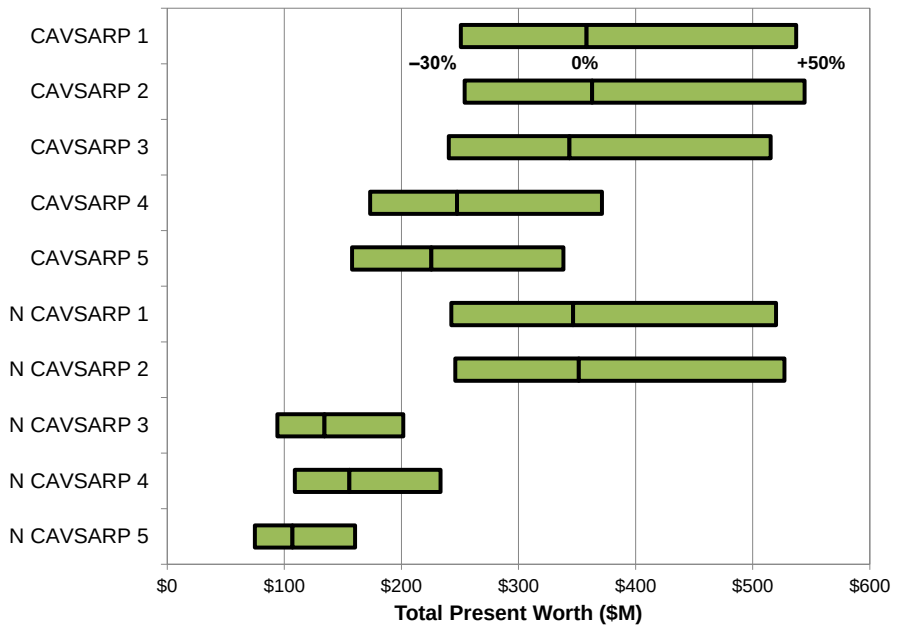

Figure 5-19. Conceptual Opinion of Total Present Worth for Treatment Train Alternatives

5.8.5 Matrix Evaluation of Treatment Train Alternatives

The treatment train alternatives were further analyzed using a matrix evaluation to identify the most preferred treatment train alternatives. The matrix evaluation was based on important criteria for decisions regarding a future Tucson Water recycled water program employing IPR. The evaluation was accomplished by a systematic scoring and weighting of the decision criteria for each of the treatment train alternatives. The process for the matrix evaluation included the following steps:

1. Define decision criteria
2. Prioritize and weight criteria
3. Score alternatives against each decision criteria
4. Perform alternatives scoring and ranking analysis
5. Select preferred treatment process trains

Step 1 – Define Decision Criteria

The decision criteria identified as most important to Tucson Water in selecting preferred treatment train alternatives are described below:

- **Public acceptance**: Perceived potential for positive or negative public sentiment due to water quality, neighborhood factors, and water rate impacts. Alternatives with the greatest potential for public acceptance are preferable.

- **Cost**: Relative capital costs, O&M costs and total present worth. Alternatives with lower costs are preferable.

- **Multiple barrier approach**: A robust approach to treatment that provides multiple treatment technologies that remove a wide range of constituents, ensuring water quality goals are met. Alternatives that utilize a multiple barrier approach to treatment are preferable.

- **Mineral content reduction**: Ability to address groundwater basin salinity issues or, at a minimum, to meet upper mineral content goals for the Clearwater Blend from Decision H_2O (650 mg/L TDS). Alternatives that address basin salinity issues are preferable.

- **Proven IPR process**: Treatment train utilized in successful IPR programs at other locations. Alternatives that utilize a proven IPR process are preferable.

- **Refractory chemicals**: Ability to remove or destroy challenging non-biodegradable refractory chemicals. Alternatives that perform better with respect to removal or destruction of refractory chemicals are preferable.

- **Microconstituent removal**: Treatment effectiveness in removing or destroying broad classes of compounds including pharmaceuticals and personal care products (PPCPs), endocrine-disrupting compounds (EDCs), industrial and agricultural compounds, etc. Alternatives that are more effective in removing microconstituents are preferable.

- **Energy usage**: Power requirements for treatment operations. Alternatives that use less energy are preferable.

- **Institutional and regulatory complexity**: Number and complexity of required agency approvals/permits and support, potential for regulatory scrutiny, and effects on agreements with regional stakeholders. Alternatives that are less susceptible to

regulatory and institutional challenges and require fewer and less complex permits or approvals are more preferable.

- **Operational complexity**: Complexity of facility operations and need for operator attention. Alternatives with fewer and less complex facilities to operate, requiring lower staffing requirements, are more preferable.

- **Utilization of existing infrastructure**: Ability to recharge and recover with existing infrastructure or through planned improvements already anticipated in the capital improvement program (CIP). Alternatives that maximize the use of existing infrastructure are more preferable.

- **Concentrate quantity**: Volume of membrane treatment process concentrate requiring additional treatment to maximize water recovery. Alternatives that generate the least amount of concentrate are preferable.

Step 2 – Prioritize and Weight Criteria

The next step of the matrix evaluation was to prioritize the decision criteria. The weighting, or assigning of relative importance between criteria, was conducted separately by the consultant team and Tucson Water staff members that are involved in the project. The weighting was accomplished by asking each team member to assign a weight to each criterion. Figure 5-20 illustrates the resulting decision criteria priorities, or weights, calculated by averaging the weights for each group. The consultant team provided weights prior to Tucson Water staff and only considered ten of the criteria. Tucson Water staff provided weights for an additional three criteria that they felt were also important to the decision. The highest weighted decision criteria were public perception and cost for both the consultant team and Tucson Water staff.

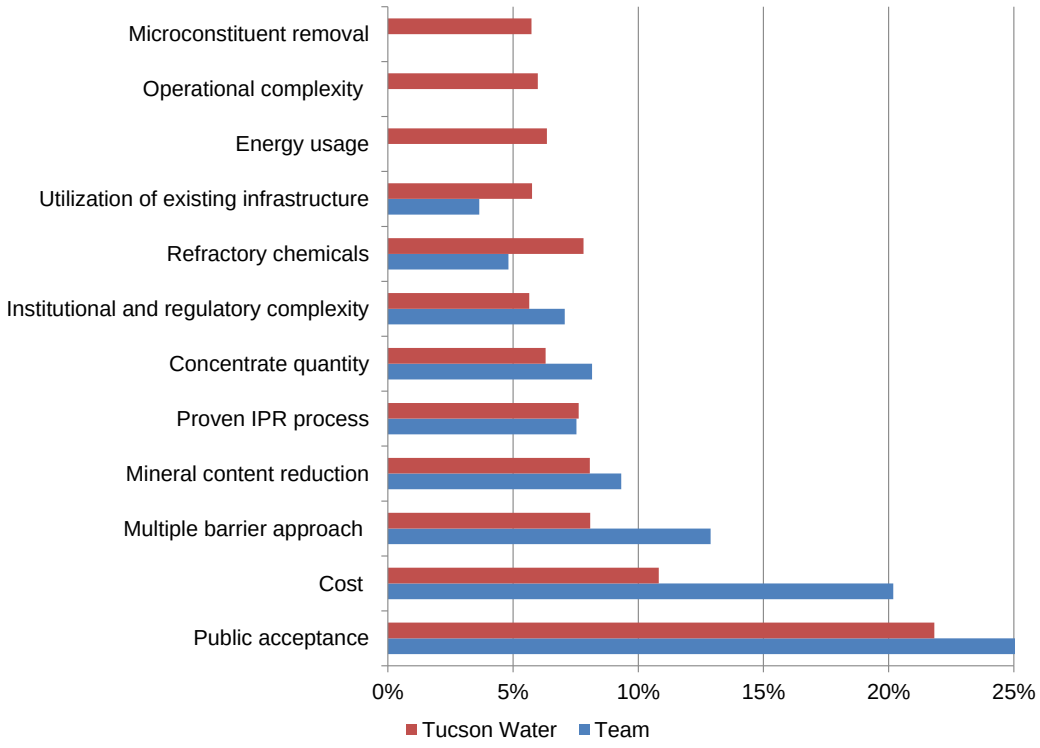

Figure 5-20. Results of Decision Criteria Priorities

Step 3 – Score Alternatives Against Each Decision Criteria

The next step of the matrix evaluation process was to score each alternative based on the alternatives' attributes under each criterion. Attachment B contains the attributes that were developed for each decision criteria and the scores assigned to each treatment train alternative based on the attributes. The consultant team and Tucson Water staff performed the scoring exercise separately. A scale of 1 to 10 was used for the scoring exercise with higher scores representing more preferred situations. Other than the cost criterion, the scoring was subjective. Therefore, it was possible that multiple alternatives could score the same under each criterion.

Step 4 – Perform Alternatives Scoring and Ranking Analysis

The next step of the matrix evaluation process was to determine the total weighted scores for the treatment train alternatives. This was accomplished by taking the sum of the criteria scores for each alternative presented in Attachment C and multiplying them by the weighted factors.

The total weighted scores for the alternatives were determined using the Criterium DecisionPlus software which is a useful tool for facilitating matrix evaluations. The Criterium DecisionPlus results from the scoring and ranking exercises are presented in Figure 5-21 and Figure 5-22 for the consultant team and Tucson Water staff, respectively. Table 5-9 provides a comparison of the scoring and ranking results.

Each team selected four treatment trains as part of their five top ranked alternatives: North CAVSARP -1, North CAVSARP-2, North CAVSARP-3 and North CAVSARP-4. The top ranking alternatives included both CAVSARP and North CAVSARP alternatives, but the majority of the top alternatives were North CAVSARP alternatives. The top five ranking alternatives include both pre-recharge and post-recovery treatment, but the majority of the alternatives were pre-recharge treatment. All top alternatives include full-stream treatment for TDS. Tucson Water's strong preference for North CAVSARP alternatives was based on recharging recycled water separately from CAP water. They felt that mixing recycled water and CAP water could result in issues related to public concerns, impacts on the facility APP permit, and potential impacts on agreements with other CAVSARP partners that utilize the facility.

The criteria scoring and ranking analysis resulted in the following key conclusions:

- There is a preference for full-stream reverse osmosis or nanofiltration treatment as they provide the most opportunity to begin addressing basin salinity issues.
- There is a strong preference for North CAVSARP over CAVSARP for the recharge location.
- There is a strong preference for pre-recharge treatment as opposed to post-recovery treatment, due primarily to potential public concerns with recharging recycled water without first further treating it.
- CAVSARP alternatives were less preferable because of mixing of CAP water and recycled water during recharge.

Step 5 – Select Preferred Treatment Trains for Further Analysis

Based on the results of the scoring and ranking analysis, four treatment train alternatives were identified as the most preferred: North CAVSARP-1 or 2 (depending on NF or RO), North CAVSARP-3, and North CAVSARP-4. The advantages and disadvantages of the four preferred treatment train alternatives are summarized in Table 5-10.

