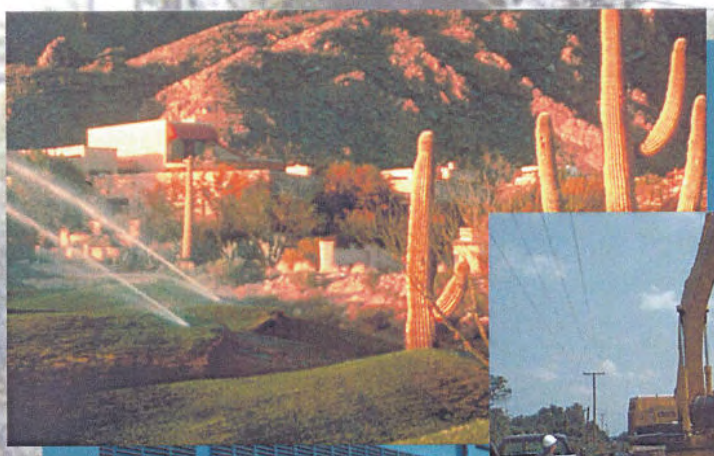
FINAL REPORT

Reclaimed Water System Master Plan



Prepared for

City of Avondale

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May 2005

Final Report

Reclaimed Water Distribution System Master Plan

Submitted to

City of Avondale

May 2005

CH2MHILL

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Acronyms and Abbreviations

A.A.C.	Arizona Administrative Code
AAC	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AMAs	Active Management Areas
APP	Aquifer Protection Permits
AZPDES	Arizona pollutant discharge elimination system
CAP	Central Arizona Project
CIP	Capital Improvement Program
COA	City of Avondale
CWA	Clean Water Act
EC_E	electrical conductivity (or salinity) of the soil
EC_W	electrical conductivity (or salinity) of the wastewater
ESA	Endangered Species Act
fps	feet per second
ft/Kft	feet (of headloss) per thousand feet (of pipe)
gpd	gallons per day
gpm	gallons per minute
HOAs	homeowners associations
kW	kilowatts
kWh	kilowatt hour
LPSCO	Litchfield Park Service Company
LR	leaching requirement
MAG	Maricopa Association of Government's
Master Plan	Reclaimed Water Distribution System Master Plan
MCESD	Maricopa County Environmental Services Department
mg/L	milligrams per liter
mgd	million gallons per day
µmhos/cm	micromhos per centimeter
ml	milliliter
N/A	not applicable
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NR	No record
PIR	Phoenix International Raceway
POPTAC	Population Technical Advisory Committee
PRVs	Pressure Reducing Valves
psi	pounds per square inch
SAR	Sodium Adsorption Ratio
SRP	Salt River Project
SWPPP	Stormwater Pollution Prevention Plan
TDS	Total Dissolved Solids
USACE	U.S. Army Corps of Engineers
WWTP	Wastewater Treatment Plant

1.0 Introduction

The City of Avondale (COA) selected CH2M HILL to develop a Reclaimed Water Distribution System Master Plan (Master Plan) to enable them to implement a non-potable water distribution system within the COA city limits. This is the first phase of a multiphase project. Subsequent phases of the project, if the Master Plan is approved by the COA, will include the phased design of a non-potable reclaimed water distribution system followed by phased construction. It has been assumed that construction of the System will begin over the next 2 to 3 years.

The overall goal of the project is to assess the potential for establishing an alternative renewable water supply, such as reclaimed wastewater, for community use. Typically, this resource is used for recharge purposes and/or to meet irrigation water demands of turf areas such as golf courses, schools, and parks as well as other areas that the COA may want to consider. Such a reclaimed water distribution system would eliminate the need to use potable water or groundwater to meet turf irrigation needs within the COA. The source of the reclaimed wastewater will be COA wastewater treatment plant (WWTP) effluent.

1.1 Background

The COA was incorporated in December 1946 and is situated 16 miles west of downtown Phoenix in Maricopa County, Arizona. The COA is ranked one of the fastest growing residential areas of Maricopa County. Between 1990 and 2000, Avondale's population grew at a rate of over 120 percent and currently has more than 55,000 residents. Various components of the COA's water resources management program are briefly reviewed in the following sections.

1.1.1 City of Avondale Water Resources

To meet their potable water supply demands, the COA currently only uses their groundwater resources. However, their annual groundwater extraction allowance from the Arizona Department of Water Resources (ADWR) is dependant on how much surface water they recharge into the regional aquifer. The COA currently recharges their surface water allocations that are delivered by the Salt River Project (SRP) and the Central Arizona Project (CAP). When total SRP and CAP water supply deliveries exceed their demand, the COA banks the excess surface water by recharging it into the groundwater aquifers.

The COA currently has a CAP allocation of 5,416 acre-feet per year. This CAP allocation is expected to remain constant for the foreseeable future. The COA has a current SRP surface water allocation of approximately 11,800 acre-feet per year, but rules regarding its use are cumbersome and currently only about 5,500 acre-feet of the allocation is available. It is expected that the useable SRP allocation could rise to as high as 13,200 acre-feet per year at final build-out conditions when all agricultural land within the COA is finally converted to residential and commercial development use. Additionally, the COA currently has an agreement with the Central Arizona Groundwater Replenishment District (CAGRD) for up

to 3,444 ac-ft per year of supplemental supply, if necessary, though at a much higher cost than CAP or SRP water.

To meet its long term potable water needs, the COA is pursuing the development of alternative water sources. Reclaimed water has been identified by the COA as a good alternative source, and has led to a series of recent studies. Table 1-1 below presents an updated current summary of the overall COA raw water supply.

TABLE 1-1
Raw Water Supply Summary

Supply Source	2004 Actual Quantity (acre-ft/year)	2005 Projected (acre-ft/year)	Build-Out Quantity (acre-ft/year)
CAP	4,746	5,416	5,416
SRP	2,800[3]	5,500[3]	13,200[3]
Phase In Allowance[1]	265	265	265
Incidental Recharge[2]	221	221	1,664
Sub-Total	**8,032**	**11,402**	**20,545**
Reclaimed Water	-	-	14,460
Total Sustainable Supply	**8,032**	**11,402**	**35,005**
Demand	10,978	13,855	37,562
Excess Purchased	2,946	2,453	2,557

[1]Assured Water Supply Rules allow a small quantity of mined groundwater to be pumped to allow providers time to "phase-in" renewable supplies (RBF, 2002b).
[2]Incidental recharge is the quantity of water that is assumed to be added to the aquifer from other uses of water, such as for crop or turf irrigation. ADWR has assigned an incidental recharge amount equal to 4.43% of total water demand (RBF, 2002b).
[3]Year 2005 and Build-Out Quantity amounts reflect total projected SRP allocations. However, actual demand may not match the allocation amount. The COA may only take from SRP the quantity required to meet the demands of current customers located within SRP entitlement area regardless of SRP's allocation. Actual SRP customer demand has typically been less than the SRP allocation. During drought years, however, SRP customer demand has exceeded SRP allocations and COA has had to purchase excess water from CAP.

As shown in Table 1-1, reclaimed water is expected to comprise a large portion (41 percent) of the COA's total sustainable supply at build-out, without which the COA would need to purchase excess CAP, SRP, or CAGRD water beyond their current allotments. Also, as shown in Table 1-1, the COA purchased excess water in 2004 because their sustainable supply was less than their potable demand. This highlights the COA's need to recharge/reuse their reclaimed water as soon as possible.

1.1.2 Existing Groundwater Recharge Program Description

A major feature of the City's water supply system is the Crystal Gardens Water Treatment Facility (also known as the Avondale Wetlands), located at 107th Avenue north of McDowell Road. This treatment facility uses natural treatment processes to remove nitrates from water distributed by the CAP and SRP. Flow from this treatment facility is directed by gravity to the COA's groundwater recharge basins, located on the east side of the Agua Fria River and on the north side of McDowell Road, across from Avondale's Friendship Park. In 2004, the

City of Avondale recharged 9,826 ac-ft of combined SRP and CAP water at their recharge facility.

In anticipation of a steadily growing annual SRP allotment over the next 25 years (5,500 ac-ft/year in 2005 to 13,200 ac-ft/year by 2030), the City is in the process of re-permitting their recharge facility to increase its allowable annual recharge capacity from 10,000 ac-ft/year to 15,000 ac-ft/year. Although the City currently recharges SRP and some CAP supplied-water at its recharge facilities, the City plans to divert their SRP and CAP allocations in the future to other regional recharge facilities. The plan to divert CAP water is certain, and the City has been diverting a majority of their CAP water to a regional recharge facility. The City's plan to divert SRP water is still being considered, but it may elect to continue recharging SRP water at its recharge basins.

1.1.3 Potable Water Distribution System

The COA meets its domestic water demands by pumping 12 groundwater wells, the water from which is stored at nine storage tank locations around the COA. Pump stations at the storage tanks then deliver the potable water to customers via a piped potable water distribution system, consisting of more than 330 total miles of pipelines. In general, the groundwater supply, the majority of which is comprised of recharged surface water, is of sufficiently good quality at the extraction sites that the COA only requires wellhead chlorination.

1.1.4 Wastewater Collection System

The COA's current wastewater collection and treatment service area covers approximately 55 square miles within the COA city limits. The wastewater collection system is primarily made up of gravity sewers, interceptors, and six lift stations. The area of the COA south of the Sierra Estrella mountain range, about 12 square miles, has no COA water or sewer service available to it at this time. The WWTP has a current average annual treatment capacity of 6.4 million gallons per day (mgd). At its peak hour, the plant has a hydraulic throughput capacity of 12.8 mgd. The plant consists of conventional and nitrogen removal wastewater treatment processes consisting of screening and grit removal, biological treatment oxidation channels, secondary clarifiers, denitrification and chlorination/dechlorination processes as well as solids storage and dewatering equipment.

In a recent study, *Wastewater Treatment and Reclaimed Water Facilities Master Plan* (DSWA 2004a), the City has identified two tentative pipeline alignments to carry either Class B+ or Class A+ reclaimed effluent from the COA's Wastewater Treatment Plant (WWTP) to the COA's recharge facility. These pipeline alignments are discussed in more detail in Section 4.1, Previous System Recommendations.

1.2 Study Objectives

This Master Plan evaluates six reclaimed water distribution system alternatives for the purposes of delivering COA reclaimed wastewater to the City's recharge facility and to major turf irrigators within the COA. These turf areas generally consist of a golf course, schools, parks, as well as other areas that the COA may want to consider. A study is required to identify all of the potential users, as well as identify those issues associated with

developing and implementing a renewable supply of reclaimed wastewater to meet the turf irrigation needs of these potential users within the COA.

1.3 Scope of Work

The specific scope of work for this project is summarized as follows:

- Conduct a project kick off meeting to introduce the COA's and CH2M HILL's project teams, review the project's scope of work, review the project schedule, discuss the project's data needs, review the project concept, review the COA's goals for the study, review the project budget, and review the project work plan.
- Review all of the existing documentation available relative to implementation of the reclaimed water distribution system, including the *Waste Water Treatment Plant and Reclaimed Water Facilities Master Plan* (DWSA 2004a).
- Interview COA department heads (Planning and Building Services, Economic Development, Community/Recreational Services, and Community Relations as a minimum) and other appropriate staff relative to this project, impacted homeowners associations (HOAs) and private golf courses, and other individuals that may have knowledge of the reclaimed water distribution system implementation issues or other relevant information.
- Review potential delivery locations and demands and develop a non-potable reclaimed water distribution system plan. Review hydraulic considerations and develop a simple hydraulic model using EPANET software to evaluate alternative distribution systems. Evaluate reclaimed water pipeline alignments based on their constructability. Review water quality considerations and identify potential impacts on users of reclaimed water. These impact analyses should include the connection impacts and modifications users would have to make to their existing potable water systems. Prepare an "order of magnitude" construction cost estimate.
- Develop a regulatory framework and review the following regulating agencies' permitting requirements:
  - ADWR
  - Arizona Department of Environmental Quality (ADEQ)
  - Maricopa County
  - COA
- Develop a phased implementation plan and schedule for the COA that identifies startup issues, reclaimed water distribution system operation and maintenance requirements, a permitting timeline, and both a capital improvements and financial implementation plan for the reclaimed water distribution system.
- Attend progress meetings during the course of the project.

2.0 Effluent Availability Projections

2.1 Land Use Plan

The COA's 2002 General Plan shows that the approximately 80 percent of all future growth will be residential (63 percent) and commercial (16 percent), the rest allocated for other uses such as public facilities and open space. The COA's general land use plan is shown in Figure 2-1.

As indicated previously, the COA has an official area of 55 square miles, 29 of which are located north of the Gila River. The remaining 26 square miles are located south of Gila River in a mountainous area. For the purpose of this study, it has been assumed that only that portion of the COA north of the Gila River will be subject to residential and associated commercial development. Of the 29 square miles north of the Gila River, it has been estimated, based on the COA's population density, that the total existing developed area comprises 10 square miles, leaving 19 square miles available for long-term development.

2.2 Population Projections

As outlined in the *Existing Wastewater Treatment Plant Technical Memorandum* (DSWA 2004b), the COA's population is expected to increase from 37,800 in 2000 to 161,400 by 2030, representing an average growth rate of approximately 5 percent per year. The COA's POPTAC (Population Technical Advisory Committee) population projections are shown below in Table 2-1.

TABLE 2-1
POPTAC Population Projections for Avondale (taken from *Existing Wastewater Treatment Plant Technical Memorandum (DSWA 2004b)*)

Year	Population	Growth Rate over Period
2000	37,800	
2005	59,950	9.7%
2010	82,100	6.7%
2020	122,500	4.1%
2025	141,600	2.9%
2030	161,400	2.7%

2.3 Effluent Projections

There have been a number of WWTP effluent production projections made for the COA over the last 10 years, and the latest effluent projections outlined in the *Existing Wastewater Treatment Plant Technical Memorandum* (DSWA 2004b) are shown in Table 2-2.

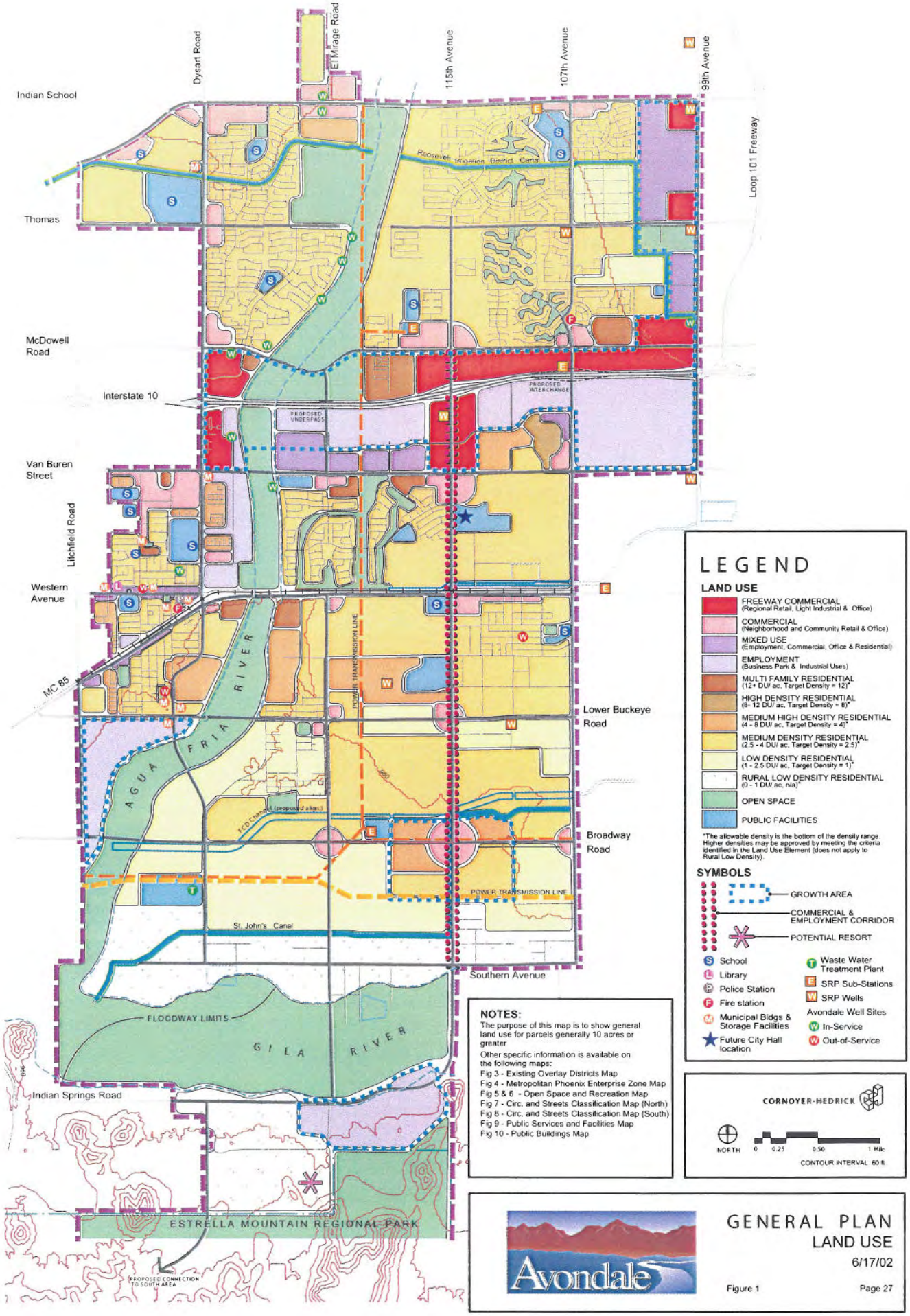

Indian School
Thomas
McDowell Road
Van Buren Street
Western Avenue
Lower Buckeye Road
Broadway Road
Southern Avenue
Dysart Road
El Mirage Road
115th Avenue
107th Avenue
99th Avenue
Loop 101 Freeway
Interstate 10
Litchfield Road
MC 85
Roosevelt Irrigation District Canal
PROPOSED INTERCHANGE
PROPOSED UNDERPASS
POWER TRANSMISSION LINE
AGUA FRIA RIVER
FCD Channel (proposed align.)
St. John's Canal
FLOODWAY LIMITS
GILA RIVER
Indian Springs Road
ESTRELLA MOUNTAIN REGIONAL PARK
PROPOSED CONNECTION TO SOUTH AREA
LEGEND
LAND USE
FREEWAY COMMERCIAL (Regional Retail, Light Industrial & Office)
COMMERCIAL (Neighborhood and Community Retail & Office)
MIXED USE (Employment, Commercial, Office & Residential)
EMPLOYMENT (Business Park & Industrial Uses)
MULTI FAMILY RESIDENTIAL (12+ DU/ ac. Target Density = 12)*
HIGH DENSITY RESIDENTIAL (8- 12 DU/ ac. Target Density = 8)*
MEDIUM HIGH DENSITY RESIDENTIAL (4 - 8 DU/ ac. Target Density = 4)*
MEDIUM DENSITY RESIDENTIAL (2.5 - 4 DU/ ac. Target Density = 2.5)*
LOW DENSITY RESIDENTIAL (1 - 2.5 DU/ ac. Target Density = 1)*
RURAL LOW DENSITY RESIDENTIAL (0 - 1 DU/ ac. n/a)*
OPEN SPACE
PUBLIC FACILITIES
*The allowable density is the bottom of the density range. Higher densities may be approved by meeting the criteria identified in the Land Use Element (does not apply to Rural Low Density).
SYMBOLS
GROWTH AREA
COMMERCIAL & EMPLOYMENT CORRIDOR
POTENTIAL RESORT
School
Library
Police Station
Fire station
Municipal Bldgs & Storage Facilities
Future City Hall location
Waste Water Treatment Plant
SRP Sub-Stations
SRP Wells
Avondale Well Sites
In-Service
Out-of-Service
NOTES:
The purpose of this map is to show general land use for parcels generally 10 acres or greater
Other specific information is available on the following maps:
Fig 3 - Existing Overlay Districts Map
Fig 4 - Metropolitan Phoenix Enterprise Zone Map
Fig 5 & 6 - Open Space and Recreation Map
Fig 7 - Circ. and Streets Classification Map (North)
Fig 8 - Circ. and Streets Classification Map (South)
Fig 9 - Public Services and Facilities Map
Fig 10 - Public Buildings Map
CORNOYER-HEDRICK
NORTH
0 0.25 0.50 1 Mile
CONTOUR INTERVAL: 60 ft
Avondale
GENERAL PLAN
LAND USE
6/17/02
Figure 1
Page 27

TABLE 2-2
City of Avondale WWTP Effluent Projections

	Effluent Projections DSWA Study (2004)				
	Average Annual		Max Month	Max Day	Peak Hour
Year	(mgd)	(acre-ft/yr)	(mgd)	(mgd)	(mgd)
2005	4.80	5,380	5.52	6.71	12.10
2010	6.57	7,360	7.55	9.20	15.73
2015	8.19*	9,180	9.41*	11.46*	18.84*
2020	9.80	10,980	11.27	13.71	21.95
2025	11.33	12,690	13.03	15.86	24.77
2030	12.91	14,460	14.85	18.08	27.62

*interpolated flow values

2.4 Competing Water Sources

Turf irrigators in the COA use a variety of water sources besides the COA's potable water for turf irrigation. These competing water sources must be taken into account when identifying potential users that may want to switch from their current water source. The following are brief descriptions of additional potable water resources such as private wells, private water companies and SRP water that are currently available in the COA.

2.4.1 Private Wells

There are a large number of private wells in the COA, many of which were originally constructed for agricultural water supply purposes, but have now been purchased by various school districts, e.g. Avondale Elementary School District, Littleton Elementary School District, for turf irrigation use. Users of these wells receive a groundwater allocation from the ADWR, and as long as they stay below their allocation they can withdraw that water for free. These private well owners may not be willing to switch from their free well source to purchased reclaimed water.

2.4.2 Private Water Companies

There are areas within the COA that are serviced by private water companies. These areas are identified in Figure 2-2. Certain areas of the far northwest portion of the COA are serviced by the Litchfield Park Service Company (LPSCO), including Estrella Mountain Community College. A large portion, approximately 2.5 square miles, of the far southeast portion of the COA, north of the Gila River, is serviced by the Rigby Water Company, although this water company is anticipated to be acquired by the COA in the next 5 to 10 years.

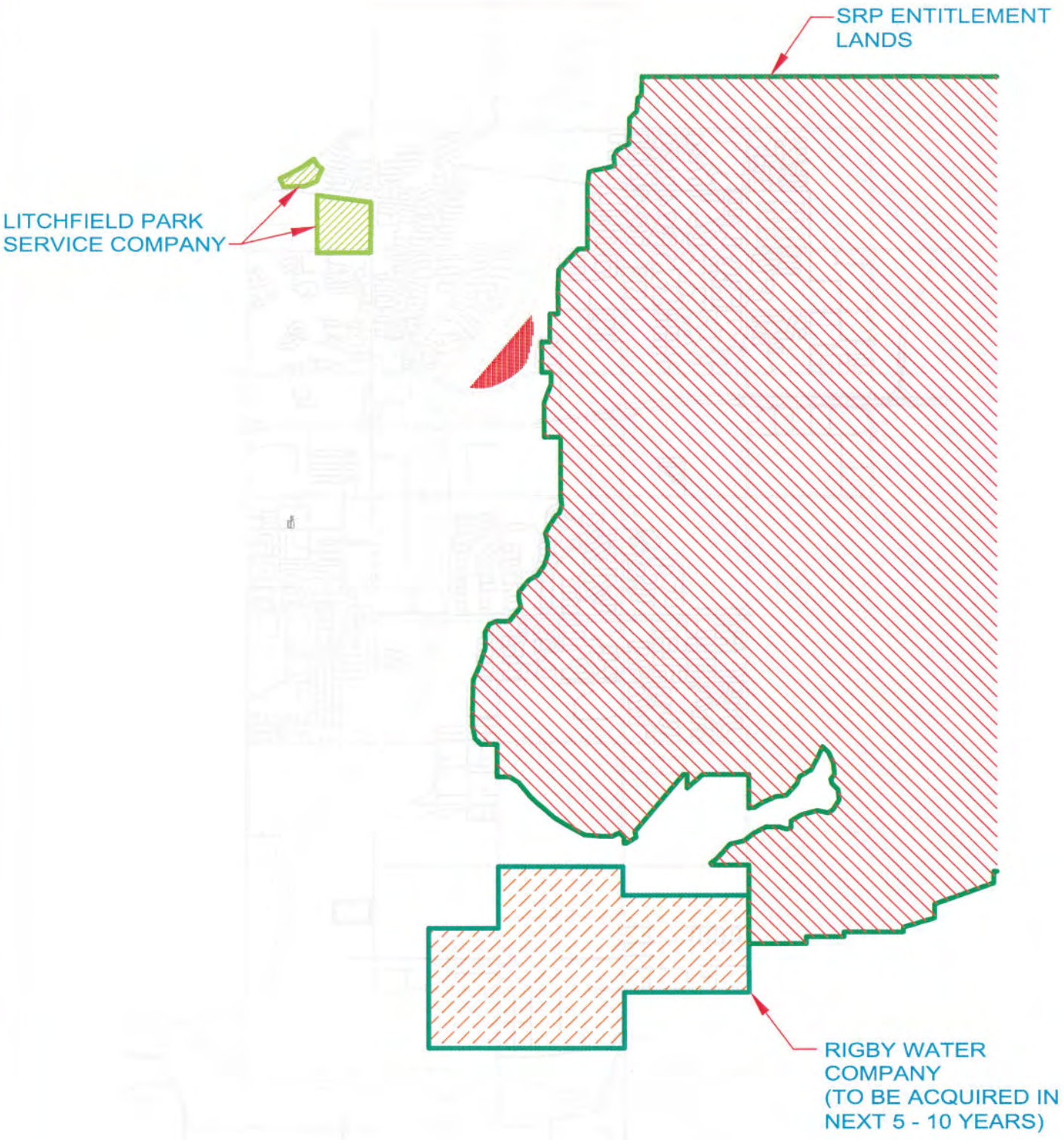


FIGURE 2-2
AVONDALE WATER UTILITY ZONES AND SRP ENTITLEMENT LANDS

CH2MHILL

AvondaleAzCityof\322128ReclaimWater\CAD\fig_2-2.dwg

2.4.3 Salt River Project (SRP) Supply

As shown in Figure 2-2, a large section of COA, primarily east of El Mirage Road and north of Lower Buckeye Road, is within the SRP entitlement area, which means certain users in this area are eligible to use SRP water for turf irrigation. SRP water is considerably cheaper than potable municipal water, and the COA may have difficulty convincing people in this entitlement area to use reclaimed water rather than SRP-supplied water.

3.0 Water Quality

Water quality is of major importance in turf-growing enterprises, specifically golf courses, parks, and other recreational facilities. A change of water source for irrigation can require changes in the type of irrigation equipment that may be used depending on the nutrient levels of the new source of water. The purpose of this section is to describe the water quality of the COA's reclaimed waste water and to compare it to the COA's potable water and SRP water currently used in the COA.