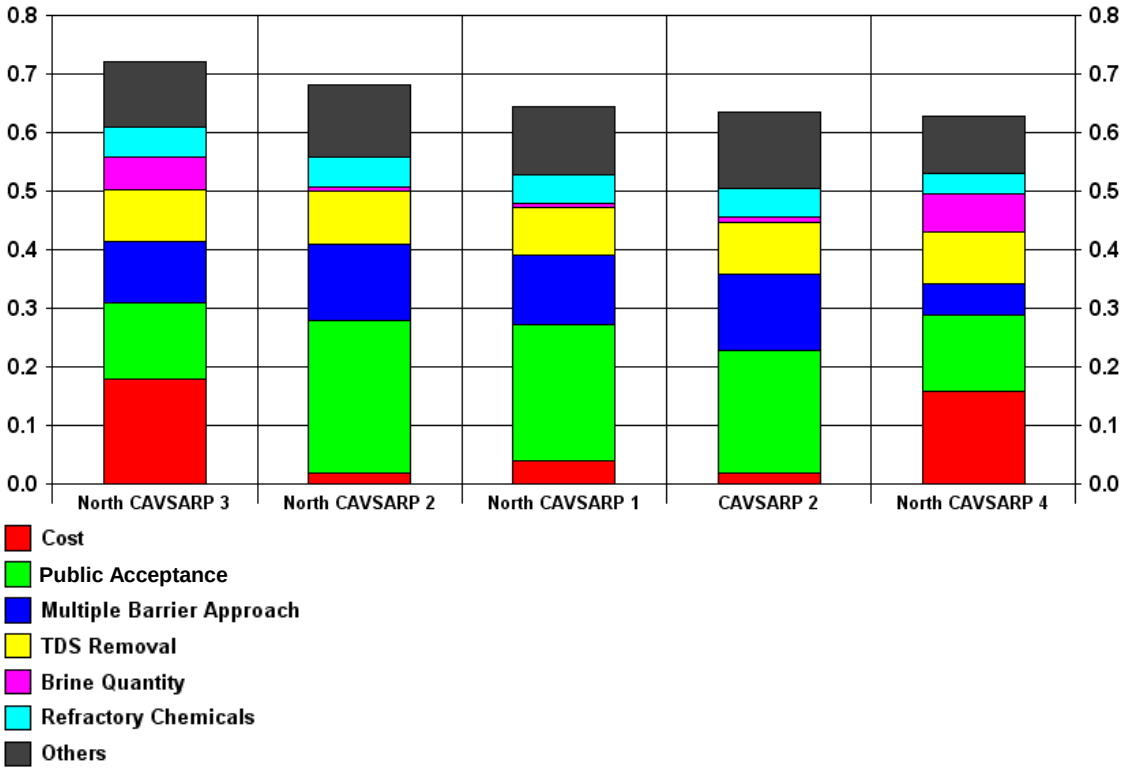

Figure 5-21. Scoring and Ranking Results for Consultant Team

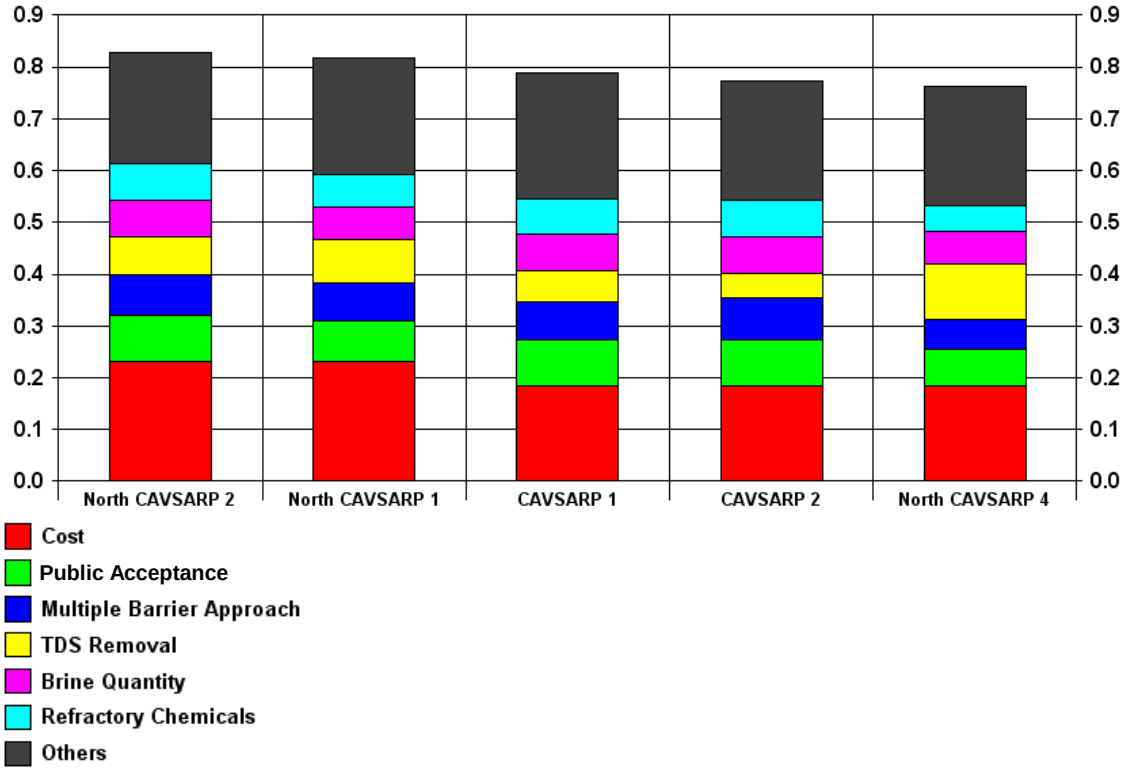

Figure 5-22. Scoring and Ranking Results for Tucson Water Staff

Table 5-9. Comparison of Scoring and Ranking Results

Team	Rank	Alternatives	North CAVSARP Recharge Location	Full Stream TDS Treatment	Pre-Recharge Treatment
Consultant	1	North CAVSARP-3	✓	✓	
Consultant	2	North CAVSARP-2	✓	✓	✓
Consultant	3	North CAVSARP-1	✓	✓	✓
Consultant	4	CAVSARP-2		✓	✓
Consultant	5	North CAVSARP-4	✓	✓	
Tucson Water	1	North CAVSARP-2	✓	✓	✓
Tucson Water	2	North CAVSARP-1	✓	✓	✓
Tucson Water	3	CAVSARP-1		✓	✓
Tucson Water	4	CAVSARP-2		✓	✓
Tucson Water	5	North CAVSARP-4	✓	✓	

Table 5-10. Comparison of Preferred Treatment Train Alternatives

Alternative	Advantages	Disadvantages
North CAVSARP-1	• High acceptance as similar process to Orange County. • Similar to proven gold standard in Orange County (NF vs. RO). • Exceeds TDS goals and improves salinity at CAVSARP.	• High cost alternative, second only to CAVSARP-2. • Less energy intensive than North CAVSARP-2 (Orange County Model) due to NF vs RO. • Highest production of treatment concentrate. • Microbial activity in SAT is not supported after MF/RO/AOP treatment; therefore, SAT will only provide pathogen and particulates removal.
North CAVSARP-2	• High acceptance as proven gold standard in Orange County. • Proven gold standard in Orange County. • Exceeds TDS goals and improves salinity at CAVSARP.	• Highest cost alternative. • Most energy intensive North CAVSARP alternative. • Highest production of treatment concentrate. • Microbial activity in SAT is not supported after MF/RO/AOP treatment; therefore, SAT will only provide pathogen and particulates removal.
North CAVSARP-3	• Utilizes post-recovery treatment to reduce treatment capacity requirements and significantly reduce cost. • Relies on a natural process (SAT) for constituent removal. • Lower production of brine due to post-recovery treatment.	• UV/AOP may result in byproduct formation (formaldehyde) in the treated water, which would be routed into the distribution system. • Potential for lower public acceptance due to complete reliance on post-recovery treatment.
North CAVSARP-4	• Utilizes post-recovery treatment to reduce treatment capacity requirements and significantly reduce cost. • Relies on a natural process (SAT) for constituent removal. • Lower production of brine due to post-recovery treatment.	• Potential for lower public acceptance due to complete reliance on post-recovery treatment.

The evaluation of treatment trains was presented to and discussed with the NWRI independent advisory panel. The panel was in general agreement with the matrix evaluation results and recommended that subsequent planning efforts should be conducted with the following changes to the selected treatment train alternatives (NWRI, May 2012):

North CAVSARP-1 and 2

- Use NF instead of RO for membrane treatment, because full-stream RO treatment in conjunction with SAT may not be required for salt control. In IPR projects, alternative membrane treatment systems can provide a similar level of public health protection as conventional RO membranes. Membranes also provide the ability for proactive salinity management that targets the sources of TDS while preserving groundwater supplies that exhibit lower TDS levels. NF has lower energy requirements than RO.

- Considering the NWRI panel's feedback on membrane treatment, North CAVSARP-2 is no longer a preferred treatment alternative.

North CAVSARP-3

- Use NF instead of RO for membrane treatment, because full-stream RO treatment after SAT may not be required for salt control.

- Return the concentrate from the 2-stage EDR to the head of the plant, upstream of NF, to avoid returning high concentrations of organic carbon and trace organic chemicals immediately upstream of the UV/AOP.

North CAVSARP-4

- Eliminate ozone prior to SAT. Using ozone prior to SAT may not be needed and is usually beneficial when retention times of SAT are short (days or hours vs. weeks).

- Use NF instead of RO for membrane treatment, because full-stream RO treatment after SAT may not be required for salt control.

- Return the flow from concentrate treatment (downstream of cartridge filters) to the head of the plant, upstream of NF. The concentrate stream will likely contain persistent (after SAT) and uncharged compounds, which could challenge the proposed treatment sequence.

The NWRI panel also provided comments on the concentrate treatment trains. There are challenges associated with all of the concentrate treatment trains that can be evaluated during pilot testing. No changes to the concentrate treatment trains were made. Based on input from the NWRI, treatment trains North CAVSARP-1, 3 and 4 will be further analyzed with overall recycled water program alternatives in Chapter 6.

6 Evaluation of Recycled Water Program Alternatives

The preferred treatment train alternatives (North CAVSARP-1, 3, and 4) were combined with the recycled water program components identified in Chapters 4 and 5 of this technical memorandum to develop overall recycled water program alternatives for additional evaluation. Facility and treatment concepts were refined and cost opinions were further developed. This stage of evaluation included a detailed review by recycled water treatment experts on the sizing and operational information for each advanced water treatment process. The basis for conceptual cost opinions is the same as discussed in Chapter 5 (Section 5.8.3); however, some of the conceptual unit costs were refined based on recent construction bid information and water industry cost guidance, such as the EPA 2003 Drinking Water Infrastructure Needs Survey. Finally, the alternative that does not include advanced water treatment (non-IPR alternative) was brought into the evaluations.

Based on the identification of recycled water program concepts and the evaluation of advanced treatment process alternatives, the recycled water program alternatives identified for evaluation include the following:

- North CAVSARP-1
- North CAVSARP-3
- North CAVSARP-4
- SE Tucson – No Advanced Water Treatment

6.1 Concept Design Flows and Design Criteria

The evaluation of overall recycled water program alternatives were based on the same concept design flows used for evaluation of the treatment train alternatives in Chapter 5 of this technical memorandum. Table 6-1 summarizes the concept design flows that were used to size overall recycled water program facility and treatment processes.

Table 6-1. Summary of Design Flows

Infrastructure	2020		2030		2050
	Low Range (MGD)	High Range (MGD)	Low Range (MGD)	High Range (MGD)	Low Range (MGD)
Pre-recharge Treatment Equipment	19	32	26	41	N/A
Post-recovery Treatment Equipment	7	19	13	26	N/A
Conveyance (Piping and Pump Stations)	N/A				32

Table 6-1 has an additional concept design flow for conveyance facilities. Permitting and construction for conveyance facilities from the metropolitan area to the CAVSARP or SE Tucson areas would be difficult and costly. It is prudent to oversize the conveyance so that future replacement and or new construction are avoided. Thus, the conveyance facilities were sized based on the 2050 maximum month, low range projection of 32 MGD.

The conceptual design criteria to size treatment process trains and operational requirements are summarized in Table 6-2. Attachment C includes additional details on the conceptual design criteria utilized in the development of conceptual cost opinions for recycled water program alternatives.

Table 6-2. Summary of Treatment and Facility Design Criteria for Recycled Water Programs

Microfiltration	Flux Rate	25 gfd
	Recovery	90%
	Operating Pressure	10-20 psi
	Nominal Pore Size	0.04 micron
Nanofiltration	Flux Rate	10.5 gfd
	Recovery	80%
	Vessel Diameter	8 inches
	Operating Pressure	125-200 psi
UV-AOP	Target Contaminant (Photolysis)	NDMA
	Log Reduction of NDMA	1.2
	Target Contaminant (Oxidation)	1,4-dioxane
	Log Reduction of 1,4-dioxane	0.5
	Lamp Fouling Factor	0.9 to 1
	UVT	95%
	Peroxide dose	4 mg/L
Ozone	Target Ozone: TOC Ratio (mg O_3: mg TOC)	0.5
	Contact Time	10 minutes
Soil Aquifer Treatment	Infiltration Rate	1.5 ft/day
GAC (Hydrogen Peroxide Quenching)	Contactor Type	Pressure Contactors (ASME Rated)
	Contactor Configuration	Parallel
	Contactor Diameter	12 ft
	Carbon Type	Catalytic Coconut
	Empty Bed Contact Time	6 minutes
	Liquid Loading Rate	9 gpm/sf
	GAC Changeout Frequency	2 years
GAC (Adsorption)	Contactor Type	Pressure Contactors (ASME Rated)
	Contactor Configuration	Parallel
	Contactor Diameter	12 ft
	Carbon Type	Coconut Shell
	Empty Bed Contact Time	30 minutes
	Liquid Loading Rate	4 gpm/sf
	GAC Changeout Frequency	0.5 years
BAC	Contactor Type	Pressure Contactors (ASME Rated)
	Contactor Configuration	Series
	Contactor Diameter	12 ft
	Carbon Type	Coconut Shell
	Empty Bed Contact Time	20 minutes
	Liquid Loading Rate	4 gpm/sf
	GAC Changeout Frequency	4 years
Ion Exchange	Recovery	98%
Electrodialysis Reversal	Recovery / Stage	50%
	Salt Removal	75%
	Overall Water Recovery	75%
Evaporation Ponds	Pan Evaporation Rate	107 inches
	Average Precipitation	11.1 inches
Pipelines	Maximum Velocity	5 feet per second

6.2 Facility Requirements for Recycled Water Program Alternatives

Facility concepts were also developed for the overall recycled water program components of each alternative. The conveyance route from the metropolitan area facilities to CAVSARP is approximately 25 miles with a total lift of 100 feet. Pumping is assumed to take place at the origin of the pipeline, which is assumed to be at the Water Reclamation Campus where Tucson Water is to receive its recycled water based on current agreements. The conveyance route for the SE Tucson alternative is approximately 35 miles long and would require three booster stations with a total lift of 1,200 feet. In addition to source water conveyance and AWT, additional transmission infrastructure is also required for the North CAVSARP alternatives to convey recovered water from North CAVSARP to the existing CAVSARP reservoir and booster pump station.

Table 6-3 summarizes the basis of facility sizing and facility requirements for each major component of the recycled water program alternatives.

Table 6-3. Summary of Recycled Water Program Alternative Facility Components

Component	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4		SE Tucson	
2020 Flow Basis	7 MGD (Average) and 19 MGD (Peak)							
2030 Flow Basis	13 MGD (Average) and 26 MGD (Peak)							
2050 Flow Basis	32 MGD (Peak) for sizing of recycled water conveyance facilities							
Recycled Water Source	Water Campus							
Recharge Location	North CAVSARP						SE Tucson	
Recycled Water Conveyance								
Pipeline	25 miles of 48-inch DIP Pipe						35 miles of 48-inch DIP Pipe	
Pumping	32 MGD Pump Station (100 ft TDH)						3-32 MGD Pump Stations (1,200 TDH)	
Advanced Treatment Location	Pre-Recharge		Post-Recovery		Post-Recovery		None	
Mainstream Treatment Train	MF + NF + UV-AOP + Recharge		Recharge/SAT + NF + UV-AOP + GAC for H_2O_2 quenching		Recharge/SAT + NF		None	
Mainstream Treatment Sizing								
Flow Basis (Year)	2020	2030	2020	2030	2020	2030	2020	2030
MF (MGD)	22.1	30.3						
NF (MGD)	17.7	24.2	6.6	12.2	6.6	12.2		
UV-AOP (MGD)	19	26	7	13	7	13		
GAG for H_2O_2 quenching (MGD)			7	13				
SAT Recharge Acreage (acres)	76	104	112	153	112	153	86	117
Concentrate Treatment Train	Ozone + BAC + IX +2-Stage EDR		2-Stage EDR		2-Stage EDR + GAC		None	
Concentrate Treatment Sizing								
Flow Basis (Year)	2020	2030	2020	2030	2020	2030	2020	2030
Ozone (MGD)	4	5.2						
BAC (MGD)	4	5.2						
GAC and Cartridge Filtration (MGD)					1.6	3.1		
IX (MGD)	4.4	6.1						
EDR (MGD)	4.3	5.9	1.6	3.1	1.6	3.1		
Solids Handling	2.5	3.4						
Evaporation Pond Acreage (acres)	273	373	109	204	109	204		
Recovered Water Transmission Piping	4 miles of 48-inch HDPE Pipe						None	

6.3 Conceptual Cost Opinions for Recycled Water Program Alternatives

Table 6-4 and Table 6-5 provide a summary of the conceptual capital and annual O&M cost opinions for the overall recycled water program alternatives, respectively. Attachment C provides the detailed cost evaluations.

In addition to the costs summarized in Tables 6-4 and 6-5, the CAVSARP and North CAVSARP alternatives could also include potentially related costs of a SAVSARP expansion for the CAP water that would be displaced by recharge of recycled water at the CAVSARP and North CAVSARP facilities. The need for a SAVSARP expansion is unknown at this time and will depend on the actual amounts of water recharged at CAVSARP due to actual participation of all facility partners, actual facility operational capabilities, etc., which will only be determined after the facilities have been operated for some time. Tables 6-4 and 6-5 do not include the potential related costs of a SAVSARP expansion, which are conceptually estimated at $27 million capital for 40 acres of new recharge basins (to recharge up to 10 MGD) and 3.9 miles of 60-inch pipeline from the CAP Canal turnout to the recharge basins. The potential additional costs also include an estimated $1.3 million in annual O&M to recharge an average of 7 MGD.

Table 6-4. Conceptual Capital Cost Opinions for Recycled Water Program Alternatives

Component	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4		SE Tucson	
Flow Basis (Year)	2020	2030	2020	2030	2020	2030	2020	2030
CAPITAL COSTS ($ million)								
Recycled Water Conveyance								
Pipeline	$98.4		$98.4		$98.4		$141	
Pumping	$10.9		$10.9		$10.9		$36.6	
Mainstream Treatment								
MF	$44.5	$61.0						
NF	$50.9	$69.0	$26.4	$47.7	$26.4	$47.7		
UV-AOP	$11.7	$16.0	$5.3	$9.9				
GAC (for H_2O_2 quenching)			$3.5	$5.3				
SAT Recharge	$6.1	$8.3	$9.0	$12.3	$9.0	$12.3	$13.0	$17.7
Concentrate Treatment								
Ozone	$12.5	$16.3						
BAC	$5.6	$6.9						
GAC and Cartridge Filtration					$4.2	$7.1		
IX	$10.8	$13.6						
EDR	$13.4	$18.7	$10.0	$21.2	$10.0	$21.2		
Solids Handling	$2.9	$3.9						
Evaporation Ponds	$61.2	$83.1	$25.7	$46.3	$25.7	$46.3		
Recovered Water Piping			$13.7		$13.7			
TOTAL CAPITAL	**$329**	**$406**	**$203**	**$266**	**$198**	**$256**	**$191**	**$196**

Table 6-5. Conceptual Annual O&M Cost Opinions for Recycled Water Program Alternatives

Component	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4		SE Tucson	
Flow Basis (Year)	2020	2030	2020	2030	2020	2030	2020	2030
ANNUAL O&M COSTS ($ million)								
Recycled Water Conveyance								
Piping and Pumping	$0.2	$0.3	$0.2	$0.3	$0.2	$0.3	$1.1	$1.1
Mainstream Treatment								
MF	$0.6	$1.1						
NF	$1.7	$3.1	$1.7	$3.1	$1.7	$3.1		
UV-AOP	$1.0	$1.5	$0.4	$0.8				
GAC (for H_2O_2 quenching)			$0.2	$0.3				
SAT Recharge	$0.02	$0.03	$0.03	$0.04	$0.03	$0.04	$0.04	$0.05
Concentrate Treatment								
Ozone	$0.3	$0.8						
BAC	$0.2	$0.2						
GAC and Cartridge Filtration					$0.7	$1.3		
IX	$0.7	$1.3						
EDR	$0.3	$0.7	$0.4	$0.7	$0.4	$0.7		
Solids Handling	$0.06	$0.08						
Evaporation Ponds	$1.6	$2.2	$0.5	$1.0	$0.5	$1.0		
Recovered Water Piping			$0.02		$0.02			
TOTAL ANNUAL O&M	**$6.7**	**$11.1**	**$3.4**	**$6.1**	**$3.6**	**$6.4**	**$1.1**	**$1.2**

The conceptual cost opinions of recycled water program alternatives provide the following key findings:

- The North CAVSARP-1 alternative with pre-recharge treatment and full flow membrane treatment has the highest estimated capital and O&M costs.
- The North CAVSARP-3 and 4 alternatives with post-recovery treatment have similar estimated capital and O&M costs.
- The costs for the SE Tucson alternative are substantially less than alternatives with advanced treatment. Although it would contribute to long-term storage credits, the SE

Tucson alternative would not provide water that ensures future water supply reliability for the Tucson community.

7 Conclusions and Recommendations

The work to identify and evaluate recycled water programs found that Tucson Water has significant unutilized recycled water supplies currently which will increase as future infill occurs within the Tucson Water committed service area. The unutilized recycled water could be put to beneficial use by replenishing the groundwater and, after additional advanced treatment, using it to supplement future drinking water supplies.

The evaluations found that recharge of reclaimed water with no additional treatment at a location that is distant from, or hydrologically separated from, Tucson Water's groundwater basins would have costs substantially less than IPR projects. However, this practice would not fulfill Tucson Water's goals and objectives for use of its valuable recycled water resource to assure future water reliability for the community.

The preferred recycled water program alternatives that include IPR are North CAVSARP-1, 3, and 4, for the following reasons:

- Inclusion of RO or NF is highly valuable to meet water quality goals for IPR, especially where groundwater basin salinity control is an important goal
- The North CAVSARP recharge location allows recycled water to be efficiently recharged separately from CAP water, allowing greater control in recharge, monitoring, and recovery of recycled water and minimizing permitting impacts to the existing CAVSARP CAP water recharge operations.
- From a cost and sustainability perspective, the North CAVSARP-3 and 4 alternatives (post-recovery advanced water treatment) are preferred. The smaller capacity treatment facilities and use of natural SAT treatment leads to lower overall cost and lower energy requirements.
- The North CAVSARP-1 alternative is still considered competitive and may offer certain benefit. As such, it should continue to be considered in follow-up studies.