3.1 Reclaimed Water Classification

The ADEQ classifies reclaimed wastewater based on its quality. The classification ranges from Class A+ (highest quality) to Class C. The COA has the option of reusing Class A+ or Class B+ reclaimed wastewater, which is described by Arizona Administrative Code (AAC R18-11-303) and Title 18 of the same Code (R18-11-304). The COA's WWTP currently produces a Class B+ quality effluent and the COA is considering potentially expanding the application use of its reclaimed wastewater by upgrading the plant in the future to produce Class A+ water. The differences between Class A+ and B+ effluent are summarized in the following paragraphs.

Class B+ reclaimed water is wastewater that has undergone secondary treatment, nitrogen removal treatment, and disinfection. Class A+ is Class B+ water that has undergone additional filtration. Table 3-1 summarizes the water quality criteria for both Class A and Class B.

TABLE 3-1
Water Quality Criteria for Class A and Class B

Water Quality Criteria	Class A	Class B
Turbidity[a]	24-hr turbidity < 2NTU	N/A
Disinfection[b]	Fecal coliforms in 4 of 7 daily samples are nondetect	Fecal coliforms in 4 of 7 daily samples < 200/100ml
	Fecal coliforms single sample maximum < 23/100 ml	Fecal coliforms single sample maximum < 800/100 ml
	Enteric Virus in 4 of 7 monthly samples is nondetect	Enteric Virus in 4 of 7 monthly samples is nondetect
Nitrogen Removal for "+" status	Total N of 5-sample geometric mean is < 10 mg/L	Total N of 5-sample geometric mean is < 10 mg/L

[a] Sampled after filtration before disinfection.
[b] Sampled after disinfection and before discharge to distribution.
ml = milliliter
mg/L = milligrams per liter

Alternative treatment methods, alternative turbidity criteria, or blending the reclaimed water with other water sources may also be used if the facility can demonstrate that the Class B+ or Class A+ nitrogen and disinfection criteria are met prior to discharge to a reclaimed water distribution system. This may be demonstrated through pilot testing, existing water quality data, or other means the state deems to be suitable.

Table 3-2 shows the water quality requirements for different types of direct reuse. A person may use Class A+ reclaimed water for a type of direct reuse listed as Class A, Class B, or Class C in Table 3-2. A person shall not use Class B+ reclaimed water for a type of direct reuse listed as Class A in Table 3-2.

TABLE 3-2
Reclaimed Water Quality Requirements for Direct Reuse

Type of Direct Reuse	Minimum Class of Reclaimed Water Required
Irrigation of food crops	A
Recreational impoundments	A
Residential landscape irrigation	A
Schoolground landscape irrigation	A
Open access landscape irrigation (e.g. parks)	A
Toilet and urinal flushing	A
Fire protection systems	A
Spray irrigation of an orchard or vineyard	A
Commercial closed loop air conditioning systems	A
Vehicle and equipment washing (does not include self-service vehicle washes)	A
Snowmaking	A
Surface irrigation of an orchard or vineyard	B
Golf course irrigation	B
Restricted access landscape irrigation	B
Landscape impoundment	B
Dust control	B
Soil compaction and similar construction activities	B
Pasture for milking animals	B
Livestock watering (dairy animals)	B
Concrete and cement mixing	B
Materials washing and sieving	B
Street cleaning	B
Pasture for nondairy animals	C
Livestock watering (nondairy animals)	C
Irrigation of sod farms	C
Irrigation of fiber, seed, forage, and similar crops	C
Silviculture	C

3.2 Effect of Water Quality on Turf

Table 3-3 shows the average analytical results for COA's potable water, WWTP effluent, and SRP water. It also includes limits for most constituents when the water is used for general irrigation purposes. The WWTP effluent water is higher in most constituents than Avondale potable water but is, with the exception of sodium, of better quality than SRP water. The WWTP effluent has several constituents which might present some problem for some sensitive plant species, but, in general COA's effluent is of very good quality as a source water for turf irrigation purposes. The constituents that may be problematic for turf irrigation purposes are discussed in more detail in the following sections.

3.3 Water Quality Parameters Limiting Use

As shown in Table 3-3, it appears that the Class B+ effluent currently being generated at the COA's WWTP has high concentrations of some specific parameters that may influence the ability to beneficially reuse treated wastewater effluent for turf irrigation. The parameters include:

- Salinity (Total Dissolved Solids [TDS] and Electrical Conductivity)
- Sodium
- Chloride
- Phosphorous

No single parameter listed above is at a sufficiently high level to prevent the successful reuse of COA treated wastewater for turf irrigation. These identified parameters are at a level that may cause a reduction in viability of some types of turf grass, but with good management these potential problems can be controlled.

3.3.1 Salinity (Total Dissolved Solids and Electrical Conductivity)

The TDS of the water is a measure of the total amount of mineral salts that are dissolved in the water, or its salinity. The most predominant constituents of TDS in treated wastewater are commonly sodium, calcium, magnesium, chloride, and sulfate. Salinity levels in treated wastewater normally exceed normal drinking water standards by about 250 to 400 mg/L (MWD 1999). Salinity can impair plant growth by osmosis on the root system, thus making less water available to the plant. It also has the potential to create nutrient imbalances from excess calcium or magnesium.

TDS is often correlated with electrical conductivity of the wastewater (EC_W) which is measured in micromhos per centimeter (µmhos/cm). Most turfgrasses are not affected by salinity levels of less than about 3,000 µmhos/cm (2,000 mg/L TDS), although some species may experience marginal growth. Turfgrass growth is only restricted at levels between about 3,000 and 10,000 µmhos/cm (2,000 and 7,000 mg/L TDS). As such, the TDS of the reclaimed wastewater in COA, although high for horticultural or agricultural purposes, is suitable for turf irrigation.

Table 3-4 shows the soil salinity tolerance of several types of turfgrasses.

TABLE 3-3
Comparison of Water Quality Data in Avondale

Constituent	Unit	Avondale Potable (2004)	WWTP Effluent (2004)	Effluent Discharge MDL	SRP (2004)	Threshold Limits for Irrigation[a]
Total Dissolved Solids	mg/L	571	840	N/A	946 – 1060	450-2000[b]
Electrical Conductivity	µmhos/cm		1400	N/A	1710 – 1850	700-3000[b]
Sodium	mg/L	92	150	N/A	114 – 125	69.0[b]
Calcium	mg/L	49	67	N/A	123 – 147	0-400[c]
Magnesium	mg/L	23	39	N/A	71 – 74	0-60[c]
Sodium Absorption Ratio	Units		10.1	N/A		NA
pH	Units	7.2 – 8.9	7.1 – 7.5	6.5 – 9.0 (AZPDES)	7.2 – 7.5	6.5-8.4[c]
Chloride	mg/L	248	260	N/A	322 – 360	112
Boron	mg/L		<0.50	N/A	0.24 – 0.39	0.70
Bicarbonate	mg/L		210	N/A	206 – 265	92-520[b]
Residual Sodium Carbonate	meq/L			N/A		1.25-2.50
Nitrate	mg/L	5.2	2.4 (2004)	10.0 (APP)	69 – 85	5-30[2]
Total Kjeldahl Nitrogen	mg/L		4.3 (2004)	N/A		NA
Phosphorus	mg/L	0.05	0.97 (2004)	N/A		0.200
Copper	mg/L	0.010	<0.02	0.033 (AZPDES)	Nondetect	0.200
Zinc	mg/L	0.020	0.099	N/A	Nondetect	2.000
Nickel	mg/L		<0.05	0.100 (APP)	Nondetect	0.200
Cadmium	mg/L	Nondetect	<0.05	N/A	Nondetect	0.010

[a]Threshold limits for irrigation taken from: Ayers, R.S. and D.W. Westcot. 1989; Farnham, D.S. 1985.
[b]Range indicating slight to moderate reduction in yield and plant growth.
[c]Normal range in irrigation water.

meq/L = milliequivalents per liter
AZPDES = Arizona Pollutant Discharge Elimination System
APP = Aquifer Protection Permit
N/A = not applicable

TABLE 3-4
Soil Salinity Tolerance of Turfgrasses

Cool Season	Warm Season
Sensitive (<3,000 µuhos/cm)	
Annual bluegrass	Centipedegrass
Colonial bentgrass	
Kentucky bluegrass	
Moderately Sensitive (3,000-6,000 µuhos/cm)	
Annual ryegrass	Bahiagrass
Chewings fescue	
Creeping bentgrass	
Creeping red fescue	
Hard fescue	
Moderately Tolerant (6,000-10,000 µuhos/cm)	
Creeping bentgrass cv. Seaside	Blue gramma
Fairway wheatgrass	Buffalograss
Perennial ryegrass	Zoysiagrass
Slender creeping red fescue cv. Dawson	
Tall fescue	
Western wheatgrass	
Tolerant (>10,000 µuhos/cm)	
Alkaligrass	Bermudagrass
	Seashore paspalum
	St. Augustinegrass

Source: *Plant-Environment Interactions*, Second Edition, "Chapter 7: Irrigation of Turf with Effluent Water," Marcel Dekker. 2000.

3.3.1.1 Managing Salinity for Turf Irrigation

Soil salinity is related to water salinity because as the water salinity increases, a higher amount of excess irrigation water is required to maintain the soil salinity. Potential reuse water customers who are switching from potable water may have to increase their application rates to account for increased soil leaching requirements. This excess water is called the leaching requirement and can be calculated with the following formula:

$$LR = \frac{EC_W}{5(EC_E) - EC_W}$$

where:

LR is the leaching requirement,
EC_W is the salinity of the water (as conductivity), and
EC_E is the maximum tolerable salinity of the soil (as conductivity).

Using this formula, it can be seen that with a water salinity level of 1,400 µmhos/cm as is currently found in the COA's reclaimed water, the leaching requirement for a turf grass variety with a maximum salinity tolerance of 3,000 µmhos/cm would be:

$$LR = \frac{1,400}{5(3,000) - 1,400} = 10.3\%$$

In this case, a potential user with a 10.3-percent leaching requirement would have to increase their total irrigation application by approximately 10-percent.

Leaching requirements below about 15 percent are considered practical (Dekker 2000), so the use of water with a salinity of 1,400 µmhos/cm should not limit the growth of the most common turfgrasses. To exceed a LR of 15 percent, the water salinity would have to exceed about 2,000 µmhos/cm.

3.3.2 Sodium

In addition to its contribution to salinity, sodium itself can also pose problems for plant growth. Most turfgrasses are sodium-tolerant, although certain levels of sodium are harmful to all plants (USGA 1994). High levels of sodium in the water can cause the soil structure to break down which results in reduced infiltration and permeability to both air and water (Dekker 2000). A ratio of sodium to calcium and magnesium, called the Sodium Adsorption Ratio (SAR) is commonly used along with salinity (as EC_W) to define the development of a sodic soil (different than a saline soil). Sodicity causes infiltration and permeability problems, but it can also cause severe salt loading issues and corresponding poor plant growth. The sodium ion (when hydrated) is large compared to a hydrated divalent (e.g., calcium [Ca] or magnesium [Mg]) or trivalent (e.g., aluminum [Al]) cation. Figure 3-1 shows the levels of SAR and salinity that affect soil permeability.

The SAR for COA's treated wastewater effluent has been calculated to be 10.1 based on the October and November 2004 sample data. When associated with an EC_W of 1,400 µmhos/cm, Figure 3-1 shows that using reclaimed waste water for general irrigation purposes can cause slight to moderate reductions in the soil infiltration rate.

3.3.2.1 Managing Sodium for Turf Irrigation

Sodic soils, also referred to sometimes as alkali soils, are commonly treated with the addition of calcium, most often in the form of gypsum, that may be applied directly to the soil or as an electrolyte in the irrigation water. Soil amendment routines are dependant on local soil conditions and the degree of sodicity, and detailed amendment methodologies may be found in the FAO's Soils Bulletin No. 31: *Prognosis of Salinity and Alkalinity* (1978) and USDA Handbook 60: *Diagnosis and Improvement of Saline and Alkali Soils* (1954). A common approach is to incrementally land apply up to five tons of gypsum per acre until the soil infiltration rate visibly improves. Calcium additions at this level are generally beneficial to plant growth.

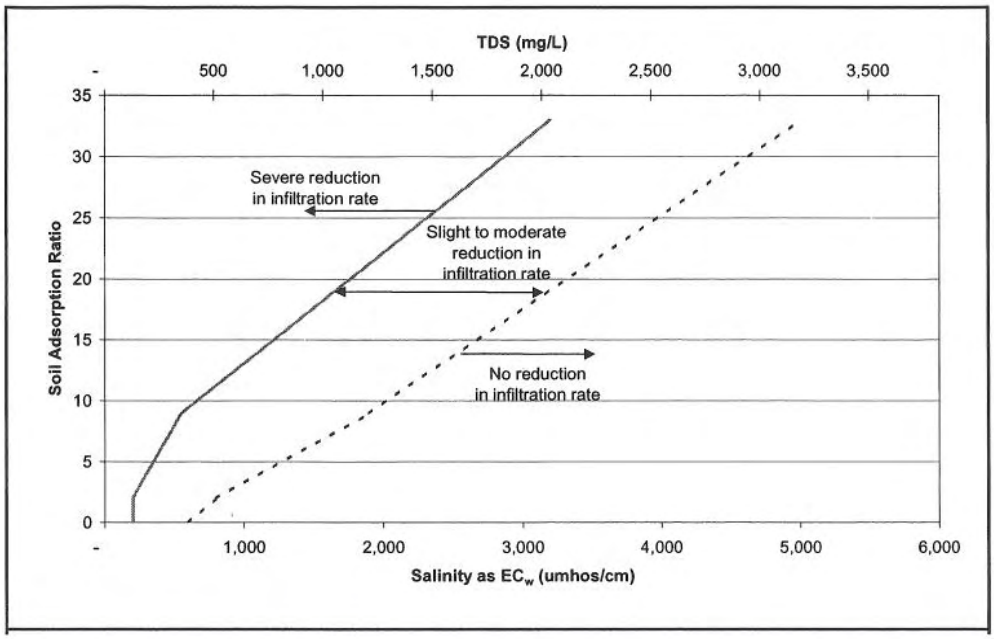


Figure 3-1. Effects of Sodium and Salinity on Soil Permeability (adapted from table)

3.3.3 Chloride

Chloride toxicity is also a commonly reported symptom when using treated wastewater as an irrigation source. This is because, many times, chlorination is part of the treatment process. In COA, the COA's potable water has chloride levels of approximately 250 mg/L, which is considered above the irrigation threshold limit.

Some plants are susceptible to chloride toxicity at levels as low as about 120 mg/L. Turfgrasses, however, have been reported to be capable of withstanding levels of up to 500 mg/L of chloride (Dekker 2000). Although turfgrasses may be more tolerant, chloride levels above 120 mg/L can cause a decrease in plant productivity. It can be expected that using the COA's reclaimed wastewater will cause a slight decrease in turfgrass productivity but would not prevent the use of the City's reclaimed wastewater for horticultural and agricultural purposes. It is very important to monitor chloride in the plant and soil system to avoid levels that are potentially harmful.

3.3.1.1 Managing Chloride for Turf Irrigation

Chloride will build up in the soil profile within the root zone if leaching events are not routinely implemented. Chloride leaching requirements are calculated in a similar manner to calculating salinity leaching requirements, with the following adjustments to the formula:

$$LR_{Cl} = \frac{Cl_W}{5(Cl_E) - Cl_W}$$

where:

LR_{Cl} is the chloride leaching requirement,
Cl_W is the chloride concentration of the water, and
Cl_E is the maximum tolerable chloride concentration of the soil.

Using this formula, it can be seen that with a water chloride level of 260 mg/L as is currently found in the COA's reclaimed water, the chloride leaching requirement for a turf grass variety with a maximum salinity tolerance of 500 mg/L would be:

$$LR_{Cl} = \frac{260}{5(500) - 260} = 11.6\%$$

In this case, a potential user with a 11.6-percent chloride leaching requirement would have to increase their total irrigation application by approximately 11-percent, or approximately the same amount required for salinity management. Given the available water quality data and known common grass tolerances to salinity and chloride, both parameters may be successfully managed using a common leaching requirement of approximately 10 percent.

3.3.4 Phosphorous

Reclaimed wastewater is typically higher in phosphorous than other sources of irrigation water. The phosphorous can be taken up as a nutrient by plants, but if an excess of phosphorous is applied, it can contaminate surface water in the area. Phosphorous contamination is the primary cause of algae blooms and associated fish kills.

3.4 Effect of Reuse Water on Storage Ponds

The addition of waters containing higher levels phosphorus to storage ponds can cause algae growth, which is mainly an aesthetic problem. To control algae growth, several solutions are available—use of a dye (Aquashade) will reduce light penetration and control algal growth, alum can be used to precipitate phosphorus, which again can control algal growth. Water hyacinths or other vegetation can be used to uptake the excess phosphorus and limit the light penetration, but these plants can become unsightly if they are not routinely removed. Another approach is to add commercially-available combinations of bacteria and enzymes, which can also uptake the algal nutrients. As a last resort, use of algaecides such as copper sulfate has been used to control algal growth in lakes and ponds (GCSAA 2001).

3.5 Other Water Quality Considerations

In addition to the preparation of this Reclaimed Water Distribution Master Plan, the COA requested that CH2M HILL also address other water quality issues related to the safety of their potable water supply due to the recharge of reclaimed water in the vicinity of their production wells. A separate Technical Memorandum (TM) was prepared, titled "Impacts of Water Quality at City of Avondale Potable Water Production Wells Due to Recharging Reclaimed Water at Avondale's Existing Recharge Facilities", and is included as Appendix B in this report. The purpose of this study was to address the following specific issues:

- Investigate the potential for contaminant transfer from the recharge basin to the City's potable water production wells, some of which are located within a 1/2 mile of the recharge basins. The COA would like to address this issue from the perspective of currently regulated contaminants. However, the COA is also generally interested in the contaminant transport potential of currently unregulated contaminants, such as

endocrine disrupters, pharmaceuticals, and personal care products that may become regulated in the next 10 to 15 years.

- Without additional filtration treatment and thus removal of additional particulate organic matter at the WWTP, the COA is concerned that chlorination of the current Class B+ effluent will create higher levels of Disinfection By-Products (DBPs), specifically Total Trihalomethanes (TTHMs), resulting from the long contact time the chlorine has with the WWTP effluent organic matter within the proposed 6½ mile pipeline from the City's WWTP to its recharge basin. Once recharged, these TTHMs could contaminate the groundwater and nearby potable water production wells. The COA would like to determine if treating to Class A+ at the WWTP would significantly reduce DBP levels in the recharge basins.

- Future regulations may require that all recharged water be at least Class A+ quality. The City is generally interested in the national and state regulatory environment regarding the recharge of WWTP effluent.

- The general public perception is that recharging Class A+ effluent is safer than recharging Class B+, even if that isn't necessarily true. The City is generally interested in the public perception of recharge programs on going in other municipalities in the Phoenix area.

- Given that there are other municipalities in the Phoenix area who recharge their WWTP effluent, the distance their potable water production wells are from their recharge basins and how such separation determinations were made is also of interest to the COA.

Based on the results of this study, which are presented in their entirety in Appendix B, CH2M HILL made the following recommendations:

- The COA's existing recharge facility has adequate capacity to accommodate ultimate reclaimed water flows, provided that the City's SRP and CAP allotments are diverted to other regional recharge basins as planned. In the event that the City needs to continue to recharge SRP water at its facility (a possibility that has been raised), the existing recharge facility would have inadequate capacity to accommodate both SRP and City generated reclaimed water flows by Year 2013, and would require that the City find additional sites prior to 2013 to augment their recharge program.

- The COA's WWTP Class B+ effluent is of sufficiently good quality to meet the Aquifer Water Quality Standards at the existing recharge basins, with the exception of fecal coliforms. Given the well documented ability of soil aquifer treatment systems to remove fecal coliforms, it is believed the COA would be able to comply with all Aquifer Water Quality Standards by selecting new points of compliance, i.e. constructing new monitoring wells, to be ideally located 300 to 400 feet away from the boundary of the existing recharge facilities.

- There are similar ADEQ-permitted surface recharge facilities in the Phoenix area for Class B+ reclaimed water that suggest that the COA would also be able to permit their existing facility for Class B+ recharge. However, there is no guarantee that ADEQ will approve an APP permit. As such, it is recommended that the City begin the APP process

immediately, prior to construction of the reclaimed water pump station and pipeline from the WWTP to the recharge basins.

- Based on a cursory model analysis of the COA recharge basin vicinity, a preliminary estimate is that the time of travel between the recharge basin and the nearest production well, Well 12, is approximately two to three years.
- Based on recent laboratory test results from effluent samples collected at the COA WWTP, disinfection using chlorine will not create high levels of TTHMs or other DBPs. Based on COA's anticipated chlorine dosage rate of 2.5 mg/L to achieve Class A+ standards, the estimated TTHM concentration at the recharge basin would be approximately 3 µg/L which is well below the Aquifer Water Quality Standards MCL of 100 µg/L. To address the COA's concerns, a) the disinfection of either Class A+ or Class B+ effluent would not produce TTHM's of sufficient concentration to violate the Aquifer Water Quality Standards, and b), the low chlorine dosage rates needed to achieve non-detect levels of total coliforms would not require the COA to de-chlorinate their reclaimed water prior to recharging.
- PPCP and EDC concentrations may be attenuated during tertiary treatment and during soil-aquifer treatment. However, there is still a strong likelihood that some currently un-regulated PPCP and EDC constituents will migrate from the recharge basins to the COA production wells located down-gradient. PPCP and EDC contamination risk may be minimized by additional treatment processes or by increasing the separation distance between recharge facilities and production wells, providing more opportunity for dilution.
- Reclaimed water recharge facilities in the Phoenix area have not experienced significant public opposition during their implementation, including Class B+ surface recharge facilities. This has been especially true when recharge facilities were constructed at existing wastewater treatment plant sites. It is anticipated that the COA will not experience strong public opposition to their recharging either Class A+ or Class B+ reclaimed water.
- There is no indication at this time that ADEQ intends to adopt California Title 22 regulations. However, in the event that ADEQ adopted portions of the California Title 22 regulations, the COA could expect to be required to treat their effluent to Class A+ prior to recharge. Additionally, Title 22-style regulations would require routine sampling for PPCPs and EDCs, although MCLs for these constituents have not yet been set.

3.6 Water Quality Summary

In general COA's groundwater is of very good quality as a source for turf irrigation. The WWTP effluent water is higher in several key constituents, which might present some problems for some sensitive plant turfgrass varieties. These constituents discussed earlier are salinity, sodium, chloride, and phosphorous. However, WWTP effluent water is lower in every key constituent, with the exception of sodium, that SRP water and is therefore more suitable for turf irrigation.

WWTP effluent is a viable turf irrigation option for replacing potable city water. Continuous monitoring of the reclaimed wastewater constituents discussed earlier and their potential irrigation impacts can diminish the impact of these higher constituent levels on selected turfgrasses.

4.0 Hydraulic Model System Development

A COA specific hydraulic model was developed to identify a proposed pipeline system network for the reclaimed water distribution system. Model conditions were developed by assigning turf irrigation demands to the hydraulic model. The locations of these demands were assigned within the model on the basis of maximum day and peak hour conditions that were ultimately used to size pipe diameters, select alignments, and determine pumping requirements for the system. Each step in the modeling process is detailed in the subsequent sections.

4.1 Previous System Recommendations

DSWA's report, *Wastewater Treatment and Reclaimed Water Facilities Master Plan: Existing Wastewater Treatment Plant Conditions Technical Memorandum* (2004b) identifies five different potential reclaimed water pipeline alignments from the City's WWTP to its recharge basin. Two 24-inch pipeline alignments, identified as Alternatives 3 and 4 in the report, were selected as the preferred alignments by the COA based on DSWA's recommendations. Alternative 3 starts at the City's WWTP and heads west to the Agua Fria River, and follows the east river bank north to McDowell Road, turning east to the City's recharge basin adjacent to Friendship Park. Alternative 4 starts at the City's WWTP and heads east from Dysart Road to El Mirage Road, turning north and eventually passing through Coldwater Springs Golf Course until Van Buren Street. The alignment then heads east on Van Buren Street for approximately half a mile, before continuing to the north to McDowell Road. At McDowell Road, the pipeline heads west to the City's recharge basin. Both alignments are shown in Figure 4-1. The estimated construction costs for both alternative alignments are somewhat similar but the estimated construction cost associated with Alternative Alignment 4 has been used for system model and economic analysis purposes.

Previously proposed project phasing for this conveyance system involved the installation of either pipeline alignment alternative and three pumps (two operating, one standby), with additional pumps added incrementally in the future as the need arises. Additionally, the *Treatment Facilities Master Plan* (DSWA 2004b) recommends "no onsite storage" of reclaimed water at the WWTP, but does indicate that a minimum amount of storage volume would provide additional operational flexibility. The COA Utilities Department has indicated that it would support a reclaimed water storage tank, up to 2 million gallons in size, to be located at the WWTP and this assumed storage volume has therefore been used in this analysis.

For the purposes of CH2M HILL's model development, the previously proposed 24-inch pipeline Alternative 4 alignment was used as the main trunk line for the hydraulic model simulation along with a pumping station, and a storage volume of 2 million gallons at the COA's WWTP. Although Alternative 3 was not modeled, it is anticipated that the modeling results from Alternative 4 are representative of both alignment alternatives.

4.2 Existing Potential Demand Locations and Users

Based on conversations with COA personnel, several public and private entities have been identified as potential users of reclaimed wastewater for turf irrigation. Although both Class A+ and B+ water are suitable for a number of applications as indicated in Table 3-2, only turf irrigation demands were considered in this study.

Potential COA turf irrigation users include the following:

- Public parks
- Schools
- HOAs
- Highway and median irrigation areas
- Other private turf irrigators, e.g. Golf courses, Phoenix International Raceway (PIR)

These users are discussed in greater detail in the subsequent sections.

4.2.1 Parks

All COA parks were identified as good candidates for reclaimed wastewater use. Currently, there are ten COA parks, which are listed in Table 4-1. The largest of the parks, Friendship Park, has its own well and does not use COA potable water for turf irrigation. The smallest of the parks, Sernas Park, is paved and has no irrigation requirement.