Based on the evaluation of recycled water program alternatives, it is recommended that the three North CAVSARP alternatives be taken to the next stages of development of a Tucson Water recycled water program for indirect potable reuse. The preferred treatment process trains should be taken to demonstration-scale testing.

8 References

California Department of Public Health. *Title 22 California Code of Regulations, Div. 4 Environmental Health, Ch. 3 Recycling Criteria, Article 1 Definitions*.

National Water Research Institute. *Draft Final Report of the May 12-13, 2011, Meeting of the Independent Advisory Panel for the Tucson Water Recycled Water Master Plan*. July 2011.

National Water Research Institute. *Draft Final Report of the March 7-8, 2012, Meeting of the Independent Advisory Panel for the Tucson Water Recycled Water Master Plan*. May 2012.

National Water Research Institute. *Draft Final Report of the April 24, 2013, Meeting of the Independent Advisory Panel for the Tucson Water Recycled Water Master Plan*. April 2013.

Tucson Water. *Regional Effluent Utilization Plan Phase B*. Malcolm Pirnie, Inc. June 1995.

Tucson Water. *2008 Update to Water Plan 2000-2050*. 2008.

Tucson Water. *Water Plan: 2000-2050*. November 2004.

ATTACHMENT A

DESIGN CRITERIA AND COST ESTIMATES FOR THE TREATMENT TRAIN ALTERNATIVES

Recycled Water Master Plan
Treatment Train Summary

12/20/2013
FINAL

	CAVSARP 1	CAVSARP 2	CAVSARP 3	CAVSARP 4	CAVSARP 5	N CAVSARP 1	N CAVSARP 2	N CAVSARP 3	N CAVSARP 4	N CAVSARP 5
CAPITAL COST										
Reclaimed Transmission System (Pumping & Piping)										
Microfiltration	$ 65,923,000	$ 65,923,000	$ 65,923,000	$ 62,848,000	$ 62,848,000	$ 65,923,000	$ 65,923,000			
Nanofiltration	$ 73,122,000					$ 73,122,000				
Reverse Osmosis		$ 73,122,000	$ 73,122,000	$ 35,705,000	$ 35,705,000		$ 73,122,000	$ 30,799,000	$ 30,799,000	$ 14,332,000
Soil Aquifer Treatment						$ 4,898,000	$ 4,898,000	$ 6,903,000	$ 6,903,000	$ 6,903,000
CAP Recharge	$ 15,988,000	$ 15,988,000	$ 15,988,000	$ 15,988,000	$ 15,988,000					
UV-AOP	$ 7,616,000	$ 7,616,000		$ 14,351,000		$ 7,616,000	$ 7,616,000	$ 3,492,000		$ 6,953,000
Ozone					$ 14,095,000				$ 21,144,000	$ 21,144,000
GAC (includes Cartridge Filtration)								$ 3,474,000		$ 2,633,000
Concentrate Management	$ 102,032,000	$ 102,032,000	$ 102,032,000	$ 48,611,000	$ 43,325,000	$ 102,032,000	$ 102,032,000	$ 35,179,000	$ 38,227,000	$ 19,247,000
Ozone	$ 17,621,000	$ 17,621,000	$ 17,621,000	$ 12,335,000	$ 7,049,000	$ 17,621,000	$ 17,621,000			
BAC	$ 5,528,000	$ 5,528,000	$ 5,528,000	$ 3,048,000	$ 3,048,000	$ 5,528,000	$ 5,528,000			
GAC and Cartridge Filtration									$ 3,048,000	$ 2,221,000
IX	$ 5,801,000	$ 5,801,000	$ 5,801,000	$ 2,626,000	$ 2,626,000	$ 5,801,000	$ 5,801,000			
EDR	$ 12,682,000	$ 12,682,000	$ 12,682,000	$ 7,800,000	$ 7,800,000	$ 12,682,000	$ 12,682,000	$ 9,990,000	$ 9,990,000	$ 4,487,000
Evaporation Ponds	$ 60,400,000	$ 60,400,000	$ 60,400,000	$ 22,802,000	$ 22,802,000	$ 60,400,000	$ 60,400,000	$ 25,189,000	$ 25,189,000	$ 12,539,000
Solids Handling	$ 4,710,000	$ 4,710,000	$ 4,710,000	$ 4,710,000	$ 4,710,000	$ 4,710,000	$ 4,710,000	$ -	$ -	$ -
Lamella Settlers	$ 2,175,000	$ 2,175,000	$ 2,175,000	$ 2,175,000	$ 2,175,000	$ 2,175,000	$ 2,175,000			
Centrifuge	$ 2,535,000	$ 2,535,000	$ 2,535,000	$ 2,535,000	$ 2,535,000	$ 2,535,000	$ 2,535,000			
Recovery Wells	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Recycled Water Transmission System (Pu	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress
TOTAL CAPITAL COST	$ 269,391,000	$ 269,391,000	$ 261,775,000	$ 182,213,000	$ 176,671,000	$ 258,301,000	$ 258,301,000	$ 79,847,000	$ 97,073,000	$ 71,212,000
O&M COST										
Transmission System (Pumping & Piping)										
Microfiltration	$ 926,000	$ 926,000	$ 926,000	$ 890,000	$ 890,000	$ 926,000	$ 926,000			
Nanofiltration	$ 2,328,000					$ 2,328,000				
Reverse Osmosis		$ 2,744,000	$ 2,744,000	$ 1,400,000	$ 1,400,000		$ 2,744,000	$ 3,346,000	$ 3,346,000	$ 1,489,000
Soil Aquifer Treatment						$ 15,000	$ 15,000	$ 21,000	$ 21,000	$ 21,000
Soil Aquifer Treatment	$ 48,000	$ 48,000	$ 48,000	$ 48,000	$ 48,000					
UV-AOP	$ 1,024,000	$ 1,024,000		$ 1,745,000		$ 1,024,000	$ 1,024,000	$ 410,000		$ 378,000
Ozone					$ 341,000				$ 468,000	$ 468,000
GAC (includes Cartridge Filtration)								$ 151,100		$ 99,100
Concentrate Management	$ 3,206,700	$ 3,206,700	$ 3,206,700	$ 1,408,300	$ 1,377,300	$ 3,206,700	$ 3,206,700	$ 815,000	$ 1,258,100	$ 655,100
Ozone	$ 341,000	$ 341,000	$ 341,000	$ 202,000	$ 171,000	$ 341,000	$ 341,000			
BAC	$ 152,700	$ 152,700	$ 152,700	$ 72,300	$ 72,300	$ 152,700	$ 152,700			
GAC and Cartridge Filtration									$ 443,100	$ 231,100
IX	$ 831,000	$ 831,000	$ 831,000	$ 535,000	$ 535,000	$ 831,000	$ 831,000			
EDR	$ 289,000	$ 289,000	$ 289,000	$ 119,000	$ 119,000	$ 289,000	$ 289,000	$ 280,000	$ 280,000	$ 167,000
Evaporation Ponds	$ 1,593,000	$ 1,593,000	$ 1,593,000	$ 480,000	$ 480,000	$ 1,593,000	$ 1,593,000	$ 535,000	$ 535,000	$ 257,000
Solids Handling	$ 195,000	$ 195,000	$ 195,000	$ 195,000	$ 195,000	$ 195,000	$ 195,000	$ -	$ -	$ -
Lamella Settlers	$ 43,000	$ 43,000	$ 43,000	$ 43,000	$ 43,000	$ 43,000	$ 43,000			
Centrifuge	$ 152,000	$ 152,000	$ 152,000	$ 152,000	$ 152,000	$ 152,000	$ 152,000			
Recovery Wells	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$ 9,000
Recycled Water Transmission System (Pu	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress	In Progress
TOTAL O&M COST	$ 7,736,700	$ 8,152,700	$ 7,128,700	$ 5,695,300	$ 4,260,300	$ 7,703,700	$ 8,119,700	$ 4,752,100	$ 5,102,100	$ 3,119,200

ATTACHMENT B

CRITERIUM DECISION PLUS ATTRIBUTES AND SCORING RESULTS

Rank	Criteria	Consultant Team Weight	Tucson Water Weight	CAVSARP-1	CAVSARP-2	CAVSARP-3	CAVSARP-4	CAVSARP-5
1	Public Acceptance	24	22	High acceptance as simliar process to Orange County.	High acceptance as proven gold standard in Orange County.	Demonstrated technology at Scottsdale Water Campus.	Lower public acceptance due to partial stream RO.	Lower public acceptance due to partial stream RO and ozone instead of UV-AOP.
2	Cost	19	11	High cost alternative, second only to CAVSARP-2.	Highest cost alternative.	Less costly than Orange County model.	Less costly than Orange County model.	Lowest cost CAVSARP alternative.
3	Multiple Barrier Approach	12	8	Provides most complete multi-barrier approach. Removes and destroys constituents prior to recharge.	Provides most complete multi-barrier approach. Removes and destroys constituents prior to recharge.	Removes constituents prior to recharge.	Removes constituents prior to recharge.	Relies on natural process (SAT) as a primary barrier.
4	TDS Removal	9	8	Exceeds TDS goals and improves salinity at CAVSARP.	Exceeds TDS goals and improves salinity at CAVSARP.	Exceeds TDS goals and improves salinity at CAVSARP.	Provides flexibility in meeting TDS goals and allows CAVSARP salinity to remain (non-degradation).	Provides flexibility in meeting TDS goals and allows CAVSARP salinity to remain (non-degradation).
5	Proven IPR Process	7	8	Similar to proven gold standard in Orange County (NF vs. RO).	Proven gold standard in Orange County.	Demonstrated technology at Scottsdale Water Campus.	Proven treatment technologies in conjunction with SAT.	Proven treatment technologies in conjunction with SAT.
6	Refractory Chemicals	4	8	UV-AOP provides barrier for refractory chemicals.	UV-AOP provides barrier for refractory chemicals.	No barrier for refractory chemicals.	UV-AOP provides barrier for refractory chemicals.	No barrier for refractory chemicals.
7	Microconstituent Removal	0	6	Provides the most barriers for microconstiuents (NF, UV-AOP, SAT).	Provides the most barriers for microconstiuents (RO, UV-AOP, SAT).	Multiple barriers for microconstiuents (RO, SAT).	Multiple barriers for microconstiuents (UV-AOP, SAT).	Single barrier for microconstiuents (SAT).
8	Energy Usage	0	6	Less energy intensive than CAVSARP-2 (Orange County Model) due to NF vs RO.	Most energy intensive CAVSARP alternative.	Less energy intensive than Orange County Model.	Less energy intensive than Orange County Model.	Least energy intensive CAVSARP alternative.
9	Institutional and Regulatory Complexity	7	6	Potentially requires an APP for CAVSARP	Potentially requires an APP for CAVSARP	Potentially requires an APP for CAVSARP	Potentially requires an APP for CAVSARP	Potentially requires an APP for CAVSARP
10	Operational Complexity	0	6	Utilizes several different unit processes.	Utilizes several different unit processes.	Utilizes the least number of unit processes.	Utilizes several different unit processes.	Operationally more complex due to ozone.
11	Utilization of Existing Infrastructure	3	6	Uses existing CAVSARP basins and plans already exist for expansion of SAVSARP.	Uses existing CAVSARP basins and plans already exist for expansion of SAVSARP.	Uses existing CAVSARP basins and plans already exist for expansion of SAVSARP.	Uses existing CAVSARP basins and plans already exist for expansion of SAVSARP.	Uses existing CAVSARP basins and plans already exist for expansion of SAVSARP.
12	Brine Quantity	8	6	Highest production of brine.	Highest production of brine.	Highest production of brine.	Lower production of brine due to partial stream RO.	Lower production of brine due to partial stream RO.

Rank	Criteria	Consultant Team Weight	Tucson Water Weight	North CAVSARP-1	North CAVSARP-2	North CAVSARP-3	North CAVSARP-4	North CAVSARP-5
1	Public Acceptance	24	22	High acceptance as simliar process to Orange County.	High acceptance as proven gold standard in Orange County.	Lower public acceptance due to complete reliance on post-recovery treatment.	Lower public acceptance due to complete reliance on post-recovery treatment.	Lower public acceptance due to most post-recovery treatment and partial streat RO.
2	Cost	19	11	High cost North CAVSARP alternative, second only to North CAVSARP-2.	Highest cost alternative.	Less costly than Orange County model. Utilizes post-recovery treatment to reduce treatment capacity requirements and significantly reduce cost.	Less costly than Orange County model. Utilizes post-recovery treatment to reduce treatment capacity requirements and significantly reduce cost.	Lowest cost alternative. Utilizes post-recovery treatment to reduce treatment capacity requirements and significantly reduce cost.
3	Multiple Barrier Approach	12	8	Provides most complete multi-barrier approach. Removes and destroys constituents prior to recharge.	Provides most complete multi-barrier approach. Removes and destroys constituents prior to recharge.	Relies on natural process (SAT) as a primary barrier. Multiple barriers for post-recovery treatment (blending, RO, UV-AOP).	Relies on natural process (SAT) as a primary barrier. Multiple barriers for post-recovery treatment (blending, RO, GAC on brine).	Relies on natural process (SAT) as a primary barrier. Multiple barriers for post-recovery treatment (blending, RO or UV-AOP, GAC on brine).
4	TDS Removal	9	8	Exceeds TDS goals and improves salinity at CAVSARP.	Exceeds TDS goals and improves salinity at CAVSARP.	Exceeds TDS goals with post-recovery treatment.	Exceeds TDS goals with post-recovery treatment.	Provides flexibility in meeting TDS goals.
5	Proven IPR Process	7	8	Similar to proven gold standard in Orange County (NF vs. RO).	Proven gold standard in Orange County.	Proven treatment technologies, but after SAT.	Proven treatment technologies, but after SAT.	Proven treatment technologies, but after SAT. Does employ ozone pre-recharge.
6	Refractory Chemicals	4	8	UV-AOP provides barrier for refractory chemicals.	UV-AOP provides barrier for refractory chemicals.	UV-AOP provides barrier for refractory chemicals.	No barrier for refractory chemicals.	UV-AOP and GAC provide barrier for refractory chemicals.
7	Microconstituent Removal	0	6	Provides the most barriers for microconstiuents (NF, UV-AOP, SAT).	Provides the most barriers for microconstiuents (RO, UV-AOP, SAT).	Relies on SAT for removal during recharge, blending, and dual barrier post-recovery treatment (RO, UV-AOP).	Relies on SAT for removal during recharge, blending, and single barrier post-recovery treatment (RO and GAC on brine recycle).	Relies on SAT (enhanced with ozone) for removal during recharge, blending, and single barrier post-recovery treatment (RO or UV-AOP and GAC on brine recycle).
8	Energy Usage	0	6	Less energy intensive than North CAVSARP-2 (Orange County Model) due to NF vs RO.	Most energy intensive North CAVSARP alternative.	Lower treatment capacity (therefore energy use) than CAVSARP alternatives.	Lower treatment capacity (therefore energy use) than CAVSARP alternatives.	Lower treatment capacity (therefore energy use) than CAVSARP alternatives.
9	Institutional and Regulatory Complexity	7	6	Potentially would not require an APP for CAVSARP.	Potentially would not require an APP for CAVSARP.	Potentially would not require an APP for CAVSARP.	Potentially would not require an APP for CAVSARP.	Potentially would not require an APP for CAVSARP.
10	Operational Complexity	0	6	Utilizes several different unit processes.	Utilizes several different unit processes.	Utilizes several different unit processes.	Operationally more complex due to ozone.	Utilizes the most unit processes compared to the other treatment trains.
11	Utilization of Existing Infrastructure	3	6	Requires new recharge basins and conveyance on the recovery side.	Requires new recharge basins and conveyance on the recovery side.	Requires new recharge basins and conveyance on the recovery side.	Requires new recharge basins and conveyance on the recovery side.	Requires new recharge basins and conveyance on the recovery side.
12	Brine Quantity	8	6	Highest production of brine.	Highest production of brine.	Lower production of brine due to post-recovery treatment.	Lower production of brine due to post-recovery treatment.	Lowest production of brine due to post-recovery treatment and partial stream RO.

Criteria	CAVSARP-1		CAVSARP-2		CAVSARP-3		CAVSARP-4		CAVSARP-5		North CAVSARP-1		North CAVSARP-2		North CAVSARP-3		North CAVSARP-4		North CAVSARP-5	
	Tucson Water	Team	Tucson Water	Team	Tucson Water	Team	Tucson Water	Team	Tucson Water	Team	Tucson Water	Team	Tucson Water	Team	Tucson Water	Team	Tucson Water	Team	Tucson Water	Team
Public Acceptance	8	7	8	8	7	6	7	5	7	4	10	9	10	10	7	5	8	5	7	3
Cost	5	2	4	1	4	3	6	5	6	6	7	2	6	1	9	9	9	8	9	10
Multiple Barrier Approach	10	9	10	10	9	5	7	6	6	3	9	9	10	10	9	8	8	4	7	7
TDS Removal	9	9	10	10	10	10	5	5	5	5	9	9	10	10	7	10	7	10	4	5
Proven IPR Process	10	9	10	10	9	9	8	9	7	9	9	9	10	10	8	6	7	6	6	6
Refractory Chemicals	10	10	10	10	9	5	8	9	7	5	9	10	10	10	8	10	9	7	7	9
Microconstituent Removal	10	10	10	10	9	7	8	10	7	6	9	10	10	10	8	10	9	8	7	9
Energy Usage	7	2	5	1	5	3	7	4	7	5	7	2	5	1	6	6	6	5	8	6
Institutional and Regulatory Complexity	6	3	6	3	6	3	7	2	6	2	7	4	7	4	6	7	6	5	6	5
Operational Complexity	6	5	6	5	6	6	6	5	7	4	6	5	6	5	7	5	6	4	6	3
Utilization of Existing Infrastructure	9	7	9	7	9	7	9	7	9	7	6	4	6	4	6	4	6	4	5	4
Brine Quantity	5	1	5	1	5	1	7	5	7	5	5	1	5	1	8	7	8	8	8	9

ATTACHMENT C

DESIGN CRITERIA AND COST ESTIMATES FOR THE RECYCLED WATER PROGRAM ALTERNATIVES

MF Design Criteria	North CAVSARP-1	
	2020 Low Range	2030 Low Range
Conceptual Design Parameters		
Denitrified Effluent Supply Flow Rate (MGD)	19	26
MF Feed - *with BW & Conc Recycle* (MGD)	24.6	33.6
MF Filtrate (MGD)	22.1	30.3
MF BW Recycle Flow Rate (MGD)	2.3	3.2
Filtrate turbidity (NTU)	< 0.02	< 0.02
Conceptual Equipment Sizing		
Number of MF Units (N+1)	24	32
Modules Per Unit	119	119
Instantaneous Flux Rate (gfd)	25	25
Solids Waste (MGD)	0.12	0.17
Recovery	90%	90%
Pressurized configuration	yes	yes
Operating Pressure (psi)	10 - 20	10 - 20
Nominal Pore Size (micron)	0.04	0.04

NF Design Criteria	North CAVSARP-1		North CAVSARP-3 &4	
	2020 Low Range	2030 Low Range	2020 Low Range	2030 Low Range
Conceptual Design Parameters				
Denitrified Effluent Supply Flow Rate (MGD)	19	26	7	13
NF Feed (MGD)	22.1	30.3	8.2	15.3
NF Permeate (MGD)	17.7	24.2	6.6	12.2
Target Permeate TDS (mg/L)	650	650	650	650
Recovery (%)	0.8	0.8	0.8	0.8
Conceptual Equipment Sizing				
Number of RO Trains	10	14	4	7
Flow per Train (MGD)	1.8	1.8	1.7	1.7
Elements per Train	420	420	392	392
Flux Rate (gfd)	10.5	10.3	10.5	10.3
Vessel Diameter (in)	8	8	8	8
Array Configuration	40:20	40:20	38:18	40:20
Elements per Vessel	7	7	7	7
Number of Stages	2	2	2	2
Operating Pressure (psi)	125 - 200	125 - 200	125 - 200	125 -200

IX Design Criteria	North CAVSARP-1	
	2020 Low Range	2030 Low Range
Conceptual Design Parameters		
Denitrified Effluent Supply Flow Rate (MGD)	19	26
IX Feed (MGD)	4.4	6.1
IX Product (MGD)	4.3	5.9
Recovery	98%	98%
Conceptual Equipment Sizing		
Number of Vessels	5	7
Vessel Diamerter (ft)	6	6
Vessel Height (ft)	11	11
Dillution Water Tank	10' x 10'	12' x 12'
Regeneration Tank	12'	12'

EDR Design Criteria	North CAVSARP-1		North CAVSARP-3 & 4	
	2020 Low Range	2030 Low Range	2020 Low Range	2030 Low Range
Conceptual Design Parameters				
Denitrified Effluent Supply Flow Rate (MGD)	19	26	7	13
EDR Feed (MGD)	4.3	5.9	1.6	3.1
EDR Product (MGD)	3.3	4.5	1.2	2.3
Recovery / Stage	50%	50%	50%	50%
Conceptual Equipment Sizing				
Salt Removal (%)	75%	75%	75%	75%
Number of Stages	2	2	2	2
Overall Water Recovery (%)	75%	75%	75%	75%

Evaporation Pond Design Criteria	North CAVSARP-1		North CAVSARP-3 & 4	
	2020 Low Range	2030 Low Range	2020 Low Range	2030 Low Range
Conceptual Design Parameters				
Denitrified Effluent Supply Flow Rate (MGD)	19	26	7	13
Average Evap Feed (MGD)	0.95	1.3	0.38	0.71
Pan Evaporation Rate (in)	107	107	107	107
Average Precipitation (in)	11.1	11.1	11.1	11.1
Conceptual Equipment Sizing				
Total Acreage	269	368	107	199
Salt Accumulation (tons per year)	38,700	52,958	12,500	23,214