TABLE 4-1
Existing Park Irrigation Demands

Park	Acres	Annual Water Use (acre-ft)	Max Month (acre-ft)	Max Day (gpd)	Avg Day (gpd)	Peak Hour (gpm)	ADWR Allotment (acre-ft)
Avondale Municipal Supply							
Donnie Hale	**7.9**	11.7	2.8	30,027	10,443	50.0	NR
Las Ligas	**8.4**	12.4	2.9	31,927	11,104	53.2	NR
Coldwater	**10**	**14.1**	**3.7**	**39,968**	**12,587**	66.6	NR
Sernas Plaza	**1/8**	**0**	**0**	**0**	**0**	**0**	NR
Dessie Lorenz	**4.6**	6.8	1.6	17,484	6,081	29.1	NR
Mountain View	**2.0**	3.0	0.7	7,602	2,644	12.7	NR
Fred Campbell	**4.75**	**7.4**	**1.6**	**16,943**	**6,579**	28.2	NR
Doc Rhodes	**0.5**	0.7	0.2	1,900	661	3.2	NR
Dennis DeConcini	**5**	7.4	1.8	19,004	6,609	31.7	NR
Total	**43.3**	63.5	15.3	164,855	56,708	274.7	
Other Supply (e.g. well, SRP)							
Avondale Friendship Park	**22**	107.8	25.5	276,699	96,231	461.2	NR

Values in **bold** indicate verified data. Values not in bold have been derived using assumptions and unverified data.

ADWR = Arizona Department of Water Resources
NR = No Record
gpd = gallons per day
gpm = gallons per minute

4.2.2 Schools

The head operations/landscaping personnel from all six school districts in the COA, with the exception of Litchfield Park Elementary School District, were contacted regarding this project. Information was collected regarding acreage, hours of irrigation, the source of water, and willingness to use reclaimed wastewater for irrigation purposes. Water meter data was supplied by the COA for only two of the schools. However, based on the information that was gathered, reasonable estimates could be made when necessary to approximate the maximum day, average day, and peak hour values for the schools listed in Table 4-2. For the purposes of this study, it can be seen that the school irrigation volumes represent a very small portion of overall potential reclaimed water use. However, these school irrigation demand values should be verified prior to any physical implementation projects, if that is how the COA proceeds.

TABLE 4-2
Existing School Irrigation Demands

School	Turf Acres	Annual Water Use (acre-ft)	Max Month (acre-ft)	Max Day (gpd)	Avg Day (gpd)	Peak Hour (gpm)	ADWR Allotment (acre-ft)
Avondale Municipal Supply							
Agua Fria HS	21.7	**112.0**	14.8	160,968	**99,980**	268.3	**106.3**
Corte Sierra ES	5.7	**28.0**	3.7	40,242	**24,995**	67.1	NR
Rancho Santa Fe ES	6.8	33.0	4.4	47,428	29,458	79.0	NR
Collier ES	**12**	**29.0**	3.8	41,679	**25,888**	69.5	NR
Canyon Breeze ES	3.7	**18.0**	2.4	25,870	**16,068**	43.1	NR
Garden Lakes ES	6.5	**8.0**	**4.2**	**11,503**	**7,141**	19.2	NR
Rio Vista ES	7.1	**16.0**	2.1	22,995	**14,283**	38.3	NR
LaJoya HS	**16**	**70.0**	9.3	100,605	**62,488**	167.7	NR
Westview HS	**18.5**	**77.0**	10.2	110,666	**68,736**	184.4	**65.8**
Total	98.0	391.0	54.9	561,956	349,037	936.6	
Other Supply (e.g. well, SRP)							
Avondale MS	0	0	0	0	0	0	NR
Lattie Coor ES	0	0	0	0	0	0	NR
Michael Anderson ES	7.0	**34.1**	**4.5**	**49,092**	**30,440**	81.8	NR
Littleton ES	**15**	36.3	4.8	52,099	32,360	86.8	NR
Quentin K-8	**10**	24.2	3.2	34,733	21,573	57.9	NR
Underdown JHS	5.1	12.3	1.6	17,726	11,010	29.5	NR
Garden Lakes ES	6.5	**23.8**	**4.2**	**34,222**	**21,246**	57.0	NR
Rio Vista ES	7.1	18.8	2.5	26,984	16,760	45.0	NR
Estrella Mountain CC	1.5	7.4	1.0	10,564	6,561	17.6	NR
St. Thomas K-8	1.0	4.9	0.6	7,042	4,374	11.7	NR
Total	**53.2**	**161.8**	**22.4**	**232,462**	**144,324**	**387.3**	

Values in **bold** indicate verified data. Values not in bold have been derived using assumptions and unverified data.

4.2.3 HOAs

RBF Consulting's Water Infrastructure Master Plan (2002a) indicates that the average number of home units per acre of development, within a typical HOA development, is approximately four. This number represents the number of building lots plus roadways, sidewalks and common areas. Based upon this number of lots, each actual home lot will average approximately 0.15 acres, or 6,500 square feet. Conversations with local irrigation equipment and design companies indicate that the average home yard is approximately 1,000 square feet, although this area often contains areas of gravel, dirt or paving. For planning purposes, we believe a reasonable assumption is that there will be, on average, 500 square feet of turf area per home and four homes per acre, or 2,000 square feet of turf area per acre of HOA development.

Turf in the Phoenix area, depending on the quality of turf used, can be assumed to have an average annual water need of between 4.1 and 4.9 acre-ft/acre/year. Using an average value of 4.5 acre-ft/acre, it has been estimated that each acre of existing HOA development would use approximately 67,300 gallons/year, or 0.2 acre-ft/year. Assuming a 4-inch distribution system network to supply each development with reclaimed water, and approximately 200-feet of 4-inch pipeline per acre, the cost per acre for the City to provide reclaimed water service to each home within each acre has been estimated to be $2,500 for new developments. The cost for retrofitting existing developments is considerably higher, including repaving and connecting to existing irrigation systems, and has been estimated to cost $6,000 per acre. These costs do not include pipeline costs from the 24-inch force main to the HOA perimeter, which will depend on the location of the HOA in relation to the 24-inch force main alignment.

Economic Analyses for various alternatives are presented in Section 6.0 Economic Analysis. However, CH2M HILL conducted a cursory economic analysis to determine the feasibility of providing individual homes in new HOAs with reclaimed water for turf irrigation purposes. Assuming an annual Operations and Maintenance (O&M) cost of approximately $190/acre (see Section 6.2.3.1 Distribution System O&M Costs) per acre, the Present Value (PV) of an HOA distribution network in a new development has been estimated to be $4,700, assuming a 20-year period at 5.0-percent interest. The total reclaimed water demand per acre over 20 years is estimated to be 4 acre-feet (0.2 acre-ft/year x 20 years). Dividing the total reclaimed water demand by the PV, it has been estimated that the required reclaimed water rate necessary to recoup all capital and O&M costs would be approximately $27 per 1,000 gallons, and would actually be higher when considering the pipeline costs from the 24-inch force main to each HOA and when retrofitting existing HOAs. This cursory reclaimed water rate is more than ten times higher than the existing potable water rate. As such, there is no financially incentive for the City to provide reclaimed water to homes in new HOAs unless, in the case of new developments, all costs were borne by the developer/home owners.

Therefore, based on the results of the cursory economic analyses related to delivering reclaimed water to individual homes within new HOA developments, CH2M HILL and COA personnel collectively agreed that there were other potential users that were more economically viable to serve than new and existing homeowners, and that extending reclaimed water service to new and existing homeowners at this time was not economically feasible.

4.2.4 Highways and Medians

Meter data provided by the COA shows that the majority of the turf irrigation adjacent to the highways occurs at interchange locations along the I-10 freeway, as shown in Table 4-3. An additional significant roadside irrigation area is in the vicinity of Friendship Park on McDowell Road.

TABLE 4-3
Existing Highway & Median Irrigation Demands

Highway/Median Area	Turf Acres	Annual Water Use (acre-ft)	Max Month (acre-ft)	Max Day (gpd)	Avg Day (gpd)	Peak Hour (gpm)	ADWR Allotment (acre-ft)
Avondale Municipal Supply							
Dysart Rd & I-10	6.2	**9.3**	**2.3**	**24,654**	**8,320**	41.1	106.3
99th Ave & I-10 (north)	2.2	**3.2**	**0.6**	**6,517**	**2,883**	10.9	NR
99th Ave & I-10 (south)	2.2	**3.3**	**0.7**	**7,603**	**2,982**	12.7	NR
115th & I-10 (north)	8.2	**12.3**	**2.8**	**30,737**	**10,953**	51.2	NR
115th & I-10 (south)	8.2	**12.3**	**2.6**	**27,804**	**10,944**	46.3	NR
12325 W. McDowell Rd.	6.7	**10.1**	**2.4**	**26,392**	**8,980**	44.0	NR
1825 N. 107th	2.4	**3.7**	**0.7**	**7,820**	**3,276**	13.0	NR
Total	36.1	**54.2**	**12.1**	**133,527**	**48,338**	219.2	

Values in **bold** indicate verified data. Values not in bold have been derived using assumptions and unverified data.

4.2.5 Other Private Turf Irrigators

Within the COA, there are a very limited number of private entities with large turf irrigation demands. Two potential private users are listed in Table 4-4. It should be noted that these two identified private users both use non-municipal water supply sources. PIR has very limited turf acreage and irrigates with their own well. Coldwater Springs Golf Course has its own well and ADWR groundwater allotment to meet its needs, but also supplements its turf irrigation needs with SRP and agricultural tailwater from a nearby farm.

TABLE 4-4
Other Existing Irrigation Demands

Other	Turf Acres	Annual Water Use (acre-ft)	Max Month (acre-ft)	Max Day (gpd)	Avg Day (gpd)	Peak Hour (gpm)	ADWR Allotment (acre-ft)
Other Supply (e.g. well, SRP)							
Coldwater Springs Golf Course	117.3	**574.7**	135.8	**1,745,309**	**513,087**	2,459	**539.0**
Phoenix International Raceway (PIR)	1.5	7.4	1.7	18,866	6,561	31.4	NR
Total	118.8	582.1	137.5	1,764,175	519,648	2,490	

Values in **bold** indicate verified data. Values not in bold have been derived using assumptions and unverified data.

4.2.6 Summary of Existing Potential Delivery Locations and Users

Existing potential reclaimed wastewater users have been identified. It is acknowledged that not all potential users will accept reclaimed wastewater for their turf irrigation. This is especially true for those users that have a private water source, such as wells or access to SRP water that is cheaper than the COA's municipally supplied potable water. Figure 4-1 shows the locations and demands for all existing potential reclaimed water users.

A breakdown of the turf irrigation demands for all currently identified potential users is provided in Figure 4-2, while a comparison of total turf irrigation demand to available WWTP effluent is provided in Figure 4-3. Note that approximately 62 percent of demand from all existing potential reclaimed water users is from non-COA potable water supplies.

4.3 Future Potential Demand Locations and Users

The COA would like to consider providing reclaimed water for turf irrigation for new users in the following categories:

- All new COA parks
- All new schools
- All new HOAs, yards plus common irrigation areas
- Landscaping along major transportation corridors
- Riparian Restoration projects

As indicated in Figure 2-2, much of the undeveloped land in the COA falls within the boundaries of other private water utilities or within the SRP entitlement zone.

4.3.1 Parks

As per the COA's *Parks, Recreation and Open Space Master Plan* (2002), the COA is planning to develop between 100-240 acres of new parks as outlined below:

- School/district park facilities in the north area of the COA.
  Proposed location: Existing sand and gravel mining operation north of Thomas Road, just west of the Agua Fria River.
  Proposed size: 40 acres.

- School/district or community park facilities located in the central area of the COA.
  Proposed location: unknown/unidentified.

- Community parks facilities located in the south area of the COA.
  Proposed location: southwest corner of Broadway Road and El Mirage Road.
  Proposed size: 40 acres.

Funds have been budgeted for the costs of acquiring these park lands. However, the COA is still in the process of acquiring these parks. Park development was slated to begin in FY2004, though it is likely this will slip to FY2005 or FY2006. Assuming that approximately 120 additional acres of park land is developed, the approximate annual park turf irrigation requirement would rise from 63.5 acre-ft currently to 651.5 acre-ft by FY 2005/6.

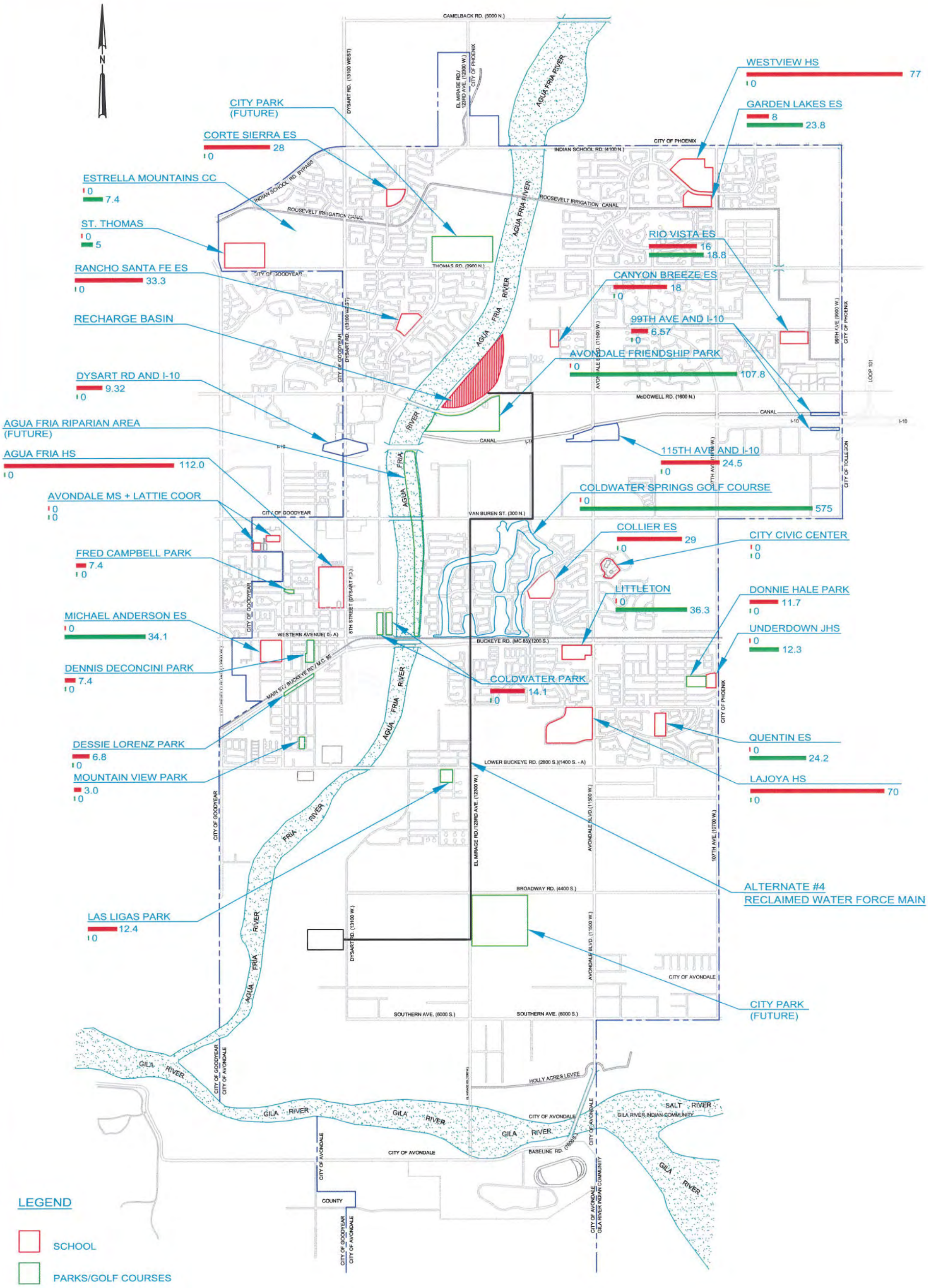


FIGURE 4-1

EXISTING AND FUTURE POTENTIAL DEMAND LOCATIONS

CH2MHILL

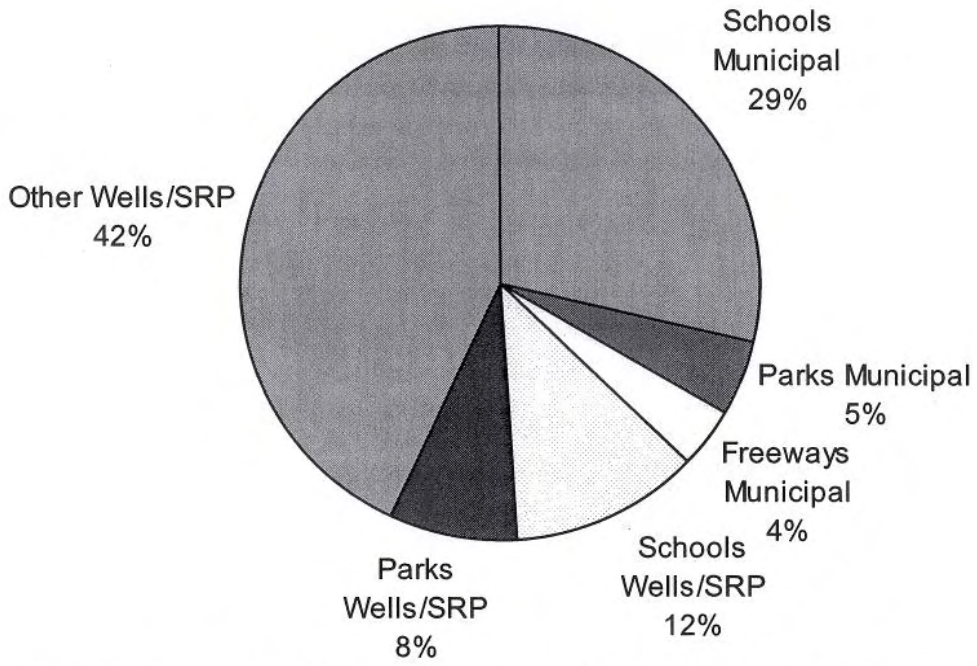


Figure 4-2. 2004 Turf Irrigation Demands for All Currently Identified Users

"Municipal" refers to user groups that exclusively use municipal potable water for turf irrigation. "Wells/SRP" refers to user groups that have a non-municipal water supply, most commonly referring to SRP and/or privately owned wells. "Other" users include various large commercial users, e.g. Coldwater Springs Golf Course.

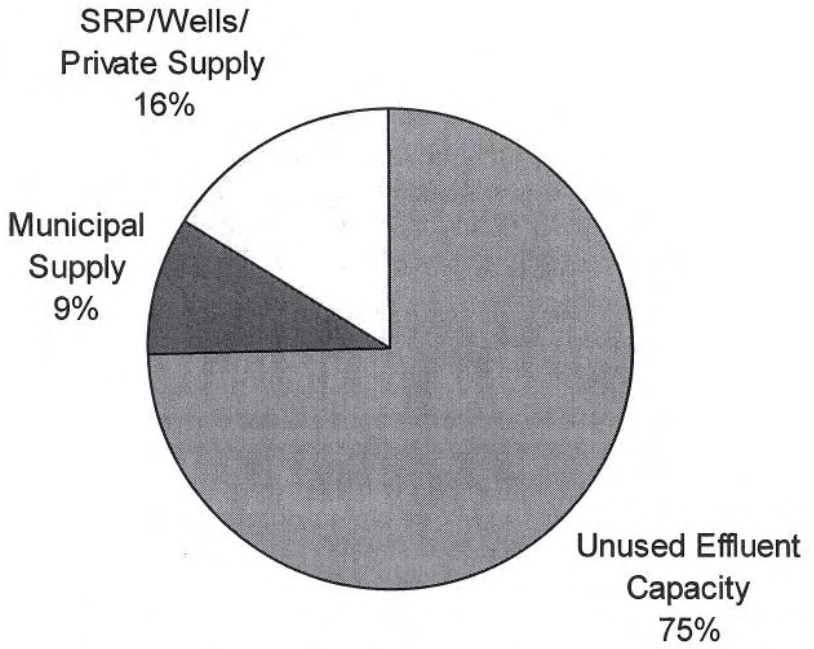


Figure 4-3. Comparison of All Currently Identified Irrigation Demands to 2004 Effluent Production Rates

In addition to these identified parks, the COA is also planning to develop a multimodal trail system on the east side of the Agua Fria River, which will stretch from McDowell Road south to Riley Drive. This trail system is being planned in conjunction with Maricopa Association of Government's (MAG's) *West Valley Multi-Modal Transportation Master Plan* (2001). This trail system will provide a linkage between the Avondale Friendship and Coldwater parks. The COA is also hoping to develop a separate riparian area with the Army Corps of Engineers that will be adjacent to the proposed multimodal trail system. The proposed riparian area development is outlined in the U.S. Army Corps of Engineers' (USACE's) *Detailed Project Report for the Agua Fria Riparian Restoration Project* (2002).

The multimodal trail system being recommended by MAG is primarily a low-water use system that incorporates sand, gravel, and asphalt trails with native vegetation. The entire fully builtout trail system for the COA (Trail Segments S-14, S-15, and S-16), which includes trails on both sides of the Agua Fria, recommends a total of 3,580 square feet of drip irrigation, or less than 1/10 of an acre. The annual water requirements for the multimodal trail system will be approximately 0.5 acre-ft, which is considered negligible for study purposes.

There is much higher potential to use reclaimed water for the riparian habitat areas identified by USACE. In addition to the "No Action" alternative, the Corps has identified six additional alternatives for developing these riparian areas. Alternatives 2, 3, and 4, titled "Low Water Use," "Moderate Water Use," and "High Water Use," respectively, outline the three primary alternatives. Alternatives 5, 6, and 7 are simply variations of Alternatives 2, 3, and 4, respectively. The water use requirements for Alternatives 2, 3, and 4 are shown below in Table 4-5.

TABLE 4-5
Agua Fria Riparian Area Development Alternatives

Alternative	Summary of Water Needs
Alternative 2: Low Water Use	2.0 mgd
Alternative 3: Moderate Water Use	2.9 mgd
Alternative 4: High Water Use	10.6 mgd

The COA's *Parks, Recreation, and Open Space Master Plan* (2002) indicates that they have estimated budget costs from FY2002 through FY2007 for the development of Alternative 2: Low Water Use. However, Alternatives 3 and 4 represent extensions of Alternative 2 (i.e., moderate and high water use represents a spatial expansion of the riparian areas rather than different vegetation types). The COA could opt in the future to expand the riparian areas as shown in Alternative 4: High Water Use. With an increasing supply of reclaimed wastewater this may be realistic.

4.3.2 Schools

With six school districts in the COA it is very difficult to know exactly where new schools will be located. All development areas considered in this study are north of Southern Avenue, or rather, on the north side of Gila River. As indicated earlier, although the COA comprises an area of approximately 55 square miles, the development area identified in this study is approximately 29 square miles.

There are currently eleven elementary schools in Avondale, two of which are K-8. Using information provided by the COA, CH2M HILL has assumed that there will be one new elementary school (or K-8) constructed per square mile of development, and that one additional high school will be constructed. Based on the development area of 29 square miles and eleven existing elementary/K-8 schools, it has been assumed that there will be 19 additional elementary/K-8 schools constructed over the next 25 years, or approximately one every 16 months. The average annual turf irrigation demand for an elementary school in the COA is 25 acre-ft per year, and the average demand for high schools is 86 acre-ft per year. As such, the approximate annual school turf irrigation requirement would rise from 391 acre-ft currently to 952 acre-ft by 2030.

4.3.3 HOAs

As shown in Table 2-1, the population of Avondale is projected to triple in the next 25 years. The COA's land use data shows that residential development accounts for approximately 63 percent of all development. Using an assumed available development area of approximately 19 square miles, we can estimate that residential development will account for 12 square miles, or approximately 7,680 acres. It has been estimated that if all new HOAs had 3-pipe systems installed, their annual water requirement for turf irrigation would be 1,560 acre-ft at City build out.

As discussed in Section 4.2.3, it was collectively determined by CH2M HILL and COA personnel that providing a 3-pipe system within existing or new HOAs or other existing residential areas was not economically feasible. As such, CH2M HILL does not recommend the City undertake the cost of installation of 3-pipe systems and/or delivery of reclaimed water to new HOA developments at this time.

However, if a future COA building initiative or state legislative action would require developers to install 3-pipe systems in new HOA developments at the developer's (home owner's) expense, then this action would make it more financially attractive for the City to provide reclaimed water to HOAs for turf irrigation purposes.

4.3.4 Landscaping Along Major Transportation Corridors

A major east-to-west four-lane highway is anticipated through the southern half of the COA, along the Southern Avenue alignment. It is expected that there will be some landscaping and irrigation requirements, at least at the interchange locations. For planning purposes, it is expected that the irrigation demands for this thoroughfare will equal the irrigation demands at the existing I-10 interchanges in the COA. Based on this assumption, the future demand for highway turf irrigation is expected to be 31 acre-ft per year. It has further been assumed that this highway will be constructed by 2015.

4.3.5 Summary of Future Potential Demand Locations and Users

Future reclaimed water demands are heavily weighted towards the construction of the riparian areas along the Agua Fria River. The heavy water use Alternative 4, which involves the construction of wetlands from McDowell Road south to the confluence of the Agua Fria and Gila Rivers, has a daily water demand of 10.6 mgd, which is more than twice the expected annual average WWTP effluent discharge in 2005.

The potential largest unknown reclaimed water demand is the extent to which new HOAs may elect, or be required by ordinance, to use reclaimed wastewater for turf irrigation purposes. However, at this time, it is not economically feasible for the COA to provide reclaimed water delivery and 3-pipe distribution systems to serve individual homes in either existing or new HOA developments unless the costs of installing the 3-pipe distribution portion of the system costs is paid by the developers or home owners. A summary of the potential future reclaimed water user demands is provided in Figure 4-4.

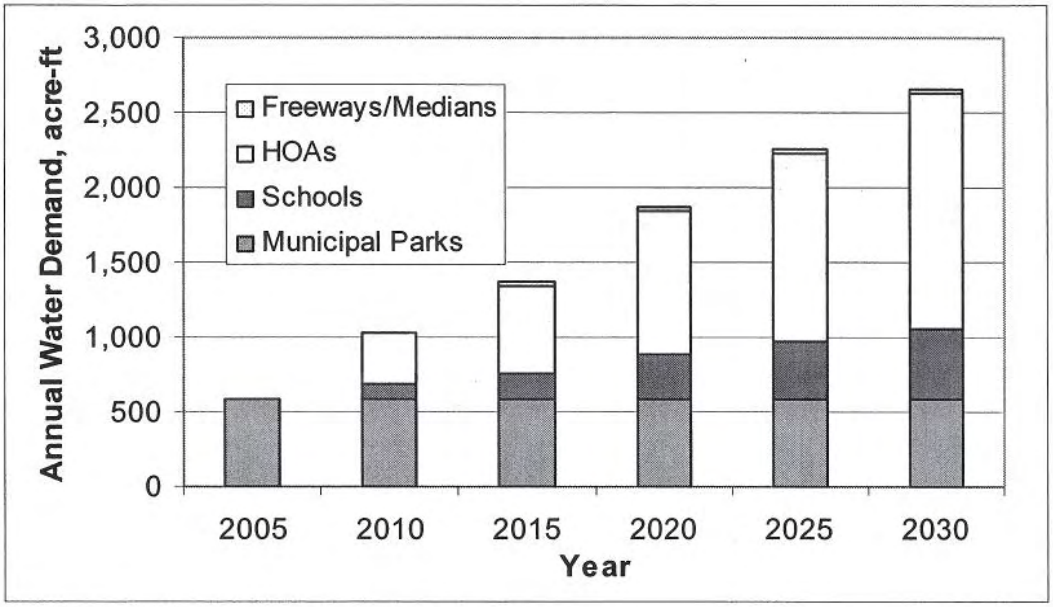


Figure 4-4. Summary of Future Reclaimed Water User Demands
Given the uncertainty regarding the future development of the Agua Fria Riparian Area, reclaimed water demands were not included.

4.4 Comparing Potential Existing + Future Reclaimed Water Demands to Effluent Production Rates

Using the potential reclaimed water demands provided in the previous sections, we can compare the demands from these potential users to the WWTP effluent production projections shown in Table 2-2. This comparison is shown in Figure 4-5.

As seen in Figure 4-5, future demands may exceed the COA's projected WWTP effluent production rates by 2025, although this is primarily dependant on full development of the riparian zones along the Agua Fria River. Without the development of these riparian areas, the total potential demand will never rise above 25 percent of the COA's WWTP effluent production rate, even if every other potential user elects to irrigate with reclaimed water.

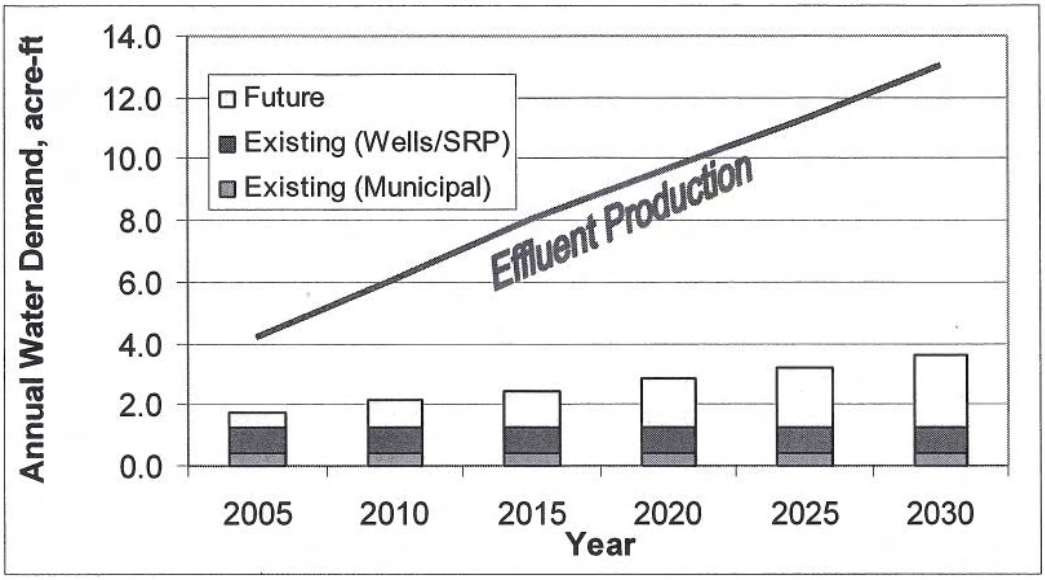


Figure 4-5. Existing and Future Potential User Demands versus Effluent Production Rates.
Given the uncertainty regarding the future development of the Agua Fria Riparian Area, reclaimed water demands were not included.

5.0 Hydraulic Model Analysis

The EPANET model was used to investigate various reclaimed wastewater distribution system tank, pump, and pipeline improvement alternatives. Tanks and pumps were strategically placed into the system model to provide adequate pressures to customers, as well as provide storage capacity to facilitate operational flexibility. The final results, which are discussed in the following sections, reflect the recommended proposed improvements required to provide the COA with the most cost effective options for either reusing or recharging their reclaimed wastewater.

5.1 Hydraulic Criteria

The COA does not have any specific hydraulic criteria developed for a reclaimed water distribution system. The design criteria listed below, used for sizing pumps and identifying reclaimed water line additions or improvements, were developed based on comments made by potential customers as well as the COA's potable water distribution water main criteria:

- Under peak hourly demand conditions, pressures should be maintained above 50 psi. This criteria was based on comments made by potential customers, who indicated that there was currently insufficient pressure in the City's potable water distribution system to efficiently run their irrigation systems. The desired delivery pressure from the reclaimed water system is 50-60 psi.
- Under maximum day demand conditions, pipes of all diameters should not have a head loss in excess of ten feet per 1,000 feet of length or a velocity in excess of 5 feet per second, whichever is limiting.

5.2 Model Development

As indicated, a hydraulic model of the proposed reclaimed water distribution system was created using EPANET. Pipelines, tanks, pumps, and demand "node" locations were entered manually to create the model. New reclaimed water distribution lines were extended from the proposed 24-inch force main between the city's WWTP and recharge basin to existing and future potential users that are represented by demand nodes. The reclaimed water distribution system was overlaid above a scaled GIS base map provided by the COA. Pipeline lengths were derived automatically by EPANET based on the scale of the base map and the length of the pipeline symbol entered. Node and pipeline end point elevations were all based off of USGS quad maps.

To develop a reclaimed water distribution system pipeline network, the previously proposed 24-inch reclaimed water force main from the WWTP to the COA's groundwater recharge basins was used as the backbone for the model. Figure 4-1 shows the alignment for this reclaimed water force main in relation to all existing and future potential customers which were identified in Sections 4.2 and 4.3.

5.2.1 Assigning User Demands into the Model

Model simulations were conducted by placing existing and future demands on the system at the nearest servicing node. Maximum day demands, rather than average day demands, were entered at the nodes. The rationale for using maximum day demands is that the system components, such as pipes and pumps, should be sized based on their ability to handle a maximum day event, as outlined in the hydraulic criteria established in Section 5.1. Based on preliminary economic evaluations and discussions with COA staff during this master planning process, system demands were limited to existing turf irrigators that currently use COA potable water and which are located in close proximity to the proposed 24-inch force main. SRP and private well owners were not considered because their water costs are so low ($0.03 per 1,000 gallons for SRP water) that the COA would be unable to provide a water source at a cheaper price. For those existing and future potential users who were not clustered or located in near proximity to the 24-inch force main, the costs associated with extending the reclaimed water distribution system to those existing and potential users was found to be very high compared to the limited revenues expected to be generated solely from the sale of reclaimed water for turf irrigation purposes.

Existing and future potential users discussed in Sections 4.2 and 4.3 of this report were condensed into Table 5-1, which lists only those potential users that were included in the final hydraulic model.

TABLE 5-1
Existing and Potential Reclaimed Water Users and Estimated Usage

User	Avg Day (gpd)	Max Day (gpd)
Agua Fria Riparian Area	2,000,000	2,000,000
New 40 acre park – Thomas Rd	53,000	153,700
New 40 acre park – Broadway Rd	53,000	153,700
Avondale Friendship Park	96,231	276,699
Donnie Hale Park	10,443	30,027
Las Ligas Park	11,104	31,927
Coldwater Park	12,587	39,968
Dennis DeConcini Park	6,609	19,004
Agua Fria High School	99,980	160,968
Corte Sierra Elementary School	24,995	40,242
Rancho Santa Fe Elementary School	29,458	47,428
Collier Elementary School	25,888	41,679
Canyon Breeze Elementary School	16,068	25,870
Garden Lakes Elementary School	7,141	11,503
Rio Vista Elementary School	14,283	22,995
LaJoya High School	62,488	100,605
Westview High School	68,736	110,666
St. Thomas K-8	100,000*	161,000*
Dysart Rd & I-10	8,320	24,654
115th & I-10 (north)	21,906	61,474
Total Estimated Use	**2,722,237 gpd** or **2.72 mgd**	**3,514,109 gpd** or **3.51 mgd**

*Note: St. Thomas K-8 is expanding to a K-12 school and although it currently has no athletic fields, it has been assumed that it will in the near future although this has yet to be verified. Agua Fria High School water demands have been used as an estimate for this school.

5.2.2 Diurnal Patterns

Diurnal patterns are used in hydraulic models to account for the temporal variability in user demands. Specifically, they are used to adjust static demand flows by a factor that is dependent on the time of day. For instance, although a given user may have an average daily demand of 10 gpm, they may use 15 gpm at 8 a.m. and only 5 gpm at midnight. There are two diurnal patterns used in the COA reclaimed water hydraulic model:

- User demands
- WWTP effluent production

The rates at which reclaimed water is produced and used are different. Each diurnal cycle is discussed in more detail below.

5.2.2.1 User Demand Diurnal Pattern

Based on interviews with potential reclaimed water customers, it was found that most users turf irrigated at night. The primary reason for this was that major turf irrigators, such as the Parks Department and high schools, are encouraged by the COA to irrigate at night during non-peak hours to conserve the use of potable water. Irrigating at night also relieves stress on the City's potable water distribution system during the day when other customer demands are highest. Although potential users would have additional flexibility to irrigate longer hours if provided reclaimed water, it has been assumed that they would still tend to irrigate at a constant rate for approximately 8 hours at night to minimize human contact with the irrigation water. Based on this assumption, the average daily water demand for all turf irrigators would then be applied in 8 hours, which results in a diurnal factor of 3.0, as shown in Figure 5-1.

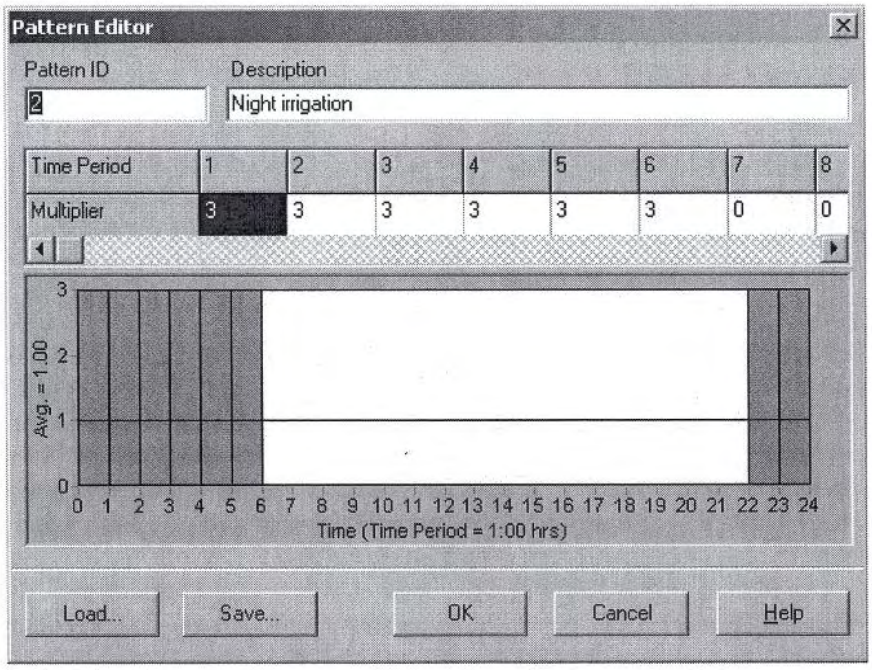


Figure 5-1. User Demand Diurnal Cycle

5.2.2.2 WWTP Effluent Production Diurnal Pattern

Based on information provided in the *Treatment Facilities Master Plan* (DSWA 2004a), the peak hour peaking factor for wastewater entering the WWTP on a maximum day was shown to be 1.24. Or, in other words, during maximum day events, the peak influent rate is 1.24 times higher than the average maximum daily flow. This peaking factor should not be confused with the peaking factor used to describe maximum day, peak hour flow to average day flow. The 1.24 peaking factor is a good measure for the variability in flow during a maximum day event, and therefore used in the model for the reclaimed water distribution system. There was insufficient data within the *Treatment Facilities Master Plan* (DSWA 2004a) to generate hourly peaking factors, so CH2M HILL developed a typical diurnal pattern that has a 1.24 peaking factor at 8 a.m. and at 6 p.m., as shown in Figure 5-2.

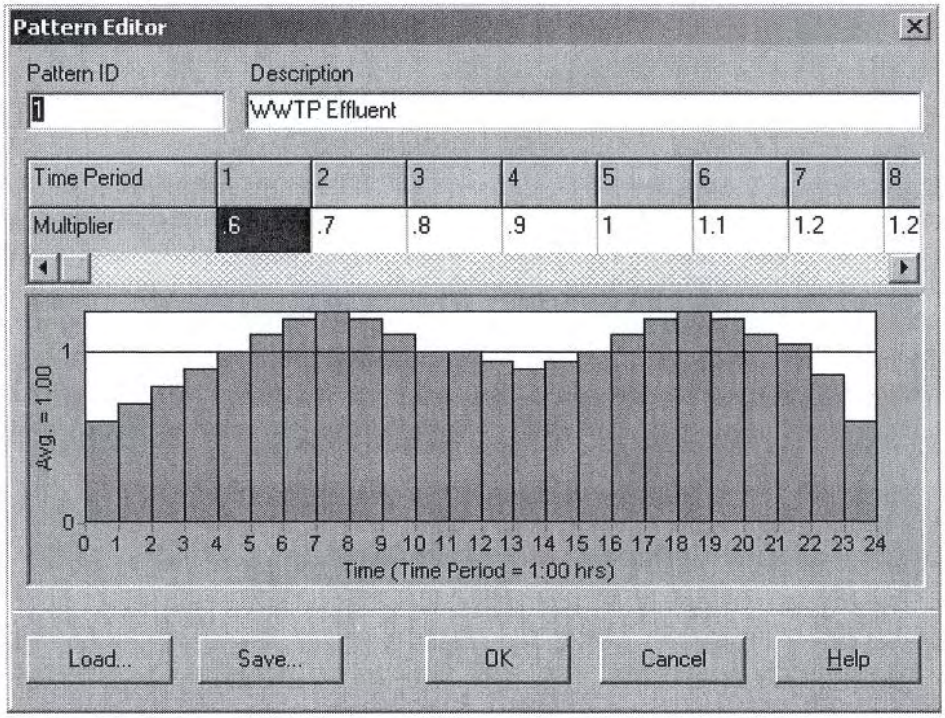


Figure 5-2. WWTP Effluent Production Diurnal Cycle

5.2.3 Modeling WWTP Effluent Production, Storage Tank, and Pumping Station

The WWTP effluent production was modeled as a negative demand node and assigned a diurnal pattern as discussed in Section 5.2.2.2. Rather than function as a user, assigning a negative demand allows the node to function as a water source. The WWTP effluent demand node was placed at the beginning of the hydraulic system, upstream of a simulated 2-million-gallon storage tank. Modeled flows from the WWTP enter the tank at a rate governed by the treatment plant diurnal cycle, as would be expected in real situations. The pump station at the WWTP then pumps water out of the simulated tank at a nearly constant rate. The pumping rate in the model is designed to pump the average maximum day effluent production rate. The simulated tank serves as a buffer during times of the day when the pumps are pumping faster than effluent is being produced, e.g. during low-production

times in the middle of the night, or during times of the day when the pumps cannot keep up with the effluent production, e.g. at high-production times in the morning and late afternoon.

5.2.4 Recharge Basins

The COA recharge basin was modeled as a constant-head reservoir. Although it is acknowledged that the water level in the basin will fluctuate to some degree, for the purposes of modeling the level is assumed to be held constant. By setting the force main discharge pressure at the recharge basin to approximately 0 pounds per square inch (psi), the resulting head at the recharge basins serves as a benchmark pressure by which the hydraulic system operates.

5.2.5 Model Evaluation

Although potential users support the idea of a high-pressure system, CH2M HILL realizes that it may not be financially feasible to extend service to new users, and that it may be in the best interest of the COA to simply recharge all of their reclaimed wastewater. To examine both cases, CH2M HILL developed two model scenarios: (1) low-pressure force main, and (2) high-pressure distribution system. Two distinct models of the proposed COA reclaimed water distribution system were developed:

- A high-volume, low-pressure system as previously recommended in the *Treatment Facilities Master Plan* (DSWA 2004a)
- A high-volume, high-pressure system. As outlined in Section 5.1, Hydraulic Criteria, potential users interviewed have said they would only be willing to switch to reclaimed water if it were cost effective and if the water pressure was above 50 psi. The low-pressure pipeline scenario assumes that users will pay for and maintain their own booster stations, a concept that was found to not be supported by the individual users during their interviews with CH2M HILL staff.

5.2.5.1 Low-Pressure Force Main Scenario

The low-pressure scenario entails the modeling of:

- The 24-inch force main from the WWTP to the COA's recharge basin
- Storage facilities at the WWTP
- Low-pressure pump station at the WWTP
- Potential user nodes at Coldwater Springs Golf Course, Friendship Park, the COA recharge basin, and the future Agua Fria Riparian Restoration Area

A low-pressure system precludes all users, other than those listed above, from using reclaimed wastewater for turf irrigation because the low pressures associated with this system are lower than the pressures requested by potential users. Coldwater Springs Golf Course and Friendship Park are different from the other users in that they have their own water storage ponds and pumping facilities that allows them to receive low-pressure water supplies. The future Agua Fria Riparian Restoration Area also does not require a

pressurized reclaimed water supply. Figure 5-3 shows the Low-Pressure Force Main Scenario.

5.2.5.2 High-Pressure Distribution System Scenario

The high-pressure scenario is an expansion of the Low-Pressure Force Main Scenario, and includes the following additional elements:

- A high-pressure rather than a low-pressure pump station at the WWTP
- A pipe distribution network that connects all potential users identified in Table 5-1 to the 24-inch force main.

The high-pressure reclaimed water distribution system also allows the COA the flexibility to serve all potential customers in close proximity to the proposed 24-inch force main alignment. The High-Pressure Distribution System Scenario pipe network is shown in Figure 5-4.

5.2.6 Low-Pressure Force Main Scenario Model Results

The Low-Pressure Force Main Scenario was modeled for Years 2005, 2010, 2020, and 2030. For each year modeled, the WWTP effluent production rate was modeled for both average day and maximum day conditions, the values for which are shown in Table 2-2.

5.2.6.1 Pumping Power Requirements

The pumping requirement to convey water from the WWTP to the COA recharge basins becomes greater and greater every year as the COA population grows and more effluent is produced. As previously proposed in the DSWA report (2004b), a phased pump station expansion will be required.

Assuming a 24-inch ductile iron pipeline with a standard Hazen-Williams friction coefficient of 140 is installed, CH2M HILL was able to estimate the pumping power requirement on an annual basis. A generic pump was used within the model to estimate pipe friction and thus a resulting system head curve. With a known flow and head, the pumping power requirement can be calculated as indicated in Table 5-2 below.

TABLE 5-2
Low-Pressure Force Main Scenario Pumping Requirements

Year	Average Annual Effluent Projection (mgd)	Low Pressure Power Requirement (kW)	Low Pressure Pumping Head Requirement (psi)
2005	4.80	38	23
2010	6.57	71	30
2020	9.80	181	52
2030	12.91	347	76

kW = kilowatts

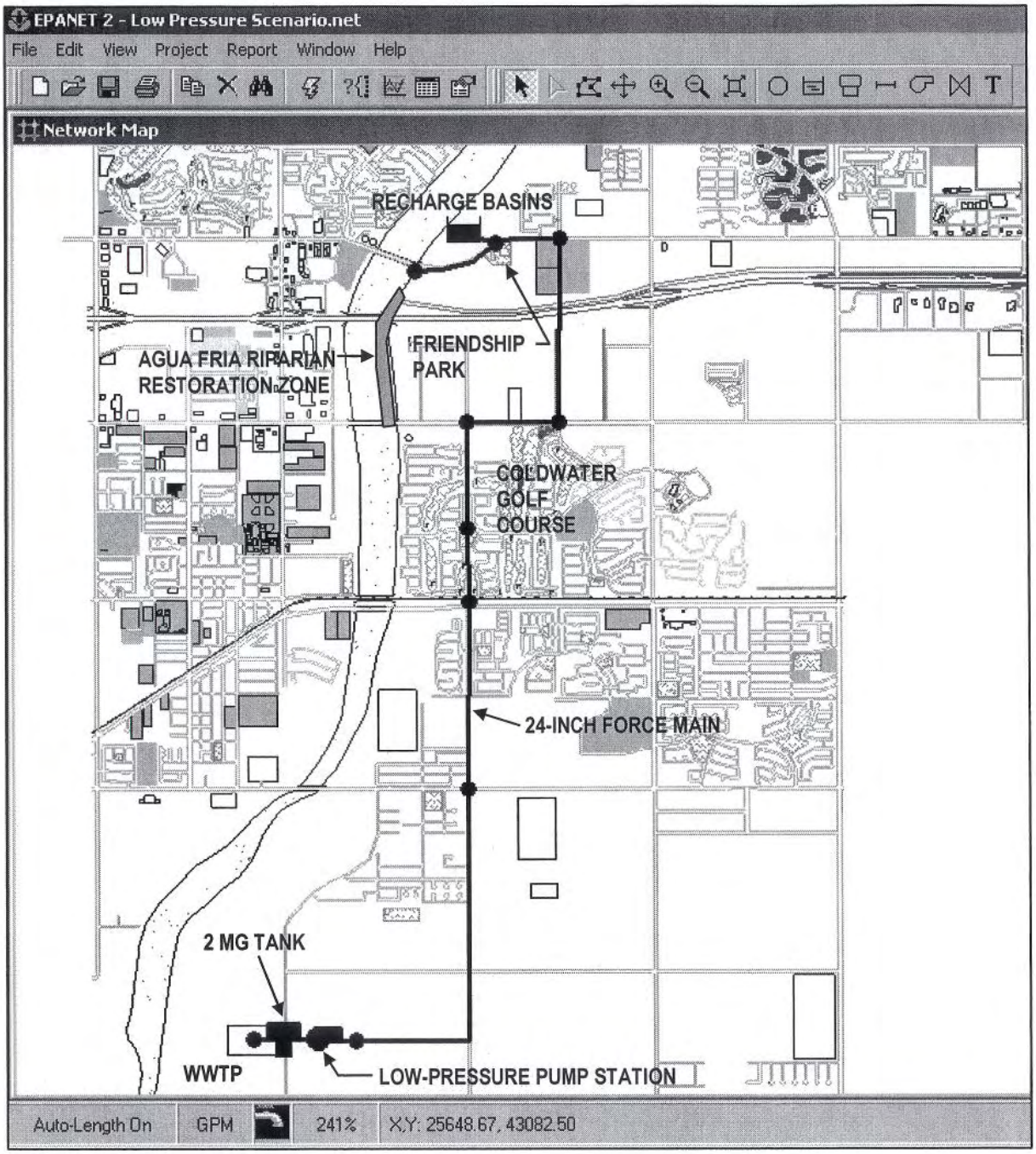


Figure 5-3. Low-Pressure Force Main Scenario

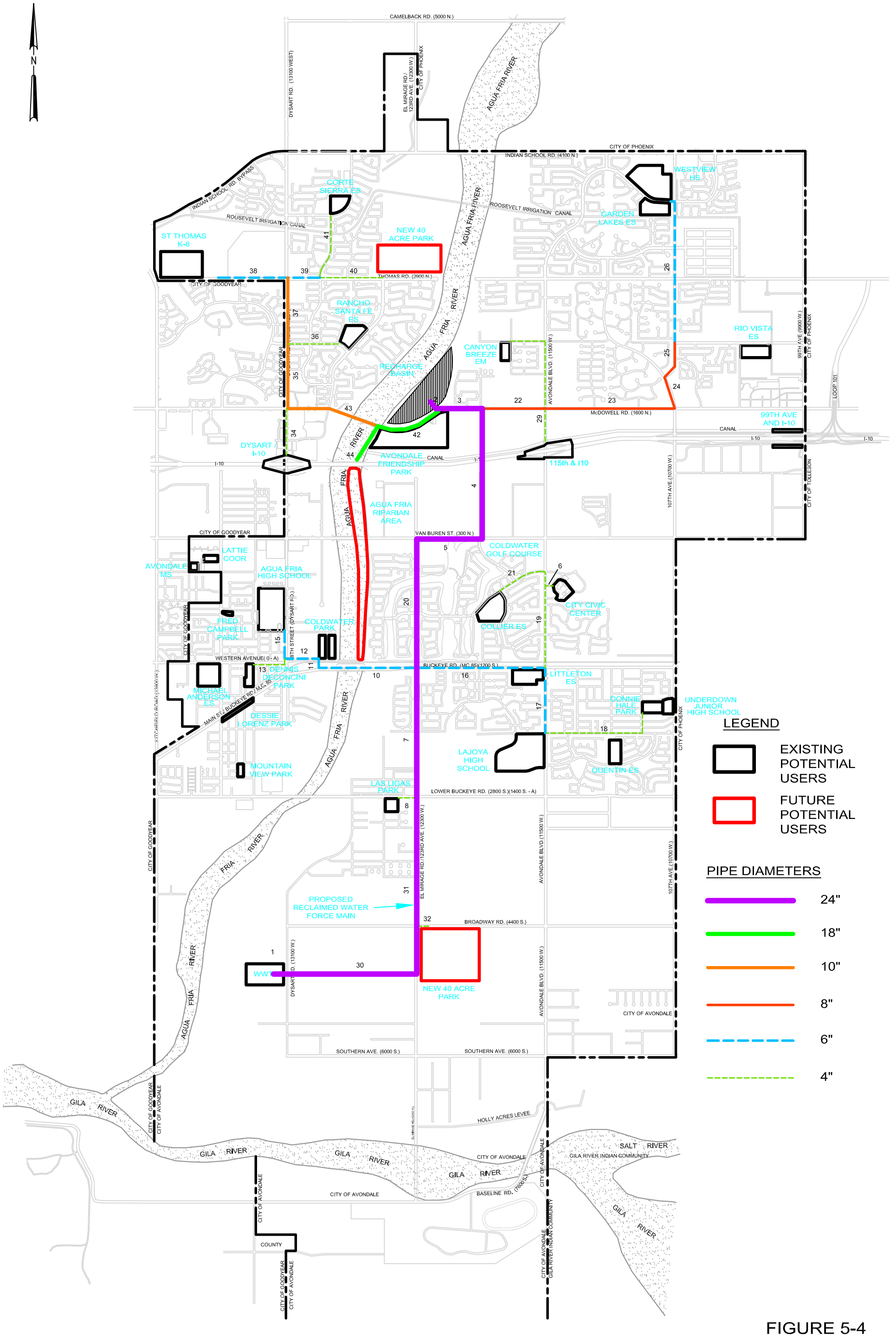


FIGURE 5-4

HIGH PRESSURE DISTRIBUTION SYSTEM SCENERIO

CH2MHILL

AvondaleAzCityof\322128ReclaimWater\CAD\FIG_5-4.DWG

5.2.6.2 Storage Requirements

Storage volume is required as a buffer in water supply/demand situations. Pumps are generally designed for maximum day conditions. However, during peak hour conditions production volumes will surpass the design pumping capacity, and storage volume is required to hold these excess flows until the pumps can catch back up. For the model simulation, the storage tank was modeled as being 2 million gallons, round, 20 feet in height, and 130 feet in diameter.