UV-AOP Design Criteria	North CAVSARP-1		North CAVSARP-3	
	2020 Low Range	2030 Low Range	2020 Low Range	2030 Low Range
Conceptual Design Parameters				
Flow Rate (MGD)	19	26	7	13
Target Contaminant (Photolysis)	NDMA	NDMA	NDMA	NDMA
Log Reduction	1.2	1.2	1.2	1.2
Target Contaminant (Oxidation)	1,4-dioxane	1,4-dioxane	1,4-dioxane	1,4-dioxane
Log Reduction	0.5	0.5	0.5	0.5
Lamp Fouling Factor	1	1	1	1
UVT	95%	95%	90%	90%
Conceptual Equipment Sizing				
Number of UV AOP Trains	3	4	2	3
Flow per Train (MGD)	6	7	4	4
Vessels per Train (2 Reactors per Vessel)	3	3	2	2
Lamp Technology	LPHO	LPHO	LPHO	LPHO
Vessel Diameter (in)	30	30	30	30
Flange Connection Size (in)	18	18	18	18
Peroxide Dose (mg/L)	4	4	3.5	3.5
Peroxide Concentration (%)	35	35	35	35
Peroxide 30-day Storage (gallons)	5,925	8,107	1,910	3,547
Peroxide Residual (mg/L)	3.2	3.2	2.8	2.8
Peroxide Quenching Method	SAT	SAT	GAC	GAC

Ozone Design Criteria	Concentrate-1 (Full Stream RO)	
	2020 Low Range	2030 Low Range
Max Flow Rate (MGD)	4	5.2
Average Flow Rate (MGD)	1	3
Number of Trains		
Flow per Train (MGD)		
Target Ozone:TOC Ratio (mg O3: mg TOC)	0.5	0.5
Max Ozone Dose (mg/L)	45	9
Average Ozone Dose (mg/L)	35	7
Contact Time (minutes)	10	10
Design Required Production (ppd ozone)	1,500	390
Average Required Production (ppd ozone)	411	175
TOC - 90th Percentile (mg/L)	90	18
TOC - 50th Percentile (mg/L)	70.5	14

SAT Design Criteria	Expansion of SAVSARP		North CAVSARP-1 (New basins North of CAVSARP)		North CAVSARP-3 & 4 (New basins North of CAVSARP)	
	2020 Low Range	2030 Low Range	2020 Low Range	2030 Low Range	2020 Low Range	2030 Low Range
Peak Recharge (MGD)	19	26	19	26	19	26
Average Recharge (MGD)	7	13	7	13	7	13
Infiltration Rate (ft/day)[1]	1.5	1.5	1.5	1.5	1.5	1.5
Wet:Dry Cycle	0.50	0.5	0.5	0.5	0.33	0.33
Total Area (acres)	76	104	76	104	112	153
Available Existing Recharge Area (acres)	0	0	0	0	0	0
Recharge Area Needed (acres)	76	104	76	104	112	153

[1] *Infiltration rate from Tucson Water*

GAC Design Criteria	North CAVSARP-3 (Hydrogen Peroxide Quenching)		North CAVSARP-4 (Microconstituent Removal)	
	2020 Low Range	2030 Low Range	2020 Low Range	2030 Low Range
Flow Rate (MGD)	7	13	1.6	3.1
Contactor Type	Pressure Contactors (ASME Rated)		Pressure Contactors (ASME Rated)	
Contactor Configuration	Parallel		Series	
Contactor Diameter (ft)	12	12	12	12
Contactor Straight Side Height (ft)	8	8	8	8
Bed volume (gallons)	5540	5540	5540	5540
Number of Trains	5	9	3	5
Number of Contactors/Train	1	1	2	2
Flow Rate per Contactor (MGD)	1.4	1.4	0.5	0.6
Carbon Type	Catalytic Coconut		Coconut Shell	
Empty Bed Contact Time (EBCT; minutes)	6	6	30	26
Liquid Loading Rate (gpm/sf)	9	9	4	4
GAC Changeout Frequency (yr)	2	2	0.5	0.5

BAC Design Criteria	Concentrate-1 Full Stream RO (North CAVSARP-1)	
	2020 Low Range	2030 Low Range
Flow Rate (MGD)	4.0	5.2
Contactor Type	Pressure Contactors (ASME Rated)	
Contactor Configuration	Series	
Contactor Diameter (ft)	12	12
Contactor Straight Side Height (ft)	8	8
Bed volume (gallons)	5540	5540
Number of Trains	5	8
Number of Contactors/Train	2	2
Flow Rate per Contactor (MGD)	0.8	0.7
Carbon Type	Coconut Shell	
Empty Bed Contact Time (EBCT; minutes)	20	25
Liquid Loading Rate (gpm/sf)	4	4
GAC Changeout Frequency (yr)	4	4

Solids Handling Design Criteria

Solids Design Criteria	North CAVSARP-1	
	2020 Low Range	2030 Low Range
Flow (mgd)	2.5	3.4
Lamella Settlers		
Footprint, gpd/sf	1500	1500
Percent Solids, %	2	2
Centrifuge (mgd)	0.1	0.17
Percent Water, %	4	4
Solids, lb/day	59,875	84,823

Scenario	Flow (mgd)	Pipe Size (inch)	Pump Size Route #1 (Rattle Snake Pass)	North CAVSARP Pipe Length (ft)
2050 Max Month - Low	32	48	32 mgd @ 100 feet	129,380

Conveyance Design Criteria	
Item	**Criteria**
Velocity	5 feet per second
Pressure at Recharge Location	10 – 20 psi
Headloss	3 feet per 1,000 feet of pipe for transmission (12” and larger)
	10 feet per 1,000 feet of pipe for distribution (less than 12”)

Recycled Water Master Plan
Treatment Train Summary

12/20/2013
FINAL

	N CAVSARP 1	N CAVSARP 3	N CAVSARP 4
CAPITAL COST			
Conveyance Route to Avra Valley (Pumping & Piping)	$ 109,330,000	$ 109,330,000	$ 109,330,000
Microfiltration	$ 44,486,000		
Nanofiltration	$ 50,884,000	$ 26,422,000	$ 26,422,000
Reverse Osmosis			
Soil Aquifer Treatment	$ 6,101,000	$ 8,970,000	$ 8,970,000
CAP Recharge			
UV-AOP	$ 11,723,000	$ 5,337,000	
Ozone			
GAC (includes Cartridge Filtration)		$ 3,490,000	
Concentrate Management	$ 103,544,000	$ 35,649,000	$ 39,864,000
Ozone	$ 12,503,000		
BAC	$ 5,609,000		
GAC and Cartridge Filtration			$ 4,215,000
IX	$ 10,806,000		
EDR	$ 13,384,000	$ 9,990,000	$ 9,990,000
Evaporation Ponds	$ 61,242,000	$ 25,659,000	$ 25,659,000
Solids Handling	$ 2,868,000	$ -	$ -
Lamella Settlers	$ 2,175,000		
Centrifuge	$ 693,000		
Recovery Wells	$ -	$ -	$ -
Recovered Water Transmission System (Piping)	$ -	$ 13,706,000	$ 13,706,000
SUBTOTAL: EQUIPMENT	$ 219,606,000	$ 93,574,000	$ 88,962,000
SUBTOTAL: CONVEYANCE	$ 109,330,000	$ 109,330,000	$ 109,330,000
TOTAL CAPITAL COST	$ 328,936,000	$ 202,904,000	$ 198,292,000

O&M COST			
Conveyance Route to Avra Valley (Pumping & Piping)	$ 182,000	$ 182,000	$ 182,000
Microfiltration	$ 610,000		
Nanofiltration	$ 1,732,000	$ 1,732,000	$ 1,732,000
Reverse Osmosis			
Soil Aquifer Treatment	$ 19,000	$ 27,000	$ 27,000
Soil Aquifer Treatment			
UV-AOP	$ 1,041,000	$ 410,000	
Ozone			
GAC (includes Cartridge Filtration)		$ 151,100	
Concentrate Management	$ 3,027,700	$ 892,000	$ 1,589,200
Ozone	$ 310,000		
BAC	$ 152,700		
GAC and Cartridge Filtration			$ 697,200
IX	$ 666,000		
EDR	$ 303,000	$ 355,000	$ 355,000
Evaporation Ponds	$ 1,596,000	$ 537,000	$ 537,000
Solids Handling	$ 61,000	$ -	$ -
Lamella Settlers	$ 47,000		
Centrifuge	$ 14,000		
Recovery Wells	$ -	$ -	$ -
Recovered Water Transmission System (Piping)	$ -	$ 15,000	$ 15,000
SUBTOTAL: EQUIPMENT	$ 6,490,700	$ 3,227,100	$ 3,363,200
SUBTOTAL: CONVEYANCE	$ 182,000	$ 182,000	$ 182,000
TOTAL O&M COST	$ 6,672,700	$ 3,409,100	$ 3,545,200

Capital Cost	$ 328,936,000	$ 202,904,000	$ 198,292,000
Annual O&M Cost	$ 6,672,700	$ 3,409,100	$ 3,545,200
Present Worth of Annual O&M	$ 115,384,551	$ 58,950,271	$ 61,303,716
Total Present Worth	$ 444,320,551	$ 261,854,271	$ 259,595,716
Annualized Capital Cost	$ 19,022,401	$ 11,733,958	$ 11,467,246
Total Equivalent Annual Cost	$ 25,695,101	$ 15,143,058	$ 15,012,446

Rate (i) = 4%
Years (n) = 30

POTENTIAL RELATED CAPITAL COSTS			
SAVSARP Expansion	$ 27,193,000	$ 27,193,000	$ 27,193,000

POTENTIAL RELATED O&M COSTS			
SAVSARP Expansion	$ 1,252,000	$ 1,252,000	$ 1,252,000

Recycled Water Master Plan
Treatment Train Summary

12/20/2013
FINAL

	N CAVSARP 1	N CAVSARP 3	N CAVSARP 4
CAPITAL COST			
Conveyance Route to Avra Valley (Pumping & Piping)	$ 109,330,000	$ 109,330,000	$ 109,330,000
Microfiltration	$ 60,994,000		
Nanofiltration	$ 68,993,000	$ 47,726,000	$ 47,726,000
Reverse Osmosis			
Soil Aquifer Treatment	$ 8,346,000	$ 12,275,000	$ 12,275,000
CAP Recharge			
UV-AOP	$ 16,039,000	$ 9,912,000	
Ozone			
GAC (includes Cartridge Filtration)		$ 5,332,000	
Concentrate Management	$ 138,554,000	$ 67,473,000	$ 74,544,000
Ozone	$ 16,252,000		
BAC	$ 6,889,000		
GAC and Cartridge Filtration			$ 7,071,000
IX	$ 13,619,000		
EDR	$ 18,705,000	$ 21,213,000	$ 21,213,000
Evaporation Ponds	$ 83,089,000	$ 46,260,000	$ 46,260,000
Solids Handling	$ 3,937,000	$ -	$ -
Lamella Settlers	$ 2,959,000		
Centrifuge	$ 978,000		
Recovery Wells	$ -	$ -	$ -
Recovered Water Transmission System (Piping)	$ -	$ 13,706,000	$ 13,706,000
SUBTOTAL: EQUIPMENT	$ 296,863,000	$ 156,424,000	$ 148,251,000
SUBTOTAL: CONVEYANCE	$ 109,330,000	$ 109,330,000	$ 109,330,000
TOTAL CAPITAL COST	$ 406,193,000	$ 265,754,000	$ 257,581,000