For the wastewater production diurnal curve shown in Figure 5-2, the pumping capacity was sized to pump the average flow rate, as shown as a blue line in Figure 5-5. The area above the blue line is equal to the area below it, but the storage tank must be capable of containing the volume associated with the portion of the curve above the line. This volume may be determined by integrating the shaded area shown in Figure 5-5. Under the highest production scenario examined—2,030 with a maximum day flow of 18.08 mgd—the total storage volume required is 1.15 million gallons.

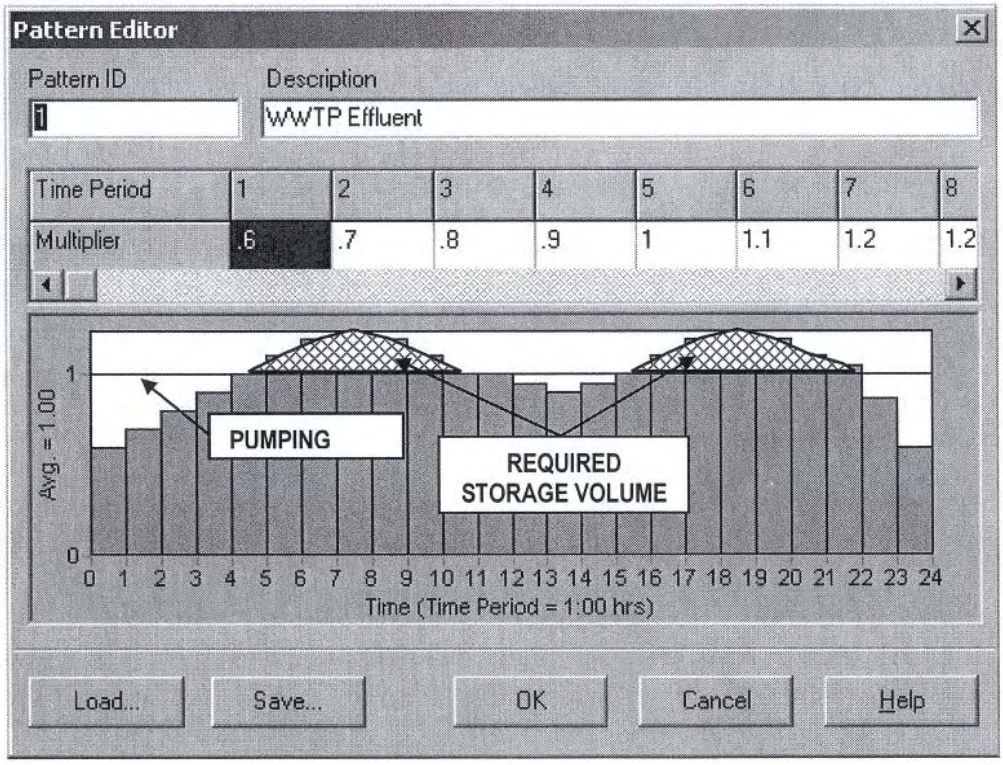


Figure 5-5. Storage Volume Requirement

The model simulation results show that a time-series plot of the water level in the simulated 2-million-gallon storage tank, as shown in Figure 5-6, fluctuated between 3 feet and 17 feet. The 3 feet of freeboard and unused volume at the bottom of the tank provide operational flexibility. Based on the model results, the appropriate size for the storage tank at the WWTP is 2-million-gallons.

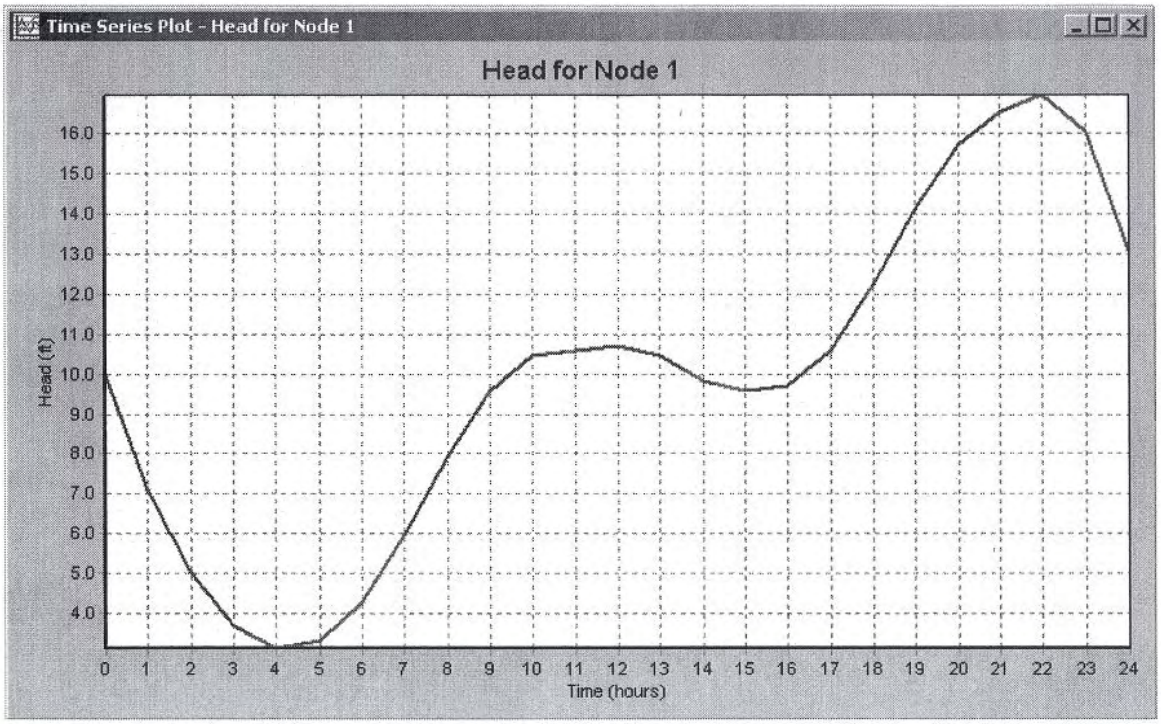


Figure 5-6. Storage Tank Level Fluctuation, Simulated

5.2.7 High-Pressure Distribution System Scenario Model Results

CH2M HILL and COA personnel collectively selected potential users that were more economically viable to serve than others. Those potential users are listed in Table 5-1. A hydraulic model was developed that extended a pipe network to these potential users.

5.2.7.1 Pipe Sizing

Pipelines in the hydraulic model were sized as outlined in Section 5.1, Hydraulic Criteria. Specifically, the pipes were sized such that "...under maximum day demand conditions, pipes of all diameters should not have a head loss in excess of ten feet per 1,000 feet of length or a velocity in excess of 5 feet per second, whichever is limiting."

Pipe identification numbers assigned to each pipe within the model are shown in Figure 5-4. Table 5-3 lists the simulated hydraulic data associated with these pipes, such as velocity and unit head loss. As shown in Table 5-3, all pipes meet the pipe sizing hydraulic criteria, the exception being the 24-inch force main, which violates the velocity criterion of being less than 5 feet per second. However, the 24-inch force main meets the unit head loss requirement. Based on the future WWTP maximum day flows, anticipated to be approximately 18.08 mgd by 2030, the total head loss along the 24-inch force main will be approximately 320 feet. The long-term pumping costs associated with this head loss will be significant. In DSWA's report (2004b), a cost analysis was performed that evaluated capital and operations costs for both 24-inch and a 30-inch pipelines. The result of this cost analysis favored the 24-inch pipeline. CH2M HILL has not verified this analysis as part of this Master Plan.

TABLE 5-3
Pipe Modeling Results (2030 Max Day, 5 a.m. Simulation Time)

Pipe ID	Description	Diameter (in)	Length (ft)	Flow (gpm)	Velocity (fps)	Unit Headloss (ft/Kft)
1	WWTP to Storage Tank	30	1,167	13,811.0	6.27	3.78
2	Force Main	24	974	9,147.7	5.37	3.21
3	Force Main	24	1,920	11,186.6	6.81	4.99
4	Force Main	24	5,412	11,408.9	6.97	5.2
5	Force Main	24	2,639	11,408.9	6.97	5.2
7	Force Main	24	5,507	11,863.1	7.29	5.66
20	Force Main	24	5,316	11,408.9	6.97	5.2
30	Force Main	24	6,567	11,996.6	7.39	5.79
31	Force Main	24	5,393	11,886.2	7.31	5.68
42	Force Main to Agua Fria Riparian Area	18	2,351	1,838.4	2.32	0.95
44	Force Main to Agua Fria Riparian Area	18	1,283	1,388.9	1.75	0.56
35	To NW quadrant	10	2,726	432.9	1.77	1.14
37	To NW quadrant	10	2,696	370.8	1.51	0.86
43	To NW quadrant	10	4,229	449.5	1.84	1.22
22	To NE quadrant	8	2,674	222.3	1.42	0.98
23	To NE quadrant	8	5,430	143.2	0.91	0.44
24	To NE quadrant	8	1,353	143.2	0.91	0.44
25	To NE quadrant	8	1,601	143.2	0.91	0.44
10	To SW quadrant	6	3,715	248.3	2.82	4.9
11	To Coldwater Park	6	336	248.3	2.82	4.9
12	To SW quadrant	6	1,712	222.1	2.52	3.98
15	To Agua Fria High School	6	1,240	208.3	2.36	3.54
16	To Littleton Elementary School	6	5,405	151.9	1.72	1.97
17	To LaJoya High School	6	2,765	151.9	1.72	1.97
26	To Westview High School and Garden Lakes Elementary School	6	5,932	143.2	1.62	1.77
38	To St. Thomas K-8	6	3,284	208.3	2.36	3.54
39	To New Park and Corte Sierra Elementary School	6	1,395	162.5	1.84	2.23
6	To COA Hall	4	200	~0	~0	~0
8	To Las Ligas Park	4	670	23.1	0.59	0.44
13	To Dennis DeConcini Park	4	1,358	13.8	0.35	0.17
18	To Donnie Hale Park and Underdown Junior High School	4	5,363	21.8	0.56	0.39
19	To COA Hall and Collier Elementary School	4	2,892	53.9	1.38	2.09
21	To Collier Elementary School	4	3,214	53.9	1.38	2.09
28	To Canyon Breeze Elementary School	4	4,207	33.5	0.85	0.86
29	To I-10 and 115th Avenue	4	1,324	45.6	1.16	1.53
32	To New Park (Broadway/El Mirage)	4	347	110.4	2.82	7.87
34	To I-10 and Dysart Road	4	1,890	17.3	0.44	0.26
36	To Rancho Santa Fe Elementary School	4	2,201	61.4	1.57	2.65
40	To New Park (Thomas Road)	4	2,603	110.4	2.82	7.87
41	To Corte Sierra Elementary School	4	2,783	52.1	1.33	1.96

fps = feet per second
ft/Kft = feet (of headloss) per thousand feet (of pipe)

5.2.7.2 Pumping Power Requirements

Using the same approach as outlined in Section 5.2.6.1 for the low-pressure force main scenario, the pumping power requirements for the high-pressure force main scenario were determined and are presented in Table 5-4 below. In general, approximately 75 psi additional pumping pressure is required for the high-pressure force main scenario to maintain a minimum pressure of 50 psi at the most remote customers.

TABLE 5-4
High-Pressure Force Main Scenario Pumping Requirements

Year	Average Annual Effluent Projection (mgd)	High Pressure Power Requirement (kW)	High Pressure Pumping Head Requirement (psi)
2005	4.80	168	99
2010	6.57	248	106
2020	9.80	437	126
2030	12.91	685	149

5.2.7.3 System Pressures

The minimum pressures recorded during maximum day model simulations occurred during the peak use hours of 10 p.m. and 6 a.m. The simulated pressure results for 2030 maximum day conditions at the potential user "nodes" are shown in Table 5-5. Note that these pressures were derived using a generic pump curve for the simulated pump station located at the COA's WWTP. Actual pressures at the potential user locations will be decided by a final pump selection; however, Table 5-5 is useful for examining the pressure differences between the various potential users. Those potential users located nearer the WWTP, or adjacent to the 24-inch force main, have significantly higher pressures than users located in the City's upper northeast or northwest areas. In some cases, Pressure Reducing Valves (PRVs) will be required to reduce pressures to the turf irrigation systems for some users close to the 24-inch force main.

5.2.7.4 Storage Requirements

The storage requirements for the high-pressure scenario are the same as for the low-pressure scenario, as discussed in Section 5.2.6.2.

TABLE 5-5
Simulated Model Pressures at Potential User Locations, 2030 Maximum Day Conditions

User	Pressure (psi)
Las Ligas Park	118.2
Friendship Park	74.6
Coldwater Springs Golf Course	86.7
New 40 acre Park (Broadway/El Mirage)	137.6
LaJoya High School	87.8
Donnie Hale Park	85.6
COA Civic Center	82.3
Collier Elementary School	85.1
Coldwater Park	95.8
Agua Fria High School	90.0
Dennis DeConcini Park	92.3
115th and I-10	68.7
Canyon Breeze Elementary School	65.4
Westview High School	53.5
Agua Fria Riparian Area	77.6
Dysart Road and I-10	67.7
Rancho Santa Fe Elementary School	61.0
St. Thomas K-8*	53.2
Corte Sierra Elementary School	50.2
New 40-acre Park (Thomas/El Mirage)	51.0

TABLE 7-1
Proposed Capital Improvement Program—Phased Reclaimed Water Distribution System Implementation Plan

Project	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Phase 1																
2-Million-Gallon Storage + Low-Pressure Pump Station + 24-inch Force Main	← $10,060,000 →															
Phase 2																
Pump Station Upgrade No. 1							← $196,000 →									
Phase 3																
Pump Station Upgrade No. 1											← $196,000 →					
Phase 4 (Optional)[1]																
Additional Treatment No. 1	← $3,615,000 →															
Pump Station Upgrade No. 1	← $619,000 →															
Distribution System Extension				← $2,075,000–$5,000,000+ →												
Additional Treatment No. 2						← $1,205,100 →										
Pump Station Upgrade No. 2							← $392,000 →									
Pump Station Upgrade No. 3											← $392,000 →					
Additional Treatment No. 3														← $1,205,100 →		

Notes:

Costs presented above include a 20 percent allowance for engineering and construction administration, and a 30% contingency allowance.

[1]Subject to the COA developing a significant new reuse customer base for the reclaimed water.

6.0 Economic Analysis

The purpose of this section is to discuss and summarize economic considerations that may be useful to the COA in planning for the implementation of a reclaimed water distribution system.

6.1 Reclaimed Water Distribution System Alternatives

CH2M HILL looked at six alternatives to compare costs to revenue and overall water conservation potential. A description of each alternative is provided below. Detailed costs and revenues were developed for each alternative and are presented in Section 6.2 Reclaimed Water Cost Analyses. Section 6.3 compares reclaimed water system alternative costs, and Section 6.4 outlines the rate increases necessary to implement each alternative.

6.1.1 Alternative 1 (Do Nothing)

Alternative 1 is a benchmark cost, and examines the impact to the City's overall water supply without recharging or reusing their wastewater effluent. Although the City is not considering this alternative, it is a helpful parameter for comparing other alternatives.

6.1.2 Alternative 2 (Recharge Only)

Alternative 2 is the cost of installing and operating a recharge system only. The components of this system include a 2-million-gallon storage tank and low-pressure pumping station at the COA's WWTP and a 24-inch force main from the WWTP to the City's recharge basins. There are no added treatment costs or revenues generated associated with Alternative 2.

6.1.3 Alternative 3 (Recharge + Reuse at Coldwater Springs Golf Course)

Coldwater Springs Golf Course does not require water to be supplied at high pressures. Coldwater Springs Golf Course has holding ponds and onsite pumping facilities. Therefore, high-pressure pumping capacity at the WWTP would not be required. The golf course currently uses their own wells and SRP supply to meet their demands. However, the COA has indicated that they may supply the golf course with reclaimed water in the future if an equitable arrangement can be worked out between the parties. Alternative 3 is being presented to reflect this possibility. As with Alternative 2, the reclaimed water would not need to be treated to Class A+ because golf courses are allowed to use Class B+ water for turf irrigation. Connection costs to Coldwater Springs Golf Course are assumed to be negligible because it is located adjacent to the proposed 24-inch force main alignment.

6.1.4 Alternative 4 (Recharge + Reuse at Friendship Park, Agua Fria Riparian Area & Coldwater Springs Golf Course)

Friendship Park currently uses their own well water, which is pumped into a pond at the park. Water from the pond is pumped onsite at sufficient pressure to feed the irrigation system. Alternative 4 assumes that reclaimed water would replace the park's well water

supply, and that the existing onsite pumping facilities would continue to be used. Therefore, high-pressure pumping capacity at the WWTP would not be required. It is not expected that revenues would be generated from the sale of reclaimed water to Friendship Park. The future Agua Fria Riparian Area will be located on the east side of the Agua Fria River at McDowell Road, approximately one half mile west of Friendship Park. This future Riparian Area will also not require a pressurized water supply but, similar to Friendship Park, the reclaimed water would need to be treated to Class A+. Connection costs to Friendship Park are assumed to be negligible because Friendship Park is again located adjacent to the proposed 24-inch force main alignment. Additional capital costs would be required to extend service to the Agua Fria Riparian Area.

6.1.5 Alternative 5 (Recharge + Reuse at Coldwater Springs Golf Course, Friendship Park and all other potential users)

Alternative 5 outlines the costs and revenues for a high-pressure reclaimed water distribution system that supplies all of the existing and known future potential users that are identified in Table 5-1. This alternative has the highest revenue-generating potential for all alternatives presented herein, but it also has the highest distribution and pumping costs of the alternatives presented herein. Treatment costs for Alternative 5 are the same as Alternative 4.

6.1.6 Alternative 6 (Recharge + Reuse at Coldwater Springs Golf Course, Friendship Park, LaJoya HS, Coldwater Park, Agua Fria HS, Las Ligas Park, New 40-acre COA Park, Collier ES, I-10 & 115th)

During the master planning process, CH2M HILL and the City selected several of the more cost effective potential turf irrigators from Alternative 5 that were considered to have higher revenue to capital cost ratios than the other users. Alternative 6 outlines the costs and revenues for a high-pressure reclaimed water distribution system that supplies these more economically viable potential users that are in close proximity to the proposed 24-inch force main with Class A+ reclaimed water.

6.2 Reclaimed Water Cost Analysis

CH2M HILL conducted a detailed reuse/recharge cost analysis to assist the COA in prioritizing their reclaimed water distribution system plan. The specific cost elements that were examined as part of this analysis are as follows:

- Purchased water costs;
- Distribution system costs;
- Treatment costs;
- Pumping costs;
- Storage costs; and
- Operations and maintenance costs.

Each of these specific cost elements is discussed in more detail below.

6.2.1 Purchased Water Costs

As presented in Section 1.0 of this report, the COA will need to purchase water from other sources in the future to supplement their current SRP and CAP allotments. Maximizing the recharge or reuse of their reclaimed water has been presented as an option to offset the need of purchasing water. Purchasing water beyond the City's current SRP and CAP allotments is expensive, and cannot be considered a sustainable supply because the COA has not reached a contractual agreement with any water-selling entity to secure a supply beyond their current allotments. The COA currently has an agreement with CAGRD for replenishment up to 3,444 ac-ft per year of supplemental supply on COA's behalf, if necessary. In 2004, the COA's potable demand surpassed their combined SRP and CAP allotments and the COA purchased 2,946 ac-ft of CAP surplus water. However, continuing to buy water from CAP is contingent upon CAP having sufficient water resources to distribute, and during drought years this supply may not be available. The City is therefore currently investigating other purchased water supplies. The costs of the COA's current water supplies are shown in Table 6-1 below.

TABLE 6-1
Purchase Costs for COA Water Supplies

Source	2005 Purchase Cost ($/ac-ft)	Price Increase per Year (percent)	Allotment (ac-ft/yr)
SRP	23	3	5,500 (2005) to 13,200 (2030)
CAP	107	3	5,416
CAGRD	231	4	3,444
		Total	13,270 (2005) to 18,530 (2030)

The estimated price increases per year were estimated by the COA, based on historical price rate increases from 2002 to present. It has been assumed that the price rate increases will increase every year at the same rate.

6.2.1.1 Using Reclaimed Water to Offset Purchased Water Costs

The *Water Resources Master Plan* (RBF 2002) did not attempt to quantify a specific economic value of reclaimed water, but correctly stated that "reclaimed water is such a valuable water resource that it ALL should be reused or recharged." From a holistic standpoint, the value of a unit of reclaimed water, either reused for turf irrigation purposes or recharged, is the value of not having to pay for a unit of water from another source that has to be imported and/or treated. From this perspective, the economic value of reused or recharged reclaimed wastewater is the same. However, there are some additional water conservation considerations that are presented below.

6.2.1.1.1 Recharge Conservation Potential

The COA will receive a groundwater recharge credit of 95 percent when they discharge their reclaimed wastewater into their recharge basin. In other words, the ADWR credits their groundwater allotment with 95 percent of the total volume of water recharged. The COA can then withdraw this amount of water from their wells to supply their potable water system. From this perspective, the one unit of recharged water yields 0.95 units of potable well supply water.

6.2.1.1.2 Reuse Conservation Potential

For every one unit of reclaimed water used to replace potable water for turf irrigation, the COA is spared the use of one unit of potable well supply water. Additionally, the COA receives a 4.4 percent groundwater recharge credit by the ADWR for every unit of reclaimed water used in turf irrigation. From this perspective, one unit of reused reclaimed water is equivalent to 1.044 units of potable well supply water.

Using the known reclaimed water production rates and known reuse demands for each alternative, the potential for each alternative to offset purchased water costs may be calculated. The proportions of reclaimed water recharged or reused are presented in Table 6-2 below for Year 2030. The total volume recharged and/or reused will increase every year until ultimate build-out as the volume of wastewater production increases proportionally with the population.

TABLE 6-2
Reclaimed Water Use, Recharge vs. Reuse, Year 2030

Alternative	Percent Recharged (%)	Percent Reused (%)	Volume Recharged (ac-ft/yr)	Volume Reused (ac-ft/yr)	Total Recharge Credit (ac-ft/yr)
Alternative 1	0	0	0	0	0
Alternative 2	100	0	14,462	0	13,739
Alternative 3	96	4	13,887	575	13,793
Alternative 4	95	5	13,779	683	13,804
Alternative 5	93	7	13,458	1,004	13,834
Alternative 6	94	6	13,528	934	13,827

6.2.1.2 Estimated Purchased Water Costs Per Alternative

The COA's estimated potable water demands, as provided in the *City of Avondale Water Resources Master Plan* (RBF 2002b), were compared to water supply allotments and reclaimed water projections as a means of calculating future purchased water costs. For each year, any potable demands beyond the COA's reclaimed water benefit were assumed to come first from SRP, then CAP, and finally CAGRD. For the purposes of this analysis it was assumed that water in excess of the CAGRD annual allotment of 3,444 ac-ft would be purchased at CAGRD rates, from either CAGRD or some other currently unidentified source.

For each alternative, the purchased water cost rises every year to account for a) the rising cost of purchased water, and b) the higher potable water demands in the City due to an increasing population. The cumulative costs of purchasing water over the next 25 years, until expected ultimate build-out in 2030, were discounted to 2005 dollars assuming an interest rate of 5-percent. These discounted costs represent an approximate cost of what the City would have to invest in 2005 to cover the anticipated purchased water costs over the next 25 years. The discounted present value costs for each alternative are shown in Table 6-3. More detailed purchased water costs are presented in Table 6-4.

TABLE 6-3
Present Value of Purchased Water Costs per Alternative—2005 $

Alternative	Present Value Purchased Water Costs ($)
Alternative 1—Do Nothing	65,120,960
Alternative 2—Recharge Only	19,089,730
Alternative 3—Recharge plus Reuse at Coldwater Springs Golf Course	16,825,260
Alternative 4—Recharge plus Reuse at Friendship Park, Agua Fria Riparian Area & Coldwater Springs Golf Course	16,397,270
Alternative 5—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park and all other potential users	16,297,880
Alternative 6—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park, LaJoya HS, Coldwater Park, Agua Fria HS, Las Ligas Park, New 40-acre COA Park, Collier ES, I-10 & 115th)	16,320,360

6.2.2 Capital Costs

6.2.2.1 Distribution System Costs

With the exception of the 24-inch pipeline from the COA's WWTP to the recharge basins, all other distribution system costs for each alternative have been developed as part of this study. The 6.3 mile long, 24-inch pipeline was sized by others and the 2005 costs associated with this low-pressure, high-volume pipeline were previously estimated by others to be approximately $8.4 million (City of Avondale 2004b).

In Table 5-1 (and Figure 5-4), a summary of existing and potential users of reclaimed water are listed. The estimated capital costs of providing a reclaimed water distribution system to serve these users are listed in Table 6-5.

The distribution system capital costs, as presented in Table 6-5, were summarized for each alternative, and are presented in Table 6-6.

6.2.2.2 Treatment Costs

The water quality of the effluent at the COA's WWTP is currently classified as Class B+ and no additional levels of treatment would be required for the purposes of recharging, for restricted access landscape irrigation, or for golf course irrigation. However, for the purposes of reusing reclaimed water for non-restricted turf irrigation, for instance at schools and parks, the ADEQ requires that at least Class A effluent be used. Improvements, specifically filtration, would thus be required at the City's WWTP to increase the quality of the plant's effluent from Class B+ to Class A+.