O&M COST			
Conveyance Route to Avra Valley (Pumping & Piping)	$ 257,000	$ 257,000	$ 257,000
Microfiltration	$ 1,131,000		
Nanofiltration	$ 3,086,000	$ 3,086,000	$ 3,086,000
Reverse Osmosis			
Soil Aquifer Treatment	$ 25,000	$ 37,000	$ 37,000
Soil Aquifer Treatment			
UV-AOP	$ 1,452,000	$ 758,000	
Ozone			
GAC (includes Cartridge Filtration)		$ 264,200	
Concentrate Management	$ 5,108,900	$ 1,697,000	$ 3,029,200
Ozone	$ 767,000		
BAC	$ 191,900		
GAC and Cartridge Filtration			$ 1,332,200
IX	$ 1,250,000		
EDR	$ 719,000	$ 700,000	$ 700,000
Evaporation Ponds	$ 2,181,000	$ 997,000	$ 997,000
Solids Handling	$ 81,000	$ -	$ -
Lamella Settlers	$ 63,000		
Centrifuge	$ 18,000		
Recovery Wells	$ -	$ -	$ -
Recovered Water Transmission System (Piping)	$ -	$ 15,000	$ 15,000
SUBTOTAL: EQUIPMENT	$ 10,883,900	$ 5,857,200	$ 6,167,200
SUBTOTAL: CONVEYANCE	$ 257,000	$ 257,000	$ 257,000
TOTAL O&M COST	$ 11,140,900	$ 6,114,200	$ 6,424,200

Capital Cost	$ 406,193,000	$ 265,754,000	$ 257,581,000
Annual O&M Cost	$ 11,140,900	$ 6,114,200	$ 6,424,200
Present Worth of Annual O&M	$ 192,648,814	$ 105,726,950	$ 111,087,480
Total Present Worth	$ 598,841,814	$ 371,480,950	$ 368,668,480
Annualized Capital Cost	$ 23,490,181	$ 15,368,580	$ 14,895,935
Total Equivalent Annual Cost	$ 34,631,081	$ 21,482,780	$ 21,320,135

Rate (i) = 4%
Years (n) = 30

POTENTIAL RELATED CAPITAL COSTS			
SAVSARP Expansion	$ 27,193,000	$ 27,193,000	$ 27,193,000

POTENTIAL RELATED O&M COSTS			
SAVSARP Expansion	$ 2,326,000	$ 2,326,000	$ 2,326,000

APPENDIX F

COMMUNITY INVESTMENTS IN WATER RESOURCES

Appendix F: Community Investments in Water Resources

The City of Tucson has long recognized the need to reduce its historic reliance on local groundwater to meet water demand. In order to bring renewable Colorado River water into the community, Tucson Water has constructed the Central Avra Valley Storage and Recovery Project (CAVSARP) and Southern Avra Valley Storage and Recovery Project (SAVSARP) projects. Tucson Water has also constructed the Pima Mine Road Recharge Project (PMRRP) in conjunction with the CAP to recharge Colorado River water. Through recharge and recovery, Colorado River water mixes with native groundwater to produce a blended water supply. Potable water deliveries from CAVSARP started in 2001 and from SAVSARP in 2008. A portion of the water recharged at PMRRP is recovered at the Santa Cruz Wellfield. These facilities are the primary elements of the Clearwater Program – a series of projects that bring the City's annual allocation of CAP water (currently 144,172 acre-feet) into use. The Clearwater Program supplies a major portion of Tucson's future water supply, allowing for the reduction of groundwater pumping in the Central Wellfield. Implementing the Clearwater Program is a primary initiative within Tucson Water's Capital Improvement Program over the next five years and includes the design and construction of additional recovery wells, reservoirs, boosters and transmission mains necessary to bring renewable resources into the community.

In Tucson, the potable water that has been used for domestic and industrial purposes is discharged to Pima County Regional Wastewater Reclamation Department's (PCRWRD) treatment facilities. The Tucson community has made a significant investment in PCRWRD'S Regional Optimization Master Plan (ROMP) to meet new environmental regulatory requirements and ultimately improve the effluent water quality. The ROMP program includes upgrading and expanding the Ina Road Wastewater Reclamation Facility (WRF) and building a new water reclamation facility at the Water Campus in the vicinity of the existing Roger Road WRF.

CENTRAL AVRA VALLEY STORAGE AND RECOVERY PROJECT

CAVSARP was built to effectively utilize the City of Tucson's allocation of Colorado River water from the CAP water and to reduce dependence on limited groundwater supplies. The project evolved from a complex series of events and political actions related to the City of

Tucson's initial introduction of CAP to the potable distribution system from 1992 to 1994, which resulted in colored (red) water problems and some cases of failed plumbing in portions of the city's service area containing unlined steel water mains and/or galvanized home plumbing. In November 1995, voters passed an initiative that severely limits the city's ability to treat and directly serve CAP water without first recharging the water. The CAVSARP concept was developed to meet the requirements of the initiative, while also achieving compliance with state laws that require use of renewable water resources to reduce reliance on limited groundwater supplies.

CAVSARP has been in operation since May 2003 and is permitted to recharge 80,000 AFY. CAVSARP facilities include a Tucson Aqueduct interconnection, a raw CAP water delivery pipeline (54-inch to 60-inch diameter), more than 300 acres of infiltration basins, 25 deep recovery wells, wellfield collector pipelines, a 10-MG recovered water reservoir and 54-MGD booster station, 12.5 miles of 60-inch and 72-inch-diameter recovered water transmission main from the CAVSARP booster station to the Hayden-Udall Water Treatment Plant.

Table 1 summarizes the project costs for CAVSARP which includes the capital costs invested to date and the current annual O&M costs. Modifications to the chemical feed systems and water quality monitoring facilities at the Hayden Udall Water Treatment Plant are included in the capital costs. Annual O&M costs are based on the Santa Cruz Wellfield Water Quality Management Evaluation Technical Memorandum (Malcolm Pirnie, 2012).

Table 1. CAVSARP Project Costs

Item	Cost
CAPITAL COSTS	
Recharge Basins, Raw CAP Pipeline& Monitoring Wells	$11,700,000
Recovery Wellfield & Collector Pipelines	$16,400,000
10-MG Reservoir & 54-MGD Booster Station	$9,600,000
Raw and Recovered Water Transmission Mains	$22,200,000
Utility Extensions and Relocations	$300,000
Chemical Feed Modifications and Water Quality Monitoring Stations	$900,000
Professional Services	$17,600,000
Tucson Water Staff Costs	$900,000
Miscellaneous	$1,000,000
Total Capital Costs	**$80,600,000**
ANNUAL O&M COSTS	
Annual O&M[1]	$8,300,000
Total Annual O&M Costs	**$8,300,000**

[1] *Annual O&M costs based on water produced and delivered to the B1 Water Service Area. Annual O&M costs updated to September 2012 dollars.*

SOUTHERN AVRA VALLEY STORAGE AND RECOVERY PROJECT

SAVSARP is Tucson Water's second major CAP water recharge and recovery facility, which became operational in 2008. This facility was constructed to allow the City of Tucson to fully utilize its entire allocation of CAP water. SAVSARP not only increased the volume of CAP water recharged and recovered by Tucson Water, but also provided an increased opportunity for water banking and demonstrated access to additional renewable water supplies under the City's Assured Water Supply Designation. SAVSARP is located approximately two miles south of CAVSARP and operated independently from the first facility.

The initial phase of the recharge facility includes a new CAP Aqueduct turnout structure, a 60-inch diameter raw CAP water delivery pipeline, and nine recharge basins with a total surface area of approximately 220 acres that are currently permitted for up to 60,000 AFY (approximately 19.6 MG) of recharge. The master site plan developed for the facility includes provisions for future expansion with a parallel raw water pipeline and up to 14 additional recharge basins for a total of 470 acres.

The Southern Avra Valley forebay reservoir and booster station and a 48-inch diameter pipeline to connect SAVSARP and CAVSARP are currently under construction and will be completed by Fiscal Year (FY) 2013. The South Avra Valley Recovered Water Collector Lines Phase I project will install collector lines to convey water from six wells to the SAVSARP reservoir. The Collector Lines Phase I project will take place from FY 2013-2015. The Well Equipping and Well Drilling projects will result in sixteen new SAVSARP wells, and the projects will take place from FY 2013-2018. Table 2 summarizes the SAVSARP project costs including capital investments already made and planned to be made, and the current annual O&M costs.

Table 2. SAVSARP Project Costs

Item	Cost
CAPITAL COSTS	
Turnout/Flow Meter Vault and Raw Water Delivery Pipeline	$4,400,000
Raw Water Delivery Pipeline and Recharge Facilities	$21,400,000
Reservoir and Booster Station	$11,800,000
48-inch Diameter SAVSARP-CAVSARP Interconnect Pipeline	$5,500,000
South Avra Valley Recovered Water Collector Lines Phase I[1]	$7,500,000
Well Equipping[2]	$9,500,000
Well Drilling Costs	$4,800,000
Total Capital Costs	**$64,900,000**
ANNUAL O&M COSTS	
Annual O&M[3]	$8,600,000
Total Annual O&M Costs	**$8,600,000**

[1] *South Avra Valley Recovered Water Collector Lines planned for FY 2013-2015.*
[2] *Well Equipping planned for FY 2013-2018.*
[3] *Annual O&M costs based on water produced and delivered to the B1 Water Service Area. Annual O&M costs updated to September 2012 dollars.*

PIMA MINE ROAD RECHARGE PROJECT

PMRRP is a groundwater recharge project located in Pima County, approximately 15 miles south of Tucson. PMRRP was developed by the City of Tucson and the Central Arizona Water Conservation District (CAWCD) to recharge CAP water. The facility was constructed on the Santa Cruz River flood plain and has two operational components: the original pilot facility (2-mile delivery pipeline and two 7-acre infiltration basins) and an expanded facility (5,500-ft pipeline and three new infiltration basins totaling 23 acres). The total facility has 37 acres of

infiltration basins and provides a maximum permitted annual recharge capacity of 30,000 AF. The project was completed in December 2001. Table 3 summarizes the PMRRP project costs including capital investments made to date and the current annual O&M costs.

Table 3. PMRRP Project Costs

Item	Cost
CAPITAL COSTS[1]	
Pilot and Pipeline	$2,300,000
Phase II	$1,600,000
PMRRP Upgrade	$1,600,000
Total Capital Costs	**$5,500,000**
ANNUAL O&M COSTS	
Annual O&M[2]	$200,000
Total Annual O&M Costs	**$200,000**

[1] *Capital costs represent Tucson Water's contribution to PMRRP.*
[2] *Annual O&M costs based CAP Underground Storage Facility Fee ($15/AF).*

SANTA CRUZ WELLFIELD

The Tucson Water Santa Cruz Wellfield was constructed between 1954 and 1973. At one time, it had 31 active wells capable of producing up to 28 million gallons per day (MGD). The Santa Cruz Wellfield is located north and east of the PMRRP, and water levels in the Santa Cruz Wellfield are currently increasing due to recharge at PMRRP. Sixteen wells have been taken out of service due to water quality concerns or decreasing water levels, leaving 15 wells in service with a total capacity of 13.4 MGD.

The capital costs for the Santa Cruz Wellfield include three projects in Tucson Water's Capital Improvement Plan: Santa Cruz Treatment (CIP Project ID W759), Santa Cruz Well Re-equipping (CIP Project ID W857), and Sahuarita Supply Line Slipliner (CIP Project ID W796). The Santa Cruz Treatment project consists of a land acquisition and design and construction of a Chemical Feed and Water Quality Monitoring Facility to provide pH adjustment, disinfection, and water quality monitoring through SCADA. Construction will be completed in FY 2013. The Santa Cruz Well Re-equipping project will include de-equipping four wells, maintenance, and re-equipping the wells, which will be completed by FY 2018. The Sahuarita Supply Line Slipliner project includes design and installation of a high-density polyethylene pipe (HDPE) slip liner in

the existing 30-inch and 36-inch concrete cylinder pipe (CCP) Sahuarita Supply Line from Lumber Street and Old Nogales Highway to Medina Road and Nogales Highway. Design will begin in FY 2014 and construction will be complete in FY 2015. This project will increase the capacity available from the Santa Cruz well field from 12 MGD to 22 MGD. Table 4 summarizes the planned Santa Cruz Wellfield project costs including planned capital investments and current wellfield annual O&M costs.