The City's recent *Application to EPA Workplan* (2004), prepared by the City's Utilities Department, outlined $5.85 million (2004 costs) in filtration requirements to be implemented in three phases over 20 years specifically to improve plant effluent quality from Class B+ to A+. The $5.85 million in additional treatment costs has been converted to 2005 costs at an assumed rate of 3-percent annual inflation, and the individual costs and approximate dates for each phase are presented below:

- Phase 1 (2005): $3,615,300
- Phase 2 (2010): $1,205,100
- Phase 3 (2018): $1,205,100

TABLE 6-4
Estimated Purchased Water Costs per Alternative

			Non-Purchased Water				Purchased Water						
Year	Alternative	Demand (ac-ft)	Recharge Credit (ac-ft)	Phase In Allowance (ac-ft)	Incidental Recharge (ac-ft)	Acquired Water Rights (e.g. Coldwater GC, Friendship Park) (ac-ft)	SRP	$/ac-ft	CAP	$/ac-ft	CAGRD	$/ac-ft	$/yr
2005	1	13,855	0	265	221	0	5,500	23.00	5,416	107.00	2,453	231.00	**1,272,655**
2005	2	13,855	5,108	265	221	0	5,500	23.00	2,761	107.00	0	231.00	**421,927**
2005	3	13,855	5,162	265	221	575	5,500	23.00	2,132	107.00	0	231.00	**354,624**
2005	4	13,855	5,173	265	221	683	5,500	23.00	2,013	107.00	0	231.00	**341,891**
2005	5	13,855	5,173	265	221	683	5,500	23.00	2,013	107.00	0	231.00	**341,891**
2005	6	13,855	5,173	265	221	683	5,500	23.00	2,013	107.00	0	231.00	**341,891**
2010	1	18,708	0	265	510	0	7,040	26.66	5,416	124.04	5,477	281.05	**2,398,798**
2010	2	18,708	6,992	265	510	0	7,040	26.66	3,901	124.04	0	281.05	**671,566**
2010	3	18,708	7,046	265	510	575	7,040	26.66	3,272	124.04	0	281.05	**593,545**
2010	4	18,708	7,057	265	510	683	7,040	26.66	3,153	124.04	0	281.05	**578,785**
2010	5	18,708	7,087	265	510	683	7,040	26.66	3,123	124.04	0	281.05	**575,063**
2010	6	18,708	7,080	265	510	683	7,040	26.66	3,130	124.04	0	281.05	**575,940**
2015	1	23,560	0	265	798	0	8,580	30.91	5,416	143.80	8,501	341.94	**3,950,861**
2015	2	23,560	8,711	265	798	0	8,580	30.91	5,206	143.80	0	341.94	**1,013,831**
2015	3	23,560	8,765	265	798	575	8,580	30.91	4,577	143.80	0	341.94	**923,380**
2015	4	23,560	8,775	265	798	683	8,580	30.91	4,459	143.80	0	341.94	**906,412**
2015	5	23,560	8,805	265	798	683	8,580	30.91	4,429	143.80	0	341.94	**902,098**
2015	6	23,560	8,799	265	798	683	8,580	30.91	4,435	143.80	0	341.94	**903,014**
2020	1	28,413		265	1,087	0	10,120	35.83	5,416	166.70	11,525	416.02	**6,060,077**
2020	2	28,413	10,429	265	1,087	0	10,120	35.83	5,416	166.70	1,096	416.02	**1,721,405**
2020	3	28,413	10,483	265	1,087	575	10,120	35.83	5,416	166.70	467	416.02	**1,459,728**
2020	4	28,413	10,494	265	1,087	683	10,120	35.83	5,416	166.70	348	416.02	**1,410,222**
2020	5	28,413	10,524	265	1,087	683	10,120	35.83	5,416	166.70	318	416.02	**1,397,741**
2020	6	28,413	10,517	265	1,087	683	10,120	35.83	5,416	166.70	325	416.02	**1,400,518**
2025	1	33,266		265	1,375	0	11,660	41.54	5,416	193.25	14,550	506.15	**8,895,481**
2025	2	33,266	12,084	265	1,375	0	11,660	41.54	5,416	193.25	2,466	506.15	**2,779,164**
2025	3	33,266	12,138	265	1,375	575	11,660	41.54	5,416	193.25	1,837	506.15	**2,460,796**
2025	4	33,266	12,149	265	1,375	683	11,660	41.54	5,416	193.25	1,718	506.15	**2,400,564**
2025	5	33,266	12,179	265	1,375	683	11,660	41.54	5,416	193.25	1,688	506.15	**2,385,380**
2025	6	33,266	12,172	265	1,375	683	11,660	41.54	5,416	193.25	1,695	506.15	**2,388,836**
2030	1	37,562		265	1,664	0	13,200	48.16	5,416	224.03	17,017	615.81	**12,328,297**
2030	2	37,562	13,739	265	1,664	0	13,200	48.16	5,416	224.03	3,278	615.81	**3,867,684**
2030	3	37,562	13,793	265	1,664	575	13,200	48.16	5,416	224.03	2,649	615.81	**3,480,339**
2030	4	37,562	13,804	265	1,664	683	13,200	48.16	5,416	224.03	2,530	615.81	**3,407,058**
2030	5	37,562	13,834	265	1,664	683	13,200	48.16	5,416	224.03	2,500	615.81	**3,388,583**
2030	6	37,562	13,827	265	1,664	683	13,200	48.16	5,416	224.03	2,507	615.81	**3,392,884**

TABLE 6-5
Distribution System Capital Costs Summary for Extending Reclaimed Water Service—2005 $

User	Capital Cost ($)	Alternative(s)
24-inch Pipeline	8,400,000	2,3,4,5,6
Las Ligas Park	43,480	5,6
Friendship Park	0	4,5,6
Coldwater Springs Golf Course	0	3,4,5,6
New 40-acre Park (Broadway/El Mirage)	12,500	5,6
LaJoya High School	225,560	5,6
Donnie Hale Park	275,630	5
COA Civic Center	241,130	5,6
Collier Elementary School	141,880	5,6
Coldwater Park	383,210	5,6
Agua Fria High School	229,350	5,6
Dennis DeConcini Park	77,630	5
115th and I-10	212,970	5,6
Canyon Breeze ES	356,030	5
Westview HS/Garden Lakes ES	436,960	5
Agua Fria Riparian Area	584,810	4,5,6
Dysart Road and I-10	313,930	5
Rancho Santa Fe ES	328,810	5
St. Thomas K-8*	459,370	5
Corte Sierra ES	356,650	5
New 40-acre Park (Thomas/El Mirage)	348,010	5
Total	**13,427,910**	

*Note: St. Thomas K-8 is expanding to a K-12 school, and although it currently has no athletic fields, it has been assumed that it will in the near future though this has yet to be verified. Agua Fria High School water demands have been used as an estimate for this school.

TABLE 6-6
Alternative Distribution System Costs—2005 $

Alternative	Distribution System Capital Cost ($)
Alternative 1—Do Nothing	0
Alternative 2—Recharge Only	8,400,000
Alternative 3—Recharge plus Reuse at Coldwater Springs Golf Course	8,400,000
Alternative 4—Recharge plus Reuse at Friendship Park, Agua Fria Riparian Area & Coldwater Springs Golf Course	8,984,810
Alternative 5—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park and all other potential users	13,427,910
Alternative 6—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park, LaJoya HS, Coldwater Park, Agua Fria HS, Las Ligas Park, New 40-acre COA Park, Collier ES, I-10 & 115th)	10,474,890

The 2005 costs as they apply to each of the alternatives are presented below in Table 6-7.

TABLE 6-7
Treatment Costs per Alternative—2005 $

Alternative	Treatment Costs ($)
Alternative 1—Do Nothing	0
Alternative 2—Recharge Only	0
Alternative 3—Recharge plus Reuse at Coldwater Springs Golf Course	0
Alternative 4—Recharge plus Reuse at Friendship Park, Agua Fria Riparian Area & Coldwater Springs Golf Course	6,025,500
Alternative 5—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park and all other potential users	6,025,500
Alternative 6—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park, LaJoya HS, Coldwater Park, Agua Fria HS, Las Ligas Park, New 40-acre COA Park, Collier ES, I-10 & 115th)	6,025,500

6.2.2.3 Pump and Storage Tank Capital Costs

Pumping facilities will be required to convey flows in the 24-inch pipeline from the COA's WWTP to the recharge basins. Additionally, a storage tank will also be required to provide needed operational flexibility and flow attenuation. The costs and sizes of a low pressure pumping station and storage tank facility were previously estimated by others (City of Avondale 2004b) and were not investigated as part of this study, although the storage tank size was verified in Section 5.2.6.

6.2.2.3.1 Pumping Station Capital Costs

For the purposes of recharging WWTP effluent only, a low-pressure pumping station as previously proposed by others would be suitable. The required discharge pressure at the WWTP pump station necessary to deliver water to the recharge basins at a minimal pressure has been estimated to range from 23 psi for 2005 flows to 73 psi in 2030. This pressure is required to overcome pipe friction losses and the elevation difference between the two sites.

However, for the purposes of reusing reclaimed water for turf irrigation, a higher discharge pressure would be required. As indicated earlier, identified potential users have requested that reclaimed water be delivered with sufficient pressure, approximately 50-60 psi, to meet the operational requirements of their irrigation systems. As such, the difference in pressure between the low-pressure (recharge only) and high-pressure (turf irrigation purposes) pumping options has been found to be an additional 75 psi, due to the higher pressure requirements and also to overcome pipe friction losses that will occur in transit from the 24-inch force main to the more remote customers.

In addition to higher electrical costs, as discussed in Section 6.2.3 Operations and Maintenance Costs, pumping at a higher pressure also requires pumps with larger motors that are more expensive to buy than pumps used for pumping at low pressure. The incremental capital cost difference for the initially required high-pressure versus low-pressure pumping equipment is estimated to double, from $645,000 to $1,290,000 (2005

costs). As outlined in the *Wastewater Treatment and Reclaimed Water Facilities Master Plan* (DSWA 2004a), three pumps will initially be installed, and that two additional pumps will be added in subsequent phases, in 2010 and 2020, as City WWTP effluent production rates increase. The 2005 cost for each additional pump station expansion has been estimated to be $169,000 for a low-pressure system, and $338,000 for a high-pressure system.

The total pump station capital costs in 2005 dollars as they apply to each of the alternatives are indicated below in Table 6-8.

TABLE 6-8
Pump Station Capital Costs per Alternative—2005 $

Alternative	Initial Pump Station Capital Cost ($)	Phase 1 (2010) Expansion Costs ($)	Phase 2 (2020) Expansion Costs ($)	Total Pump Station Capital Costs ($)
Alternative 1—Do Nothing	0	0	0	0
Alternative 2—Recharge Only	645,000	169,000	169,000	983,000
Alternative 3—Recharge plus Reuse at Coldwater Springs Golf Course	645,000	169,000	169,000	983,000
Alternative 4—Recharge plus Reuse at Friendship Park, Agua Fria Riparian Area & Coldwater Springs Golf Course	1,290,000	338,000	338,000	1,966,000
Alternative 5—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park and all other potential users	1,290,000	338,000	338,000	1,966,000
Alternative 6—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park, LaJoya HS, Coldwater Park, Agua Fria HS, Las Ligas Park, New 40-acre COA Park, Collier ES, I-10 & 115th)	1,290,000	338,000	338,000	1,966,000

6.2.2.3.2 Storage Tank Capital Costs

With the exception of Alternative 1 (Do Nothing), a 2 million gallon storage tank, to be located at the COA's WWTP is recommended for all the other alternatives. Based on the previously estimated capital costs for such a storage tank (City of Avondale 2004b), the 2005 costs have been estimated to be $1,040,300.

6.2.2.4 Total Capital Costs

The capital costs, as outlined in Sections 6.2.2.1 through 6.2.2.3.2 are summarized in Table 6-9 for each alternative.

TABLE 6-9
Summary of Capital Costs—2005 $

Capital Cost	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Distribution System Cost	0	8,400,000	8,400,000	8,984,810	13,427,910	10,474,890
Treatment Costs	0	0	0	6,025,500	6,025,500	6,025,500
Pump Station and Storage Costs	0	2,023,300	2,023,300	2,023,300	3,006,300	3,006,300
Total	0	10,423,300	10,423,300	17,033,610	22,459,710	19,506,690

6.2.3 Operations and Maintenance Costs

The annual Operations and Maintenance (O&M) costs for each of the proposed alternatives have been estimated based on actual 2004 O&M costs for the COA potable water distribution system, as provided by the COA. O&M costs have been assigned to the following reclaimed water distribution system components:

- Distribution (piping) system;
- Pump stations;
- Storage tanks;
- Recharge basin;
- WWTP;
- Monitoring; and
- Administrative costs.

Costs for each O&M component are discussed in more detail in the subsequent sections.

6.2.3.1 Distribution System O&M Costs

In 2004, the COA estimated that they spent approximately $1,500,000 for general O&M to service their potable water supply pipeline distribution network, exclusive of well and booster pump stations, treatment and storage facilities. The COA currently maintains approximately 332 miles of pipe ranging in size from 2-inches to 36-inches. Based on the information provided, the COA spent approximately $4,520 per mile of potable water distribution system pipe in 2004. For the purposes of this study and to be conservative, it has been assumed that the annual O&M costs per mile of installed reclaimed water distribution system pipe will be approximately $5,000 per mile. For each of the alternatives investigated, the estimated annual O&M costs are provided in Table 6-10.

6.2.3.2 Pump Station O&M Costs

As previously discussed, for the purposes of recharging WWTP effluent only, a low-pressure pumping station would be suitable. However, for the purposes of reusing reclaimed water for turf irrigation, a higher discharge pressure pump station would be required.

TABLE 6-10
Reclaimed Water Distribution System Annual O&M Costs—2005 $

Alternative	Total Length of Pipe (miles)	Annual O&M Cost	Present Value Cost[1]
Alternative 1—Do Nothing	0	0	0
Alternative 2—Recharge Only	6.3	31,500	620,770
Alternative 3—Recharge plus Reuse at Coldwater Springs Golf Course	6.3	31,500	620,770
Alternative 4—Recharge plus Reuse at Friendship Park, Agua Fria Riparian Area & Coldwater Springs Golf Course	7.0	34,950	688,760
Alternative 5—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park and all other potential users	21.3	106,500	2,098,800
Alternative 6—Recharge plus Reuse at Coldwater Springs Golf Course, Friendship Park, LaJoya HS, Coldwater Park, Agua Fria HS, Las Ligas Park, New 40-acre COA Park, Collier ES, I-10 & 115th)	10.3	51,500	1,014,920

[1]Present value calculated over 25 years at 5-percent interest, assuming an annual increase in annual O&M costs of 3-percent per year.

The power requirements and costs for both pumping pressure options have been calculated and correspond to the different alternatives as shown in Table 6-11. A current cost of $0.08 per kilowatt hour (kWh) for electrical service has been assumed, with an assumed rate increase of 3 percent per year.

TABLE 6-11
Pump Station Electrical Operating Costs, Low vs. High Pressure—2005 $

Year	Electricity Cost ($/kWh)	Low Pressure Power Req'ment (kW)	Alternatives 2,3,4 Annual Cost	High Pressure Power Req'ment (kW)	Alternatives 5,6 Annual Cost
2005	0.0800	38	$41,630	168	$132,730
2010	0.0927	71	$80,870	248	$224,670
2015	0.1075	126	$145,550	343	$349,450
2020	0.1246	181	$236,570	437	$516,080
2025	0.1445	264	$379,300	561	$755,020
2030	0.1675	347	$561,500	685	$1,057,460

In addition to the electrical costs for operating the pump station, maintenance costs were estimated for the proposed reclaimed water pumps based on the 2004 maintenance costs for the potable water well and booster pump stations operated by the COA. As per COA records, $100,000 was spent in 2004 to maintain/repair 12 production wells and 10 booster pump stations. This annual cost was further broken down to include $40,000 spent on the wells, $20,000 spent on the booster pumps, $35,000 on unspecified maintenance agreements and $5,000 on preventative maintenance and testing. It has been assumed that the proportion spent on the booster pumps included $20,000 plus half of the unspecified maintenance agreement and preventative maintenance costs. The estimated annual cost to

maintain the 10 booster pumps is thus $40,000, or approximately $4,000 per pump per year. To be conservative, and considering that the size of the proposed reclaimed water pumps will be larger than the COA potable water booster pumps, it has assumed for this study that the cost to maintain each reclaimed water pump will be $5,000 per year.

As outlined in the *Wastewater Treatment and Reclaimed Water Facilities Master Plan* (DSWA 2004a), three pumps will initially be installed, and two additional pumps will be added in subsequent phases, in 2010 and 2020. The electrical costs identified in Table 6-10 were combined with the maintenance costs identified above to determine the total pump station O&M costs and are presented in Table 6-12 below.

TABLE 6-12
Reclaimed Water Pump Station Annual O&M Costs—2005 $

Alternative	Annual O&M Costs						Present Value Cost[1]
	2005	2010	2015	2020	2025	2030	
Alternative 1	0	0	0	0	0	0	0
Alternative 2	41,630	80,870	145,550	236,570	379,300	561,500	2,577,340
Alternative 3	41,630	80,870	145,550	236,570	379,300	561,500	2,577,340
Alternative 4	41,630	80,870	145,550	236,570	379,300	561,500	2,577,340
Alternative 5	132,730	224,670	349,450	516,080	755,220	1,057,460	5,728,280
Alternative 6	132,730	224,670	349,450	516,080	755,220	1,057,460	5,728,280

[1]Present value calculated over 25 years at 5-percent interest

6.2.3.3 Storage Tank O&M Costs

In 2004, the COA estimated that they spent approximately $300,000 for general O&M to service their six potable water storage tanks. Based on the information provided, the COA spent approximately $50,000 per storage tank in 2004. For the purposes of this study, it has been assumed that the annual O&M costs for the single 2 million gallon reclaimed water storage tank will be approximately $50,000. This cost applies to all alternatives, with the exception of Alternative 1 (Do Nothing). This cost was assumed to grow by 3 percent annually.

6.2.3.4 Recharge Basin O&M Costs

The O&M costs for the recharge basin were not considered in this economic analysis. The COA currently uses the recharge basin to recharge SRP and CAP water, and has an ongoing maintenance program for that facility. The maintenance costs for the recharge basin are not expected to increase substantially for any of the alternatives.

6.2.3.5 Additional WWTP O&M Costs

As previously mentioned, the water quality of the effluent at the COA's WWTP is currently classified as B+ and no additional levels of treatment would be required for the purposes of recharging or for golf course irrigation. However, for the purposes of reusing reclaimed water for non-restricted turf irrigation or use at the Agua Fria Riparian Area, at least Class A effluent would be required. Capital costs were previously identified for expanding the treatment facilities for the production of Class A+ effluent. The increased effluent treatment

processes would require higher labor and operational costs. The COA has estimated that upgrading their WWTP will increase their O&M budget by approximately 10-percent. Based on information provided by the City regarding their 2004 O&M budget at the WWTP, the 2005 treatment costs have been estimated to be $1.014 per 1,000 gallons treated. Treating to Class A+ has thus been estimated to cost approximately $0.101 more per 1,000 gallons treated. This annual O&M cost would apply to Alternatives 4, 5, and 6 only. Table 6-13 identifies the increase in treatment O&M costs.

TABLE 6-13
WWTP Increased Annual O&M Costs—2005 $

Year	Total Effluent Production (gal)	Cost/1000 gallons WWTP to B+ ($)	Cost/1000 gallons WWTP, B+ to A+ ($)	Total Added O&M Cost, B+ to A+ (Alternatives 4,5,6 only)
2005	1,752,000,000	1.014	0.101	$176,950
2010	2,398,050,000	1.175	0.118	$282,970
2015	2,989,350,000	1.362	0.136	$406,550
2020	3,577,000,000	1.579	0.158	$565,170
2025	4,135,450,000	1.860	0.186	$769,190
2030	4,712,150,000	2.122	0.212	$998,980
			Present Value Cost[1]	**$6,318,580**

[1]Present value calculated over 25 years at 5-percent interest

6.2.3.6 Monitoring Costs

Monitoring costs are not expected to increase substantially for any of the alternatives. The COA currently recharges water in their facilities and are required to sample monitoring wells as a condition of their current recharge permit. These sampling requirements are not expected to be any different in the future.

6.2.3.7 Administrative Costs

There will be such limited number of customers that costs to administer this program should be a negligible addition to the overall potable water service administrative cost. It is believed that Alternatives 5 and 6 will require slightly higher administrative costs, but this amount is too small to make any difference in this study.

6.2.3.8 Total O&M Costs

The O&M costs, as outlined in Sections 6.2.3.1 through 6.2.3.5 are summarized in Table 6-14 below for each alternative.

TABLE 6-14
Summary of Present Values[1] of Total O&M Costs—2005 $

O&M Cost	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Distribution System	0	620,770	620,770	688,760	2,098,800	1,014,920
Pump Station	0	2,577,340	2,577,340	2,577,340	5,728,280	5,728,280
Storage Tank	0	985,350	985,350	985,350	985,350	985,350
Additional WWTP	0	0	0	6,318,580	6,318,580	6,318,580
Total	0	4,183,460	4,183,460	10,570,030	15,131,010	14,047,130

[1]Present value calculated over 25 years at 5-percent interest

6.3 Present Value Cost Comparison of Reclaimed Water System Alternatives

The Present Values (PV) for each alternative was evaluated to compare the financial feasibility of each alternative. Present Value is a common evaluation method used to compare investments in different projects by discounting the current and projected future cash inflows and outflows back to the present value base year assuming a discount rate, or cost of capital. As indicated previously, a 25-year period at a discount rate of 5-percent was used. The total capital and O&M Present Value for each alternative is shown in Table 6-15.

TABLE 6-15
Total PV Analysis for Reclaimed Water Distribution System Alternatives—2005 $

Cost	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Purchased Water	65,120,960	19,089,730	16,825,260	16,397,270	16,297,880	16,320,360
Capital	0	10,423,300	10,423,300	17,033,610	22,459,710	19,506,690
O&M	0	4,183,460	4,183,460	10,570,030	15,131,010	14,047,130
Total	65,120,960	33,696,490	31,432,020	44,000,910	53,888,600	49,874,180

As seen in Table 6-15, the most economically feasible alternative for the COA is Alternative 3, using Class B+ reclaimed water for golf course irrigation and recharge only. The additional costs associated with treating and pumping reclaimed water for reuse purposes results in higher PVs for Alternatives 5 and 6, even with these alternatives potential for reduced purchased water. The highest PV in Table 6-15 is for Alternative 1 (Do Nothing). This economic analysis underscores the importance of a recharge/reuse program for the COA, both from a water resources and cost perspective.

6.4 Rate Study Analysis

Data presented in Section 6.3 above show that without some other political, legislative or socioeconomic driver, recharging all of the COA's WWTP Class B+ effluent and reusing a portion for golf course irrigation is the most cost-effective approach to the COA acquiring groundwater recharge credits.

There are other factors that have not been included in this analysis such as (1) public perception/relations of not implementing an aggressive reuse program, (2) neighboring jurisdictions and their proactive implementation of a reuse program, and (3) the likelihood of state legislative action in the future requiring reclaimed wastewater to use be used for reuse purposes. These factors in the future may lend more political support towards the installation of a high-pressure, Class A+ reclaimed water distribution system even though it is not the most cost-effective approach to the COA achieving the additional recharge credits it needs in the future.

In anticipation of the COA selecting any one of the alternatives, a rate study analysis was conducted for each alternative.

6.4.1 Assigning Costs to Potable Water and Direct Reuse Customers

The costs presented in Section 6.3 may be split between (1) providing reclaimed water to direct reuse customers, and (2) recharging reclaimed water at the COA recharge basins which benefits the community as a whole. The cost of purchasing water for all alternatives is the cost of acquiring new water resources for the COA potable water users. As such, all purchased water costs may be directly assigned to existing potable water customers. With the exception of Alternative 1 (Do Nothing), the capital and O&M costs that are related to the delivery of reclaimed water to the recharge basins are common to all alternatives, and may also be assigned directly to all existing potable water customers. The costs of distributing reclaimed water to direct reuse customers are supplementary, and therefore should be assigned to the direct reuse customers.

The costs associated with recharging reclaimed water at the COA recharge basins may be covered by a Potable Water Surcharge (PWS), which is the cost borne by all water customers to pay for that portion of the reclaimed water distribution system that benefits them by providing an additional water supply resource to the City. The costs associated with providing reclaimed water to direct reuse customers should be covered by a Reclaimed Water Rate (RWR), which is the cost borne by direct reuse customers to pay for that portion of the reclaimed water distribution system that specifically benefits them. The costs for each alternative have been assigned to the different customer groups as shown below in Table 6-16.

TABLE 6-16
Assigned PV Reclaimed Water System Costs per Customer Group—2005 $

Cost	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Purchased Water Costs						
Existing Potable Customers	65,120,960	19,089,730	16,825,260	16,397,270	16,297,880	16,320,360
Direct Reuse Customers	0	0	0	0	0	0
Sub-Total	***65,120,960***	***19,089,730***	***16,825,260***	***16,397,270***	***16,297,880***	***16,320,360***
Capital Costs						
Existing Potable Customers	0	10,423,300	10,423,300	10,423,300	10,423,300	10,423,300
Direct Reuse Customers	0	0	0	6,610,310	12,036,410	9,083,390
Sub-Total	***0***	***10,423,300***	***10,423,300***	***17,033,610***	***22,459,710***	***19,506,690***
O&M Costs						
Existing Potable Customers	0	4,183,460	4,183,460	4,183,460	4,183,460	4,183,460
Direct Reuse Customers	0	0	0	6,386,570	10,947,550	9,863,670
Sub-Total	***0***	***4,183,460***	***4,183,460***	***10,570,030***	***15,131,010***	***14,047,130***
Total	**65,120,960**	**33,696,490**	**31,432,020**	**43,994,910**	**53,888,600**	**49,874,180**

6.4.2 Potable Water Surcharge and Reclaimed Water Rates

Using the cost breakdown provided in Table 6-16, Potable Water Surcharge and Reclaimed Water Rates were developed for each year, based on a 20-year pay-back period and an interest rate of 5-percent. Because of the escalating O&M costs and rising costs of purchased water, both the Potable Water Surcharge and Reclaimed Water Rates rise each year, as shown in Table 6-17 below. Detailed rate analysis summary spreadsheets for each alternative are provided in Appendix A.

TABLE 6-17
Rate Analysis for Reclaimed Water Alternatives—2005 $/1,000 gallons

	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5		Alternative 6	
Year	PWS	RWR	PWS	RWR	PWS	RWR	PWS	RWR	PWS	RWR	PWS	RWR
2005	0.29		0.71		0.69		0.69	0.94	0.69	1.32	0.69	1.18
2010	0.41		0.62		0.60		0.60	1.09	0.59	1.50	0.60	1.37
2015	0.54		0.60		0.58		0.58	1.26	0.58	1.71	0.58	1.60
2020	0.69		0.66		0.62		0.61	1.47	0.61	1.97	0.61	1.88
2025	0.86		0.77		0.73		0.73	1.75	0.72	2.31	0.72	2.25
2030	1.06		0.88		0.84		0.83	2.07	0.83	2.70	0.83	2.67

6.5 Summary of Economic and Rate Study Analyses

The results of the economic analysis suggest that the most economically feasible alternative for the COA is Alternative 3, using Class B+ reclaimed water for golf course irrigation and recharge only. To accommodate the possibility that the COA may elect to pursue another alternative, based on political and/or socioeconomic reasons, Potable Water Surcharge and Reclaimed Water Rates were prepared for all alternatives. Both Potable Water Surcharge and Reclaimed Water Rates are expected to increase over time. The Potable Water Surcharge is expected to increase at a rate of nearly 5-percent per annum for alternative 1, whereas the PWS for the other alternatives increases at less than 1-percent per annum. The RWR is expected to increase at a rate of nearly 3-percent per annum, approximately the same rate as inflation.