Table 4. Santa Cruz Wellfield Project Costs

Item	Cost
CAPITAL COSTS	
Santa Cruz Treatment[1]	$5,400,000
Santa Cruz Well Re-equipping[2]	$1,300,000
Sahuarita Supply Line Slipliner[2]	$6,200,000
Total Capital Costs	**$6,700,000**
ANNUAL O&M COSTS	
Annual O&M[3]	$700,000
Total Annual O&M Costs	**$700,000**

[1] *Santa Cruz Treatment planned for FY 13-15.*
[2] *Santa Cruz Well Re-equipping and Sahuarita Slip Line planned for FY 14-15.*
[3] *Annual O&M costs based on water produced and delivered to the B1 Water Service Area. Annual O&M costs updated to September 2012 dollars.*

RELIABILITY, RESILIENCY, AND REDUNDANCY PROJECTS

Tucson Water has planned projects that are meant to increase the reliability, resiliency, and redundancy of the Clearwater program, including the "Hayden-Udall Prime" pipeline, augmentation mains, and the Bilby Reservoir. As summarized below and in Table 5, the "Hayden-Udall Prime" program; there are seven projects that are required to provide a redundant flow of CAP renewable water supply south around the Tucson Mountains.

- Hayden-Udall Prime Reservoir and Booster Station ($17M). Design and construct a new reservoir and booster station at the Hayden-Udall Water Treatment Plant to allow for redundant ability to move Clearwater source water into the central distribution system when the Snyder Hill Pump Station is not available. The current supply is provided

through a single point, which includes the Hayden-Udall Plant; Snyder Hill Pump Station; and Clearwell Reservoir.

- Avra Valley Transmission Main Augmentation Phase I ($30M). This project will include design and construction of approximately seven miles of 64-inch transmission main from the Hayden-Udall Treatment Plant to an A-zone drop. This project will provide redundant transmission main capacity for delivery of water to the central system and improve reliability.
- Avra Valley Transmission Main Augmentation Phase II ($20M). Design and construct 4.3 miles of 64-inch transmission main to convey water to the B-Zone to A-Zone PRV station at Drexel Road and Calle Santa Cruz Lane, B-Zone at Bilby Road and Park Avenue, and the proposed Bilby Reservoir.
- Park Ave. B-Zone Augmentation Main ($10M). Design and construct approximately 4 miles of transmission main pipe to convey B-zone water from the Avra Valley Augmentation main at Bilby Road to the 24th Street PRV along Park Ave. This main is required to provide a redundant source of supply to B-zone water in the event the 96-inch SHPS / Clearwell system fails.
- Country Club C-Zone Augmentation Transmission Main ($16M). Design and construct approximately 4.5 miles of 54-inch transmission main from the future Bilby C-Zone Reservoir and Booster Station to the Tech Drive PRV Station. The new main will deliver renewable water to the C-Zone. This main is parallel to an existing 48-inch main and will provide redundant transmission capacity.
- Bilby B-Zone Reservoir and C-Zone Booster ($23M). Design and construct a new 20 million gallon reservoir and booster station as part of the Avra Valley Augmentation Program. This program will provide redundancy of supply from the Clearwater Project.
- SAVSARP Recovered Water Transmission Main ($40M). Design and install approximately 48,000 feet of 64-inch transmission main in South Avra Valley. The pipeline will convey approximately 72,000 acre-feet of recovered, recharged Colorado River water from the SAVSARP basins to the new Hayden-Udall Prime Reservoir and Booster. This project increases reliability and redundancy for the Clearwater water supply.

Table 5. Reliability, Resiliency, and Redundancy Project Costs

Item	Cost
CAPITAL COSTS	
Hayden-Udall Prime Reservoir and Booster Station	$17,000,000
Avra Valley Transmission Main Augmentation Phase I	$30,000,000
Avra Valley Transmission Main Augmentation Phase II	$20,000,000
Park Ave. B-Zone Augmentation Main	$10,000,000
Country Club C-Zone Augmentation Transmission Main	$16,000,000
Bilby B-Zone Reservoir and C-Zone Booster	$23,000,000
SAVSARP Recovered Water Transmission Main	$40,000,000
Total Capital Costs	**$156,000,000**

REGIONAL OPTIMIZATION MASTER PLAN IMPROVEMENTS

ROMP was developed by PCRWRD in conjunction with community partners, including the City of Tucson, the Town of Oro Valley, and others. ROMP outlines the long-term plan to meet new environmental regulatory requirements mandated by the Arizona Department of Environmental Quality (ADEQ). The new environmental regulations require PCRWRD to decrease the amount of nitrogen and ammonia in wastewater effluent discharged to the Santa Cruz River. The Ina Road WRF will be upgraded and expanded, while a new water reclamation facility will be constructed at the Water Reclamation Campus next to the existing Roger Road WRF. The existing Roger Road WRF will be decommissioned after the Water Campus is completed. The Ina Road WRF and Water Campus will both include nitrification and denitrification treatment processes. Other ROMP improvements include:

- Central Laboratory Complex, which will combine all laboratory services to one location.
- Plant Interconnect to connect the Roger Road WRF and Ina Road WRFs and provide flow and capacity management between the two facilities.
- Central SCADA Control Center for the entire Pima County wastewater system.
- Optimal biosolids processing and biogas utilization for onsite power and thermal generation

Table 6 summarizes the ROMP project costs including planned investments and the anticipated annual O&M costs. The regulatory compliance date for the Ina Road WRF Upgrade and Expansion project is January 30, 2014, while the compliance date for the Water Reclamation Campus is January 30, 2015. The capital investments made to date as of July 2012 were $372,006,450 (Pima County Regional Wastewater Reclamation Advisory Committee, ROMP Program Monthly Update, July 2012).

Table 6. ROMP Project Costs

Item	Cost
CAPITAL COSTS[1]	
Plant Interconnect	$34,400,000
Ina Road WRF Upgrade and Expansion Project	$294,400,000
Water Reclamation Campus	$285,100,000
ROMP SCADA	$13,500,000
Biosolids/Biogas Utilization	$32,700,000
Total Capital Costs	**$660,100,000**
ANNUAL O&M COSTS[2]	
Annual O&M	$15,000,000
Total Annual O&M Costs	**$15,000,000**

[1] *Source: Draft Revised ROMP CIP Baseline Costs (Greeley and Hansen, August 2011).*
[2] *Source: 2007 ROMP Report (Greeley and Hansen, November 2007).*

APPENDIX G

COST INFORMATION FOR OTHER SOUTHWEST WATER SUPPLY PROJECTS

Appendix G: Cost Information for Other Southwest Water Supply Projects

Utility	Project	Category of Project	Status	Annual Water Supply (AFY)	2012 Capital Cost	2012 Annualized Capital Cost	2012 Annual O&M Cost	2012 Total Annual Cost	2012 Unit Cost ($/AF)
City of Phoenix Water Services Department	City of Phoenix McMullen Valley Transfer Project	Groundwater Importation	Concept	38,000	$111,900,000	$6,500,000	$8,600,000	$15,100,000	$397
El Paso Water Utilities	EPWU Kay Bailey Hutchinson Desalination Plant	Brackish Water Desalination	In operation	30,800	NA	NA	NA	NA	$585
El Paso Water Utilities	EPWU Rio Bosque Potable Reuse Concept	Potable Reuse	Concept	16,000	$78,500,000	$4,600,000	$5,600,000	$10,200,000	$638
Southern Nevada Water Authority[1]	SNWA Groundwater Development Project	Groundwater Importation	Concept	340,000	$4,045,400,000	$234,000,000	NA	NA	$688
City of Phoenix Water Services Department	City of Phoenix Agua Fria Linear Recharge Project	Indirect Potable Reuse	Concept	16,000	$84,100,000	$4,900,000	$6,800,000	$11,700,000	$731
Orange County Water District	OCWD Groundwater Replenishment System	Indirect Potable Reuse	In operation	72,000	$536,900,000	$31,100,000	$31,300,000	$62,400,000	$867
Colorado River Municipal Water District	Big Spring, TX Potable Reuse	Direct Potable Reuse	Under construction	2,240	NA	NA	NA	NA	$930
El Paso Water Utilities	EPWU Import from Dell Valley	Groundwater Importation	Concept	20,000	$233,400,000	$13,500,000	$11,300,000	$24,800,000	$1,240
Los Angeles Department of Water and Power	LADWP Recycled Water Phase 1 and 2 With Injection Wells	Indirect Potable Reuse	Concept	30,000	$429,100,000	$24,900,000	$18,500,000	$43,400,000	$1,447
Tucson Water	**RWMP North CAVSARP-3 (2030 Flows)**	Indirect Potable Reuse	Concept	**14,560**	**$271,800,000**	**$15,800,000**	**$6,300,000**	**$22,100,000**	**$1,500**
Tucson Water	**RWMP North CAVSARP-4 (2030 Flows)**	Indirect Potable Reuse	Concept	**14,560**	**$263,700,000**	**$15,300,000**	**$6,600,000**	**$21,900,000**	**$1,500**
West Basin Municipal Water District	West Basin Average Unit Cost of Recycled Water Projects	Indirect Potable Reuse	In operation	33,600	NA	NA	NA	NA	$1,650
Los Angeles Department of Water and Power	LADWP Recycled Water Phase 1	Indirect Potable Reuse	Concept	15,000	$294,700,000	$17,100,000	$9,600,000	$26,700,000	$1,780
Tucson Water	**RWMP North CAVSARP-3 (2020 Flows)**	Indirect Potable Reuse	Concept	**7,840**	**$207,500,000**	**$12,000,000**	**$3,500,000**	**$15,500,000**	**$2,000**
Tucson Water	**RWMP North CAVSARP-4 (2020 Flows)**	Indirect Potable Reuse	Concept	**7,840**	**$202,400,000**	**$11,800,000**	**$3,600,000**	**$15,400,000**	**$2,000**
San Diego County Water Authority	SDCWA Carlsbad Desalination Project	Seawater Desalination	Under design	48,000	NA	NA	NA	NA	$2,299
Tucson Water	**RWMP North CAVSARP-1 (2030 Flows)**	Indirect Potable Reuse	Concept	**14,560**	**$414,900,000**	**$24,000,000**	**$11,400,000**	**$35,400,000**	**$2,400**
South Central Texas Regional Water Plan	South Central Texas Seawater Desalination	Seawater Desalination	Pilot studies	28,004	$650,000,000	$37,600,000	$30,900,000	$68,500,000	$2,446
City of San Diego Public Utilities Department	San Diego Recycled Water Study	Direct Potable Reuse	Demo completed	96,162	NA	NA	NA	NA	$2,646
Tucson Water	**RWMP North CAVSARP-1 (2020 Flows)**	Indirect Potable Reuse	Concept	**7,840**	**$336,200,000**	**$19,500,000**	**$6,900,000**	**$26,400,000**	**$3,300**

[1] *Unit cost does not include annual O&M cost*