As indicated, the Reclaimed Water Rates have been derived to pay for that portion of the reclaimed water distribution system that specifically benefits reclaimed water reuse customers. Potable water customers should not be subsidizing that portion of the reclaimed water distribution system that does not directly benefit them. The Reclaimed Water Rates developed herein are higher than the Potable Water Surcharge rates, but are less than the existing water rate (approximately $1.80 per 1,000 gallons for those customers using more than 20,000 gallons per month) plus the Potable Water Surcharge. Having lower Reclaimed Water Rates than the combined potable water rates suggests that reclaimed water customers will have an incentive to purchase reclaimed water because it will be cheaper than potable water. The estimated Reclaimed Water Rate is approximately 46-percent of the estimated combined potable water rate in 2005, and would increase to approximately 94-percent of the estimated combined potable water rate by 2030.

The Potable Water Surcharge rates developed herein show that there is very little difference between the Potable Water Surcharge rates for Alternatives 2 through 6. This suggests that the costs of pursuing any of these alternatives will have no preferential impact upon potable water customers. The subtle differences in the Potable Water Surcharge Rates are due to the variations in the total recharge credit associated with each alternative. From a long-term perspective, the Potable Water Surcharge for Alternatives 2 through 6 becomes less than the Potable Water Surcharge for Alternative 1, indicating the long-term economic incentive for the COA to recharge/reuse their reclaimed water. Purchased water requirements, as outlined in Table 6-4, clearly show that the COA may surpass their CAGRD allotment as early as this year if they decide to not recharge or reuse their reclaimed wastewater (Alternative 1). Costs presented in Table 6-4 for Alternative 1 assume that the City may acquire water beyond their SRP and CAP allotments at CAGRD prices, though the costs may realistically be much higher as many municipalities in Maricopa County compete for this limited water resource.

7.0 Phased Reclaimed Water Distribution System Implementation Plan

Data presented in Section 6.0, Economic Analysis, show that without some other political, legislative or socioeconomic driver, recharging all of the COA's WWTP Class B+ effluent and reusing a portion for golf course irrigation is the most cost-effective approach to the COA acquiring groundwater recharge credits.

As indicated earlier, there are other factors that have not been included in this analysis such as (1) public perception/relations of not implementing an aggressive reuse program, (2) neighboring jurisdictions and their proactive implementation of a reuse program, and (3) the likelihood of state legislative action in the future requiring reclaimed wastewater to be used for reuse purposes. These factors in the future may lend more political support towards the installation of a high-pressure, Class A+ reclaimed water distribution system even though it is not the most cost-effective approach to the COA achieving the additional recharge credits it needs in the future.

Based upon the above, CH2M HILL has developed the following phased implementation plan for consideration by the COA.

7.1 Phase 1 (2005–2007)

Provide no additional Class A+ treatment at the WWTP plant; construct a low-pressure pump station and 2-million-gallon storage tank at the WWTP plant and construct a 24-inch force main from the pump station to the COA's recharge basin. Provide an appropriate irrigation take-off connection for the Coldwater Springs Golf Course and the COA's Friendship Park and provide reclaimed water to the golf course if an acceptable agreement can be work out.

7.2 Phase 2 (2007–2010)

Add an additional low-pressure pump as required and provide reuse water to Coldwater Springs Golf Course if an acceptable agreement can be worked out.

7.3 Phase 3 (2015–2020)

Add an additional low-pressure pump as required.

7.4 Phase 4—Optional (2005+)

If the COA decides on its own or is required by state legislative action to move to a more aggressive reuse program, then provide the additional treatment facilities to achieve a Class A+ WWTP effluent, install high-pressure pumps at the pump station and extend the

reclaimed water distribution system to serve those customers where it is cost effective and/or politically desirable to do so.

7.5 Phased Implementation Plan Capital Improvement Program

CH2M HILL has developed a tentative Capital Improvement Program (CIP) to support the phased implementation plan described above. CIP costs and schedule are shown in Table 7-1 to assist the COA in planning for future capital costs should all three phases ultimately be implemented. The COA may wish to proceed with Phase 3 earlier than shown if required or if there is local political support to do so even though it is not the least cost approach to achieving the desired recharge credits.

8.0 Regulatory Framework

This section is intended to provide an initial menu of reclaimed water distribution system permitting requirements based on CH2M HILL's cursory inquiry and evaluation of applicable regulations. Permits required for construction of the reclaimed water pipeline are also included.

8.1 Aquifer Protection & Reuse Permitting

In 2001, the ADEQ adopted new water pollution control rules that more directly tie the Aquifer Protection Permits (APP) and reuse permits under one program, and open up several new permitting options. All wastewater treatment facilities providing reclaimed water for reuse must have an individual APP, or amend their existing APP to contain certification for a particular Class (A+, A, B+, B or C) of reclaimed water.

The APP requires monitoring and reporting of reclaimed water quality to ensure that effluent limitations for reclaimed water quality classes are met. There are several different permitting options for party-to-party reuse permits. The two most applicable of these permits is the "Type 2 Reclaimed Water General Permit for Direct Reuse of Class A+ Reclaimed Water" if the COA elects to further treat their Class B+ effluent to Class A+, and the "Type 3 Reclaimed Water General Permit for a Reclaimed Water Agent."

The Type 2 General Permit is for reuse applications where there is a relatively high risk of human exposure to potential pathogens in the reclaimed water. Each end user has the responsibility of meeting all permit requirements. This permit allows for the direct reuse application of reclaimed water provided that the reclaimed water meets the quality criteria in A.A.C. R18-11-3 for Class A+. The Type 3 General Permit for a Reclaimed Water Agent is where the agent distributes reclaimed water to more than one end user. The agent, rather than the end-users, is responsible for the appropriate Type 2 permit conditions of the reclaimed water sent to the end users. End users can receive reclaimed water from an agent for appropriate reuse applications without having to notify the department to obtain permit coverage. Each agent is required to maintain contractual agreements with end users that stipulate end user responsibilities and report annually the amount of reclaimed water delivered to end users.

The applicable state regulations to both permits are found in the Arizona Administrative Code (A.A.C.), Title 18, Chapter 9, Article 7 (A.A.C. R18-9-701 et. seq.), which specifies that the Article (Article 7) "applies to a reclaimed water agent" and/or an "end user" (R18-9-702). A reclaimed water agent is defined as "a person who holds a permit to distribute reclaimed water to more than one end user;" and an end user is defined as "a person who directly reuses reclaimed water meeting the standards for Classes A+, A, B+, B, and C, established under 18 A.A.C. 11, Article 3" (R18-9-701). Under the permitting options outlined herein, the COA could either be considered a reclaimed water agent or an end user depending upon the implementation plan it actually implements.

Once a permitting scenario is selected from among the alternatives presented, CH2M HILL recommends a preapplication meeting with ADEQ. This meeting will provide all parties the opportunity to agree to the appropriateness of the desired approach, define a schedule, and discuss specific actions necessary to complete the permitting process.

8.2 ADWR

The ADWR was established in 1980 to administer state water laws that do not pertain to water quality. Their main purposes are to promote conservation of water supplies, maintain equal distribution of water within the state, and develop methods to meet future water demands. Groundwater and surface water resource use also falls under ADWR's jurisdiction as well as interfacing with external entities to protect and assure the state of Arizona's water supplies. The following fall under ADWR's jurisdiction.

- In 1980, ADWR was directed to implement the Groundwater Management Code, which regulates the state's groundwater supply, depletion, and allocation within the state.
- ADWR developed Active Management Areas (AMAs) to manage the areas where groundwater depletion is the greatest. The COA is within the Phoenix AMA. Participation in the Phoenix AMA requires the COA to meet goals that reduce the gallons per capita per day usage by the COA's water utility. This in turn requires subscribers to the COA's system to use more conservative potable water management skills.

AMAs also support ADWR in developing conservation requirements that promote efficient water use within their jurisdictions.

8.3 Maricopa County

Maricopa County Environmental Services Department (MCESD) is the county reviewer of WWTPs that want to produce reclaimed wastewater effluent. They also review recharge facilities and distribution systems. MCESD requires that all plant designs or upgrades undergo an Engineering Plan Review by their staff . Before construction begins, additional construction document reviews are required as well. These reviews include the Earth Moving Permit and Dust Control Plan that deal with the ground and environmental impact of construction.

8.4 City of Avondale (COA)

The COA has three major reviews of designs of this magnitude. They are the General Plan Amendment, Engineering/Development, and Right-of-Way (ROW) Reviews. The General Plan Amendment Review entails reviewing the project to determine if an amendment is necessary to the COA's General Plan. The Engineering/Development Review covers not only design issues but reviews the project to see if it may qualify as a Special Project, which would involve community review and more extensive interdepartmental coordination. ROW Reviews a project to identify the location of piping along the COA-owned ROWs. This

may not apply to a COA-owned project though and may not need to be performed on this project.

8.5 Summary of Permits

This section provides a general summary and description of permits, reviews, approvals and similar actions (herein after collectively referred to as "permits") that may be required as part of a reclaimed water distribution system project to be constructed within the COA. Table 8-1 is a permit summary that outlines specific information related to each permit. Permitting details discussed are permit name, permitting agency, application preparation and review duration, permit duration/renewal criteria, applicable permit fees, and responsible party for preparing/obtaining the permit. The information presented in Table 8-1 is general in nature since the specific permitting requirements will depend on the actual plan and associated facilities adopted for implementation by the COA.

The following permits may be necessary for any reclaimed water distribution system project constructed within the COA:

- COA Permits
- Non-Title V Air Permit
- Maricopa County Engineering Plan Review
- Earth Moving Permit
- Dust Control Plan
- APP Amendment
- Clean Water Act (CWA) 402 National Pollutant Discharge Elimination System (NPDES) Stormwater Notice of Intent for Construction Activities
- CWA 402 NPDES Stormwater Notice of Termination of Construction Activities
- CWA 402 Stormwater Pollution Prevention Plan (SWPPP)
- CWA 401 State Water Quality Certification
- Hazardous Waste ID Number
- Hydro Test Permit
- Arizona Protected Native Plants and Wood Removal Permit
- Notice of Intent to Clear Land
- CWA 404 Dredge and Fill Permit
- Endangered Species Act (ESA) Clearance
- Cultural Resources Clearance
- Salt River Project Right-of-Way
- Roosevelt Irrigation District Right-of-Way
- Union Pacific Railroad Crossing

Many of these permits must be completed before the start of construction. Therefore, sufficient lead time is required to ensure appropriate permitting of the project. A permitting timeline specific to the construction of Phase 1 of the proposed reclaimed water distribution system is shown in Figure 8-1.

TABLE 8-1
Permits Potentially Applicable to Phase 1 of the Reclaimed Water System Project

		Permit Action						
			Application Processing Planning Timeframe					
Permit Type	**Agency**	**When Required**	**Preparation**	**Agency Review**	**Permit Duration**	**Permit Fees**	**Permittee**	**Notes**
City of Avondale Permits								
Development Review (Engineering Review)	City of Avondale 11465 W. Civic Center Drive, Ste. 120 Avondale, AZ 85323 623.478.3270	During the design stage and prior to construction	30% design stage	Up to 6 months	N/A	N/A	Project Owner	May qualify as a Special Project, which would involve community review and more extensive inter-departmental coordination.
Right-of-Way Permit	City of Avondale 11465 W. Civic Center Drive, Ste. 120 Avondale, AZ 85323 623.478.3270	Prior to construction	3 weeks	Up to 3 months	N/A	N/A	Project Owner	May not apply to a COA-owned project. See end note.
General Plan Amendment	City of Avondale 11465 W. Civic Center Drive, Ste. 110 Avondale, AZ 85323 623.478.3333	During the planning stage	Up to 3 months	Up to one year	N/A	N/A	Project Owner	Review project to determine if a Plan Amendment is necessary.
Maricopa County Permits								
Engineering Plan Review	Maricopa County Environmental Services Department 1001 N. Central Ave., #150 Phoenix, AZ 85004 602.506.6666	Prior to construction	Approximately 1 week to complete application requirements (does not include engineering design) to compile submittal	2 months	N/A	Varies, depending on classification	Project developer	
Earth Moving Permit and overall compliance with requirements of Rule 310 (additional requirements for soil stabilization, etc.)	Maricopa County Environmental Services Department 1001 N. Central Ave., #150 Phoenix, AZ 85004 602.506.6010	Prior to construction	2 days	2 days	1 year	$36 per acre $110 applic. fee	Contractor	Required for earth moving activities that impact 0.10 acres or more.
Dust Control Plan	Same as above	Prior to construction	5 days	N/A	N/A	Required as part of the Earth Moving Permit	Contractor	Completed as part of the Earth Moving Permit.
Maricopa Association of Governments Permits								
CWA 208 Plan Amendment	Maricopa Association of Governments 302 N. 1st Avenue Phoenix, AZ 85003	Prior to construction	3 to 6 months	6 months to one year	N/A	N/A	Project Owner	May be required if reclaimed water pipeline is not currently included as part of the municipal treatment system described in the regional plan.
State of Arizona Permits								
Aquifer Protection Permit/Reuse Permit Amendment	Arizona Department of Environmental Quality Office of Water Quality 1110 W. Washington Phoenix, AZ 85007 602.771.4665	Prior to construction	1 to 12 months depending on hydrological investigation requirements	270 days	5 years	Hourly fee for permit review	Project Owner	Modifications to the WWTP associated with the reclaimed water pipeline may require an APP amendment.

TABLE 8-1
Permits Potentially Applicable to Phase 1 of the Reclaimed Water System Project

		Permit Action						
			Application Processing Planning Timeframe					
Permit Type	**Agency**	**When Required**	**Preparation**	**Agency Review**	**Permit Duration**	**Permit Fees**	**Permittee**	**Notes**
Arizona Department of Transportation (ADOT) Right-of-Way Permit	Dave Zimbro, Permits Supervisor ADOT 2140 W. Hilton Phoenix, AZ 85009 602.712.7521	100% Construction Drawings only	1 week	4-8 weeks	90 days (can apply for extensions)	No Fees	Project Owner	May be required if ADOT Right-of-Way is impacted. Completed Application needs to include Traffic Control Plan
CWA Section 402 NPDES General Permit for pipeline hydrostatic testing	Arizona Department of Environmental Quality Office of Water Quality 1110 W. Washington Phoenix, AZ 85007 602.771.4665	Prior to discharge	1 week	N/A	Described in general permit	N/A	Project Owner	For discharge to a storm drain or surface water.
CWA Section 402 NPDES Stormwater Construction General Permit Notice of Intent	Arizona Department of Environmental Quality Office of Water Quality Federal Permits Unit 1110 W. Washington Phoenix, AZ 85007 602.771.4665	Prior to construction (48 hours)	1 day	N/A	Duration of construction	None	Contractor	For construction activities disturbing more than 1 acre (certification of compliance with Endangered Species Act required). OK to proceed with construction if agency has not notified; otherwise, within 48 hours. Copy of general permit (in Federal Register) and SWPPP must be onsite.
CWA Section 402 NPDES Stormwater Construction General Permit Notice of Termination	Arizona Department of Environmental Quality Office of Water Quality Federal Permits Unit 1110 W. Washington Phoenix, AZ 85007 602.771.4665	Upon completion of construction	CWA Section 402	N/A	N/A	None	Contractor	Submit upon completion of construction (reference permit number issued by EPA from NOI submittal)
CWA Section 402 Stormwater Pollution Prevention Plan (for construction activities)	Arizona Department of Environmental Quality (Do not submit – maintain on site)	Prior to construction	5 days	N/A	N/A	None	Prepared by contractor	Required per the Construction NOI. SWPPP must be maintained onsite and must comply with general permit requirements. Completed facility should be incorporated into SWPPP for entire project once in the operational stage.
CWA Section 401 State Water Quality Certification	Arizona Department of Environmental Quality Office of Water Quality Federal Permits Unit 1110 W. Washington Phoenix, AZ 85007 602.771.4665	Prior to construction	2 weeks	30 to 60 days	Tied to construction timeframe	None	Owner	Requirement applied in conjunction with CWA Section 404 Permit. Some nationwide permits incorporate 401 certification.

TABLE 8-1
Permits Potentially Applicable to Phase 1 of the Reclaimed Water System Project

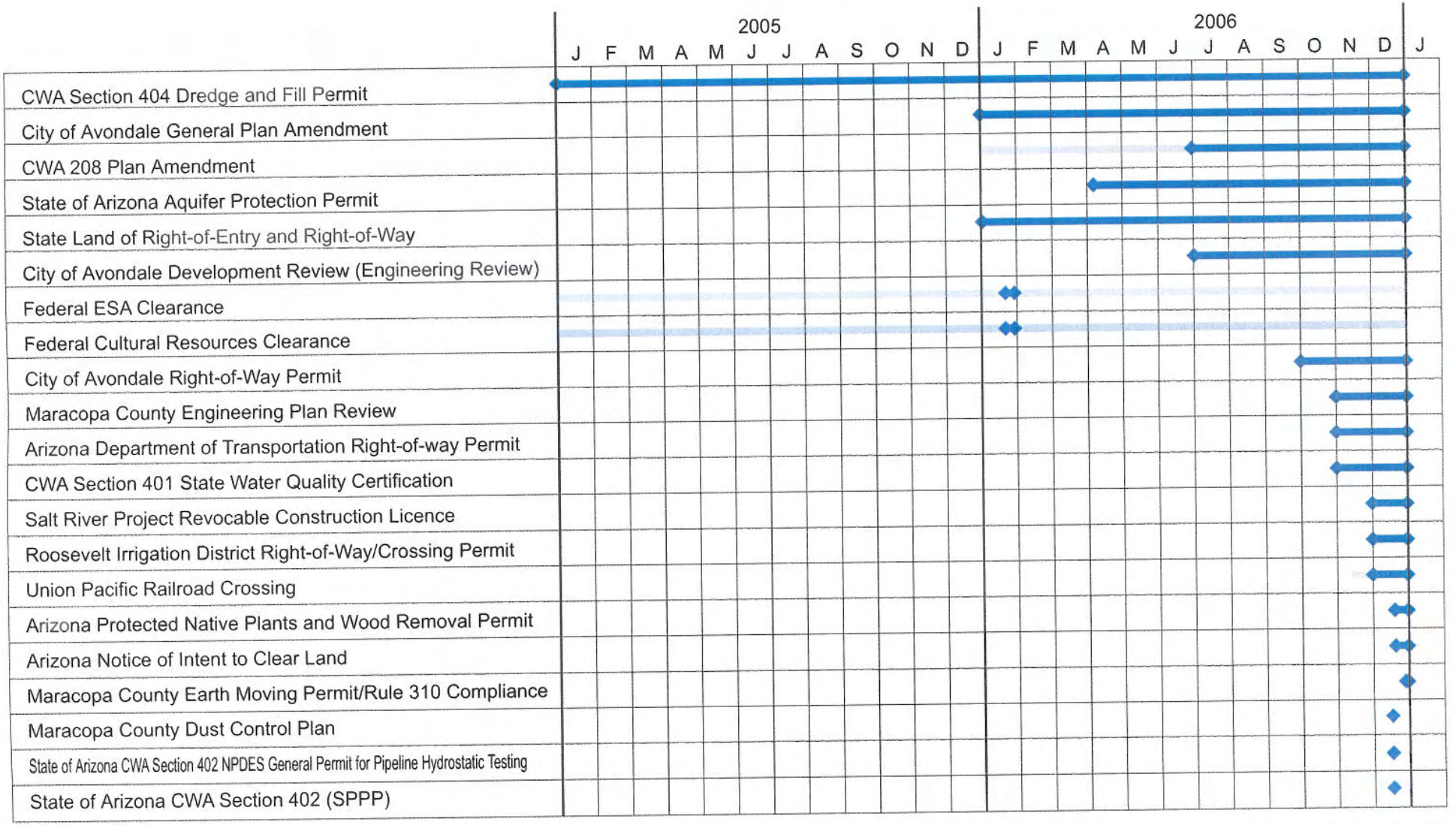
		Permit Action						
			Application Processing Planning Timeframe					
Permit Type	**Agency**	**When Required**	**Preparation**	**Agency Review**	**Permit Duration**	**Permit Fees**	**Permittee**	**Notes**
State Land Right-of-Entry and Right-of-Way	Arizona State Land Department Right-of-Way Section 1616 W. Adams Phoenix, AZ 85007	Prior to construction	1 month	Up to one year	10-year lease typical for utility lines	Significant, depending on appraised land value and other factors	Project Owner	Required if pipeline crosses state land. Includes a cultural resources clearance, endangered species clearance, native plants clearance, and related fees associated with advertising costs, surveying, appraisal work, and archaeological review.
Arizona Protected Native Plants & Wood Removal Permit	Arizona Department of Agriculture 1688 W. Adams Phoenix, AZ 85004 602.542.7182	Prior to removal of protected plants	1 week (allowing for plant inventory to proceed)	Must be processed in person	N/A	$5 Permit Tags $4 to $6 per plant Seals $0.10	Contractor Architect/Engineer must perform plant survey	Required only if protected plants will be removed from the site.
Notice of Intent to Clear Land	Arizona Department of Agriculture 1688 W. Adams Phoenix, AZ 85004 602.542.7182	Prior to start of construction	1 day	< 1 week or immediately if processed in person	N/A	None	Contractor	Required if native plants will be cleared from the site.
Federal Permits								
CWA Section 404 Dredge and Fill Permit	U.S. Army Corps of Engineers (USACE) Cindy Lester, Section Chief AZ Regulatory Branch U.S. Army Corps of Engineers 3636 N. Central Ave., Suite 760 Phoenix, AZ 85012-1936 602.640.5385	Prior to construction	5 days to 6 months (see notes)	Ranges from none (for nationwide permit) to 2 years	USACE Discretion	No permit fees, however mitigation fees possible.	Owner	Permit required for any crossings of waters of the US. Nationwide 12 for Utility Line crossings may apply.
ESA Clearance	Lead agency depends on federal permit (CWA 404 or 402) under application.	Prior to start applying for other federal permits	2 weeks or months depending on habitat/species survey needs	1 week to years if Section 7 consultation required	N/A	None	Owner	Clearance requirement associated with CWA 404 permit.
Cultural Resources Clearance	Lead agency depends on federal permit (CWA 404 or 402) under application.	Prior to start applying for other federal permits	2 weeks (Phase I Archaeological Assessment)	Depends on whether sites are present (1 week to years if NHPA consultation required).	N/A	None	Owner	Clearance requirement associated with CWA 404 permit.
Other Permits								
Salt River Project (SRP) Revocable Construction License	SRP Water Engineering MS PAB 106 PO Box 52025 Phoenix, AZ 85072-2025 602.236.3333	Prior to construction	1 day	Up to 1 month	N/A	N/A	Project Owner	Wants to review finalized drawings.

TABLE 8-1
Permits Potentially Applicable to Phase 1 of the Reclaimed Water System Project

		Permit Action						
			Application Processing Planning Timeframe					
Permit Type	Agency	When Required	Preparation	Agency Review	Permit Duration	Permit Fees	Permittee	Notes
Roosevelt Water District Right-of-Way/Crossing Permit	Roosevelt Irrigation District 103 W. Baseline Rd. Buckeye, AZ 85326 623.386.2046	60% Construction Drawings	1 week	30 days	N/A	$500	Project Owner	Have to meet RID criteria for jacking and boring.
Union Pacific R&R	Bill Ince Union Pacific Railroad Company 1400 Douglas Street, MS 1690 Omaha, Nebraska 68179	Prior to construction	1 week	30-45 days	Duration of construction	Project dependant	Project Owner	Wants to review finalized drawings.

Note: Additional rights-of-way or easements may be required depending on the alignment and whether the pipeline is crossing private property, state land, federal land, etc.

Figure 8-1
City of Avondale Reclaimed Water Permitting Timeline



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Best case scenario

Worst case scenario

Permitting time line is based upon the most recent Utilities Deptartment CIP with permitting and design of the reclaimed water backbone system starting in FY 2006.

9.0 Conclusions and Recommendations

The COA will make significant progress in positioning itself to supplement its current groundwater resources by recharging its treated wastewater treatment plant effluent. It will be necessary for the COA to use this valuable resource over the long term to meet a significant portion of the community's demand for an adequate potable water supply.

The objective of this Reclaimed Water Distribution System Master Plan is to bring the COA's previous planning efforts into sharper focus with respect to the specific course of action necessary to implement the reclaimed water distribution system. This report has verified previous recommendations made by others regarding a reclaimed water delivery force main and pumping system necessary to transport the COA's treated wastewater effluent from its WWTP to its recharge basins. Storage requirements requested by the COA to facilitate operations of the reclaimed water delivery system have also been verified. Additionally, this report has investigated the groundwater recharge potential of recharging all of the COA's Class B+ effluent versus further treating this effluent to Class A+ so that it may be reused for turf irrigation purposes by various users identified in this study.

It is recommended that the COA initially implement a recharge-only program, the components of which will be a 2-million-gallon storage tank, a low-pressure pump station, and a 24-inch force main from the COA's WWTP to their recharge basins. It is further recommended that the COA pursue an agreement with Coldwater Springs Golf Course to begin using the COA's Class B+ reclaimed water for turf irrigation at that location. By using a portion of reclaimed water for turf irrigation rather than a recharge-only program, the COA stands to gain an additional 9.4 percent recharge credit benefit for that portion of reclaimed water used for turf irrigation. Later system phases include upsizing the low-pressure pump station as wastewater effluent production from the WWTP increases in the future as the COA's population grows.

Although not cost effective at this time, the COA may elect in the future to treat their Class B+ wastewater effluent to Class A+, increase the pressure capacity of their pump station, and install reclaimed water mains to supply potential users with reclaimed water for their turf irrigation systems. This report identifies pipe diameters, alignments, and cursory capital costs to expand the reclaimed water distribution system from a low-pressure force main system into a high-pressure distribution system to supply a greater number of potential users.

Because of the close proximity of the City's recharge basins to a number of its major groundwater production wells, the City may also decide from a source-water protection standpoint to upgrade its WWTP effluent to Class A+ thus minimizing any public concerns regarding this matter.

10.0 References

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Appendix A
Detailed Cost and Revenue Calculation Tables for Each Alternative

POTABLE WATER SURCHARGE

Alternative 1

	Purchased Water			Reclaimed Water				Indicative Total Potable Water Surcharge
	Volume gpd	Cost	Surcharge per 1K gal	Volume gpd	O&M Cost	Capital Cost	Surcharge per 1K gal	Per 1K gal.
NPV		**$65,120,964**			**$0**	**$0**		
2005	11,934,261	$1,272,655	$0.2922	0	$0	$0	$0.0000	**$0.2922**
2006	12,749,101	$1,497,884	$0.3219	0	$0	-	$0.0000	**$0.3219**
2007	13,563,941	$1,723,112	$0.3480	0	$0	-	$0.0000	**$0.3480**
2008	14,378,780	$1,948,341	$0.3712	0	$0	-	$0.0000	**$0.3712**
2009	15,193,620	$2,173,569	$0.3919	0	$0	-	$0.0000	**$0.3919**
2010	16,008,460	$2,398,798	$0.4105	0	$0	-	$0.0000	**$0.4105**
2011	16,823,300	$2,709,210	$0.4412	0	$0	-	$0.0000	**$0.4412**
2012	17,638,140	$3,019,623	$0.4690	0	$0	-	$0.0000	**$0.4690**
2013	18,452,979	$3,330,035	$0.4944	0	$0	-	$0.0000	**$0.4944**
2014	19,267,819	$3,640,448	$0.5176	0	$0	-	$0.0000	**$0.5176**
2015	20,082,659	$3,950,861	$0.5390	0	$0	-	$0.0000	**$0.5390**
2016	20,897,499	$4,372,704	$0.5733	0	$0	-	$0.0000	**$0.5733**
2017	21,712,339	$4,794,547	$0.6050	0	$0	-	$0.0000	**$0.6050**
2018	22,527,178	$5,216,391	$0.6344	0	$0	-	$0.0000	**$0.6344**
2019	23,342,018	$5,638,234	$0.6618	0	$0	-	$0.0000	**$0.6618**
2020	24,156,858	$6,060,077	$0.6873	0	$0	-	$0.0000	**$0.6873**
2021	24,971,698	$6,627,158	$0.7271	0	$0	-	$0.0000	**$0.7271**
2022	25,786,538	$7,194,239	$0.7644	0	$0	-	$0.0000	**$0.7644**
2023	26,601,377	$7,761,319	$0.7994	0	$0	-	$0.0000	**$0.7994**
2024	27,416,217	$8,328,400	$0.8323	0	$0	-	$0.0000	**$0.8323**
2025	28,231,950	$8,895,481	$0.8632	0	$0	-	$0.0000	**$0.8632**
2026	29,045,897	$9,582,044	$0.9038	0	$0	-	$0.0000	**$0.9038**
2027	29,860,737	$10,268,607	$0.9421	0	$0	-	$0.0000	**$0.9421**
2028	30,675,576	$10,955,171	$0.9784	0	$0	-	$0.0000	**$0.9784**
2029	31,490,416	$11,641,734	$1.0129	0	$0	-	$0.0000	**$1.0129**
2030	31,808,925	$12,328,297	$1.0618	0	$0	-	$0.0000	**$1.0618**

POTABLE WATER SURCHARGE

Alternative 2

	Purchased Water			Reclaimed Water				Indicative Total Potable Water Surcharge
	Volume gpd	Cost	Surcharge per 1K gal	Volume gpd	O&M Cost	Capital Cost	Surcharge per 1K gal	Per 1K gal.
NPV		$19,089,729			$4,183,462	$10,423,300		
2005	7,374,443	$421,927	$0.1568	4,559,818	$123,130	$796,564	$0.5526	$0.7093
2006	7,852,920	$471,855	$0.1646	4,896,180	$133,574	796,564	$0.5205	$0.6851
2007	8,331,398	$521,783	$0.1716	5,232,543	$144,018	796,564	$0.4925	$0.6641
2008	8,809,875	$571,711	$0.1778	5,568,905	$154,463	796,564	$0.4679	$0.6457
2009	9,288,353	$621,639	$0.1834	5,905,268	$164,907	796,564	$0.4461	$0.6294
2010	9,766,830	$671,566	$0.1884	6,241,630	$175,351	796,564	$0.4266	$0.6150
2011	10,245,307	$740,019	$0.1979	6,548,534	$191,297	796,564	$0.4133	$0.6112
2012	10,723,785	$808,472	$0.2065	6,855,438	$207,242	796,564	$0.4012	$0.6077
2013	11,202,262	$876,925	$0.2145	7,162,342	$223,188	796,564	$0.3901	$0.6045
2014	11,680,739	$945,378	$0.2217	7,469,246	$239,134	796,564	$0.3799	$0.6016
2015	12,306,509	$1,013,831	$0.2257	7,776,150	$255,079	796,564	$0.3705	$0.5962
2016	12,637,694	$1,155,345	$0.2505	8,082,875	$276,772	796,564	$0.3638	$0.6143
2017	13,116,171	$1,296,860	$0.2709	8,389,601	$298,465	796,564	$0.3576	$0.6285
2018	13,594,649	$1,438,375	$0.2899	8,696,326	$320,158	796,564	$0.3518	$0.6417
2019	14,073,126	$1,579,890	$0.3076	9,003,051	$341,851	796,564	$0.3464	$0.6540
2020	14,847,081	$1,721,405	$0.3177	9,309,777	$363,544	796,564	$0.3414	$0.6591
2021	15,030,081	$1,932,957	$0.3523	9,605,254	$396,135	796,564	$0.3402	$0.6925
2022	15,508,558	$2,144,509	$0.3788	9,900,732	$428,726	796,564	$0.3391	$0.7179
2023	15,987,036	$2,356,060	$0.4038	10,196,210	$461,317	796,564	$0.3380	$0.7418
2024	16,465,513	$2,567,612	$0.4272	10,491,687	$493,907	796,564	$0.3370	$0.7642
2025	17,444,785	$2,779,164	$0.4365	10,787,165	$526,498	796,564	$0.3360	$0.7725
2026	17,422,468	$2,996,868	$0.4713	11,082,643	$567,627	796,564	$0.3372	$0.8085
2027	17,900,945	$3,214,572	$0.4920	11,378,120	$608,756	796,564	$0.3384	$0.8304
2028	18,379,422	$3,432,276	$0.5116	11,673,598	$649,885	796,564	$0.3395	$0.8511
2029	18,857,900	$3,649,980	$0.5303	11,969,075	$691,014	796,564	$0.3405	$0.8708
2030	19,544,372	$3,867,684	$0.5422	12,264,553	$732,143	796,564	$0.3415	$0.8837

POTABLE WATER SURCHARGE

Alternative 3

	Purchased Water			Reclaimed Water				Indicative Total Potable Water Surcharge
	Volume gpd	Cost	Surcharge per 1K gal	Volume gpd	O&M Cost	Capital Cost	Surcharge per 1K gal	Per 1K gal.
NPV		**$16,825,260**			**$4,183,462**	**$10,423,300**		
2005	6,812,946	$354,624	$0.1426	4,608,023	$123,130	$796,564	$0.5468	**$0.6894**
2006	7,291,424	$402,408	$0.1512	4,944,385	$133,574	796,564	$0.5154	**$0.6666**
2007	7,769,901	$450,193	$0.1587	5,280,748	$144,018	796,564	$0.4880	**$0.6467**
2008	8,248,378	$497,977	$0.1654	5,617,110	$154,463	796,564	$0.4639	**$0.6293**
2009	8,726,856	$545,761	$0.1713	5,953,472	$164,907	796,564	$0.4425	**$0.6138**
2010	9,205,333	$593,545	$0.1767	6,289,835	$175,351	796,564	$0.4233	**$0.6000**
2011	9,683,810	$659,512	$0.1866	6,596,739	$191,297	796,564	$0.4103	**$0.5969**
2012	10,162,288	$725,479	$0.1956	6,903,643	$207,242	796,564	$0.3984	**$0.5940**
2013	10,640,765	$791,446	$0.2038	7,210,547	$223,188	796,564	$0.3875	**$0.5912**
2014	11,119,243	$857,413	$0.2113	7,517,451	$239,134	796,564	$0.3775	**$0.5887**
2015	11,745,012	$923,380	$0.2154	7,824,355	$255,079	796,564	$0.3682	**$0.5836**
2016	12,076,197	$1,030,650	$0.2338	8,131,080	$276,772	796,564	$0.3617	**$0.5955**
2017	12,554,675	$1,137,919	$0.2483	8,437,805	$298,465	796,564	$0.3556	**$0.6039**
2018	13,033,152	$1,245,189	$0.2618	8,744,531	$320,158	796,564	$0.3499	**$0.6116**
2019	13,511,629	$1,352,459	$0.2742	9,051,256	$341,851	796,564	$0.3446	**$0.6188**
2020	14,285,584	$1,459,728	$0.2800	9,357,982	$363,544	796,564	$0.3396	**$0.6196**
2021	14,468,584	$1,659,942	$0.3143	9,653,459	$396,135	796,564	$0.3385	**$0.6528**
2022	14,947,061	$1,860,155	$0.3410	9,948,937	$428,726	796,564	$0.3374	**$0.6784**
2023	15,425,539	$2,060,369	$0.3659	10,244,415	$461,317	796,564	$0.3364	**$0.7023**
2024	15,904,016	$2,260,582	$0.3894	10,539,892	$493,907	796,564	$0.3354	**$0.7249**
2025	16,883,288	$2,460,796	$0.3993	10,835,370	$526,498	796,564	$0.3345	**$0.7339**
2026	16,860,971	$2,664,705	$0.4330	11,130,847	$567,627	796,564	$0.3358	**$0.7688**
2027	17,339,448	$2,868,613	$0.4533	11,426,325	$608,756	796,564	$0.3370	**$0.7902**
2028	17,817,926	$3,072,522	$0.4724	11,721,803	$649,885	796,564	$0.3381	**$0.8105**
2029	18,296,403	$3,276,431	$0.4906	12,017,280	$691,014	796,564	$0.3391	**$0.8298**
2030	18,982,875	$3,480,339	$0.5023	12,312,758	$732,143	796,564	$0.3402	**$0.8425**

POTABLE WATER SURCHARGE

Alternative 4

	Purchased Water			Reclaimed Water				Indicative Total Potable Water Surcharge
	Volume gpd	Cost	Surcharge per 1K gal	Volume gpd	O&M Cost	Capital Cost	Surcharge per 1K gal	Per 1K gal.
NPV		$16,397,269			$4,183,462	$10,423,300		
2005	6,706,717	$341,891	$0.1397	4,617,842	$123,130	$796,564	$0.5456	**$0.6853**
2006	7,185,195	$389,270	$0.1484	4,954,205	$133,574	796,564	$0.5144	**$0.6628**
2007	7,663,672	$436,648	$0.1561	5,290,567	$144,018	796,564	$0.4871	**$0.6432**
2008	8,142,149	$484,027	$0.1629	5,626,929	$154,463	796,564	$0.4631	**$0.6259**
2009	8,620,627	$531,406	$0.1689	5,963,292	$164,907	796,564	$0.4417	**$0.6106**
2010	9,099,104	$578,785	$0.1743	6,299,654	$175,351	796,564	$0.4227	**$0.5970**
2011	9,577,581	$644,310	$0.1843	6,606,380	$191,297	796,564	$0.4097	**$0.5940**
2012	10,056,059	$709,836	$0.1934	6,913,105	$207,242	796,564	$0.3978	**$0.5912**
2013	10,534,536	$775,361	$0.2016	7,219,831	$223,188	796,564	$0.3870	**$0.5886**
2014	11,013,013	$840,887	$0.2092	7,526,556	$239,134	796,564	$0.3770	**$0.5862**
2015	11,639,676	$906,412	$0.2133	7,833,281	$255,079	796,564	$0.3678	**$0.5812**
2016	11,969,968	$1,007,174	$0.2305	8,140,185	$276,772	796,564	$0.3613	**$0.5918**
2017	12,448,446	$1,107,936	$0.2438	8,447,089	$298,465	796,564	$0.3552	**$0.5990**
2018	12,926,923	$1,208,698	$0.2562	8,753,993	$320,158	796,564	$0.3495	**$0.6057**
2019	13,405,400	$1,309,460	$0.2676	9,060,897	$341,851	796,564	$0.3442	**$0.6118**
2020	14,179,355	$1,410,222	$0.2725	9,367,801	$363,544	796,564	$0.3393	**$0.6118**
2021	14,362,355	$1,608,290	$0.3068	9,663,279	$396,135	796,564	$0.3382	**$0.6449**
2022	14,840,832	$1,806,359	$0.3335	9,958,756	$428,726	796,564	$0.3371	**$0.6706**
2023	15,319,310	$2,004,427	$0.3585	10,254,234	$461,317	796,564	$0.3361	**$0.6946**
2024	15,797,787	$2,202,496	$0.3820	10,549,712	$493,907	796,564	$0.3351	**$0.7171**
2025	16,777,059	$2,400,564	$0.3920	10,845,189	$526,498	796,564	$0.3342	**$0.7263**
2026	16,754,742	$2,601,863	$0.4255	11,140,667	$567,627	796,564	$0.3355	**$0.7609**
2027	17,233,219	$2,803,162	$0.4456	11,436,145	$608,756	796,564	$0.3367	**$0.7823**
2028	17,711,696	$3,004,460	$0.4647	11,731,622	$649,885	796,564	$0.3378	**$0.8025**
2029	18,190,174	$3,205,759	$0.4828	12,027,100	$691,014	796,564	$0.3389	**$0.8217**
2030	18,876,646	$3,407,058	$0.4945	12,322,577	$732,143	796,564	$0.3399	**$0.8344**

POTABLE WATER SURCHARGE

Alternative 5

	Purchased Water			Reclaimed Water				Indicative Total Potable Water Surcharge
	Volume gpd	Cost	Surcharge per 1K gal	Volume gpd	O&M Cost	Capital Cost	Surcharge per 1K gal	Per 1K gal.
NPV		**$16,297,876**			**$4,183,462**	**$10,423,300**		
2005	6,706,717	$341,891	$0.1397	4,617,842	$123,130	$796,564	$0.5456	**$0.6853**
2006	7,179,838	$388,525	$0.1483	4,959,561	$133,574	796,564	$0.5138	**$0.6621**
2007	7,652,960	$435,160	$0.1558	5,301,279	$144,018	796,564	$0.4861	**$0.6419**
2008	8,126,081	$481,794	$0.1624	5,642,998	$154,463	796,564	$0.4617	**$0.6242**
2009	8,599,202	$528,429	$0.1684	5,984,716	$164,907	796,564	$0.4401	**$0.6085**
2010	9,072,324	$575,063	$0.1737	6,326,435	$175,351	796,564	$0.4209	**$0.5946**
2011	9,545,445	$640,470	$0.1838	6,633,160	$191,297	796,564	$0.4080	**$0.5918**
2012	10,018,566	$705,877	$0.1930	6,939,886	$207,242	796,564	$0.3963	**$0.5893**
2013	10,491,687	$771,284	$0.2014	7,246,611	$223,188	796,564	$0.3855	**$0.5869**
2014	10,964,809	$836,691	$0.2091	7,553,336	$239,134	796,564	$0.3757	**$0.5847**
2015	11,612,896	$902,098	$0.2128	7,860,062	$255,079	796,564	$0.3666	**$0.5794**
2016	11,911,051	$1,001,227	$0.2303	8,166,966	$276,772	796,564	$0.3601	**$0.5904**
2017	12,384,172	$1,100,355	$0.2434	8,473,870	$298,465	796,564	$0.3540	**$0.5975**
2018	12,857,294	$1,199,484	$0.2556	8,780,774	$320,158	796,564	$0.3484	**$0.6040**
2019	13,330,415	$1,298,613	$0.2669	9,087,678	$341,851	796,564	$0.3432	**$0.6101**
2020	14,152,575	$1,397,741	$0.2706	9,394,582	$363,544	796,564	$0.3383	**$0.6089**
2021	14,276,658	$1,595,269	$0.3061	9,690,059	$396,135	796,564	$0.3372	**$0.6434**
2022	14,749,779	$1,792,797	$0.3330	9,985,537	$428,726	796,564	$0.3362	**$0.6692**
2023	15,222,900	$1,990,324	$0.3582	10,281,014	$461,317	796,564	$0.3352	**$0.6934**
2024	15,696,021	$2,187,852	$0.3819	10,576,492	$493,907	796,564	$0.3343	**$0.7162**
2025	16,750,278	$2,385,380	$0.3902	10,871,970	$526,498	796,564	$0.3334	**$0.7236**
2026	16,642,264	$2,586,020	$0.4257	11,167,447	$567,627	796,564	$0.3347	**$0.7604**
2027	17,115,385	$2,786,661	$0.4461	11,462,925	$608,756	796,564	$0.3359	**$0.7820**
2028	17,588,506	$2,987,302	$0.4653	11,758,403	$649,885	796,564	$0.3370	**$0.8024**
2029	18,061,628	$3,187,943	$0.4836	12,053,880	$691,014	796,564	$0.3381	**$0.8217**
2030	18,849,866	$3,388,583	$0.4925	12,349,358	$732,143	796,564	$0.3391	**$0.8317**

POTABLE WATER SURCHARGE

Alternative 6

	Purchased Water			Reclaimed Water				Indicative Total Potable Water Surcharge
	Volume gpd	Cost	Surcharge per 1K gal	Volume gpd	O&M Cost	Capital Cost	Surcharge per 1K gal	Per 1K gal.
NPV		**$16,320,356**			**$4,183,462**	**$10,423,300**		
2005	6,706,717	$341,891	$0.1397	4,617,842	$123,130	$796,564	$0.5456	**$0.6853**
2006	7,181,101	$388,701	$0.1483	4,958,299	$133,574	796,564	$0.5140	**$0.6622**
2007	7,655,484	$435,511	$0.1559	5,298,755	$144,018	796,564	$0.4863	**$0.6422**
2008	8,129,867	$482,321	$0.1625	5,639,211	$154,463	796,564	$0.4620	**$0.6246**
2009	8,604,251	$529,130	$0.1685	5,979,668	$164,907	796,564	$0.4405	**$0.6090**
2010	9,078,634	$575,940	$0.1738	6,320,124	$175,351	796,564	$0.4213	**$0.5951**
2011	9,553,018	$641,355	$0.1839	6,626,974	$191,297	796,564	$0.4084	**$0.5923**
2012	10,027,401	$706,770	$0.1931	6,933,824	$207,242	796,564	$0.3966	**$0.5897**
2013	10,501,785	$772,185	$0.2014	7,240,674	$223,188	796,564	$0.3859	**$0.5873**
2014	10,976,168	$837,599	$0.2091	7,547,524	$239,134	796,564	$0.3760	**$0.5850**
2015	11,618,583	$903,014	$0.2129	7,854,374	$255,079	796,564	$0.3668	**$0.5798**
2016	11,924,935	$1,002,515	$0.2303	8,161,224	$276,772	796,564	$0.3603	**$0.5906**
2017	12,399,318	$1,102,016	$0.2435	8,468,074	$298,465	796,564	$0.3543	**$0.5978**
2018	12,873,702	$1,201,516	$0.2557	8,774,924	$320,158	796,564	$0.3487	**$0.6044**
2019	13,348,085	$1,301,017	$0.2670	9,081,774	$341,851	796,564	$0.3434	**$0.6105**
2020	14,158,532	$1,400,518	$0.2710	9,388,624	$363,544	796,564	$0.3385	**$0.6095**
2021	14,296,852	$1,598,181	$0.3063	9,684,074	$396,135	796,564	$0.3374	**$0.6437**
2022	14,771,236	$1,795,845	$0.3331	9,979,524	$428,726	796,564	$0.3364	**$0.6695**
2023	15,245,619	$1,993,509	$0.3582	10,274,974	$461,317	796,564	$0.3354	**$0.6936**
2024	15,720,002	$2,191,172	$0.3819	10,570,424	$493,907	796,564	$0.3345	**$0.7164**
2025	16,756,374	$2,388,836	$0.3906	10,865,874	$526,498	796,564	$0.3336	**$0.7242**
2026	16,668,769	$2,589,645	$0.4256	11,161,324	$567,627	796,564	$0.3349	**$0.7605**
2027	17,143,153	$2,790,455	$0.4460	11,456,774	$608,756	796,564	$0.3361	**$0.7820**
2028	17,617,536	$2,991,265	$0.4652	11,752,224	$649,885	796,564	$0.3372	**$0.8024**
2029	18,091,920	$3,192,074	$0.4834	12,047,674	$691,014	796,564	$0.3383	**$0.8217**
2030	18,856,099	$3,392,884	$0.4930	12,343,124	$732,143	796,564	$0.3393	**$0.8323**

REUSE COSTS AND RATES

	Alternative 4			Alternative 5				Alternative 6			
	Volume gpd	O&M	Capital	Indicative Reuse Rate Per 1K gal.	Volume gpd	O&M	Capital	Indicative Reuse Rate Per 1K gal.	Volume gpd	O&M	Capital	Indicative Reuse Rate Per 1K gal.
NPV		**$6,386,574**	**$6,610,310**			**$10,947,550**	**$12,036,410**			**$9,863,665**	**$9,083,390**	
2005	2,000,000	$180,402	$505,170	**$0.9391**	2,611,723	$343,052	$919,841	**$1.3248**	2,286,953	$288,052	$694,166	**$1.1767**
2006	2,000,000	$201,715	505,170	**$0.9683**	2,611,723	$377,185	$919,841	**$1.3606**	2,286,953	$320,433	694,166	**$1.2155**
2007	2,000,000	$223,029	505,170	**$0.9975**	2,611,723	$411,317	$919,841	**$1.3964**	2,286,953	$352,813	694,166	**$1.2543**
2008	2,000,000	$244,342	505,170	**$1.0267**	2,611,723	$445,450	$919,841	**$1.4322**	2,286,953	$385,194	694,166	**$1.2931**
2009	2,000,000	$265,656	505,170	**$1.0559**	2,611,723	$479,583	$919,841	**$1.4680**	2,286,953	$417,575	694,166	**$1.3318**
2010	2,000,000	$286,969	505,170	**$1.0851**	2,611,723	$513,715	$919,841	**$1.5038**	2,286,953	$449,955	694,166	**$1.3706**
2011	2,000,000	$311,813	505,170	**$1.1192**	2,611,723	$553,221	$919,841	**$1.5453**	2,286,953	$487,430	694,166	**$1.4155**
2012	2,000,000	$336,657	505,170	**$1.1532**	2,611,723	$592,727	$919,841	**$1.5867**	2,286,953	$524,905	694,166	**$1.4604**
2013	2,000,000	$361,501	505,170	**$1.1872**	2,611,723	$632,233	$919,841	**$1.6281**	2,286,953	$562,380	694,166	**$1.5053**
2014	2,000,000	$386,344	505,170	**$1.2213**	2,611,723	$671,739	$919,841	**$1.6696**	2,286,953	$599,855	694,166	**$1.5502**
2015	2,000,000	$411,188	505,170	**$1.2553**	2,611,723	$711,245	$919,841	**$1.7110**	2,286,953	$637,330	694,166	**$1.5951**
2016	2,000,000	$443,059	505,170	**$1.2989**	2,611,723	$761,301	$919,841	**$1.7635**	2,286,953	$685,031	694,166	**$1.6523**
2017	2,000,000	$474,929	505,170	**$1.3426**	2,611,723	$811,357	$919,841	**$1.8160**	2,286,953	$732,732	694,166	**$1.7094**
2018	2,000,000	$506,800	505,170	**$1.3863**	2,611,723	$861,412	$919,841	**$1.8686**	2,286,953	$780,433	694,166	**$1.7665**
2019	2,000,000	$538,670	505,170	**$1.4299**	2,611,723	$911,468	$919,841	**$1.9211**	2,286,953	$828,134	694,166	**$1.8237**
2020	2,000,000	$570,541	505,170	**$1.4736**	2,611,723	$961,524	$919,841	**$1.9736**	2,286,953	$875,835	694,166	**$1.8808**
2021	2,000,000	$611,518	505,170	**$1.5297**	2,611,723	$1,025,333	$919,841	**$2.0405**	2,286,953	$936,915	694,166	**$1.9540**
2022	2,000,000	$652,495	505,170	**$1.5858**	2,611,723	$1,089,143	$919,841	**$2.1074**	2,286,953	$997,996	694,166	**$2.0272**
2023	2,000,000	$693,471	505,170	**$1.6420**	2,611,723	$1,152,953	$919,841	**$2.1744**	2,286,953	$1,059,076	694,166	**$2.1004**
2024	2,000,000	$734,448	505,170	**$1.6981**	2,611,723	$1,216,762	$919,841	**$2.2413**	2,286,953	$1,120,156	694,166	**$2.1735**
2025	2,000,000	$775,425	505,170	**$1.7542**	2,611,723	$1,280,572	$919,841	**$2.3083**	2,286,953	$1,181,236	694,166	**$2.2467**
2026	2,000,000	$821,580	505,170	**$1.8175**	2,611,723	$1,354,851	$919,841	**$2.3862**	2,286,953	$1,252,351	694,166	**$2.3319**
2027	2,000,000	$867,735	505,170	**$1.8807**	2,611,723	$1,429,131	$919,841	**$2.4641**	2,286,953	$1,323,466	694,166	**$2.4171**
2028	2,000,000	$913,890	505,170	**$1.9439**	2,611,723	$1,503,410	$919,841	**$2.5420**	2,286,953	$1,394,581	694,166	**$2.5023**
2029	2,000,000	$960,044	505,170	**$2.0071**	2,611,723	$1,577,690	$919,841	**$2.6199**	2,286,953	$1,465,696	694,166	**$2.5875**
2030	2,000,000	$1,006,199	505,170	**$2.0704**	2,611,723	$1,651,969	$919,841	**$2.6979**	2,286,953	$1,536,811	694,166	**$2.6727**

Appendix B
Impacts of Water Quality at City of Avondale Potable Water Production Wells Due to Recharging Reclaimed Water at Avondale's Existing Recharge Facilities

Impacts On Water Quality at City of Avondale Potable Water Production Wells Due to Recharging Reclaimed Water at Avondale's Existing Recharge Facilities

PREPARED FOR: City of Avondale

PREPARED BY: Ty Morton/CH2M HILL

COPIES: George Gunn/CH2M HILL

DATE: April 21, 2005

Introduction

CH2M HILL is in the process of preparing a Reclaimed Water Distribution System Master Plan (Master Plan) associated with implementing a reclaimed water distribution system within the City limits, using City Waste Water Treatment Plant (WWTP) effluent. The Master Plan is nearing completion and recommends that the City initially recharge all of their Class B+ effluent into their existing recharge facility that is currently used to recharge Salt River Project (SRP) and Central Arizona Project (CAP) water. This recommendation was based on the selection of the least cost alternative out of six (6) alternatives that were highlighted in the Plan.

In 2004, the City of Avondale recharged 9,826 ac-ft of combined SRP and CAP water at their recharge facility. In anticipation of a steadily growing annual SRP allotment over the next 25 years (4,410 ac-ft/year in 2005 to 9,670 ac-ft/year by 2030), the City recently re-permitted their recharge facility to increase its allowable annual recharge capacity using SRP and CAP water from 10,000 ac-ft/year to 15,000 ac-ft/year. In support of this permitting process, the City secured the services of Clear Creek Associates to conduct a hydrogeological study of their recharge facilities. The study's final results and recommendations were submitted to the City in a December, 2003 report titled *Groundwater Mounding Analysis and Alert Level Modification: Avondale Wetlands Expansion* (Mounding Study).

Purpose of Study

The City of Avondale (COA) would like to address several issues related to production well proximity and recharging of Class B+ or Class A+ WWTP effluent into its recharge basins. This Technical Memorandum (TM) has been prepared to address the following specific issues:

- The COA would like to investigate the potential for contaminant transfer from the recharge basin to the City's potable water production wells, some of which are located within a ½ mile of the recharge basins. The COA would like to address this issue from the perspective of currently regulated contaminants. However, the COA is also

generally interested in the contaminant transport potential of currently unregulated contaminants, such as endocrine disrupters, pharmaceuticals, and personal care products that may become regulated in the next 10 to 15 years.

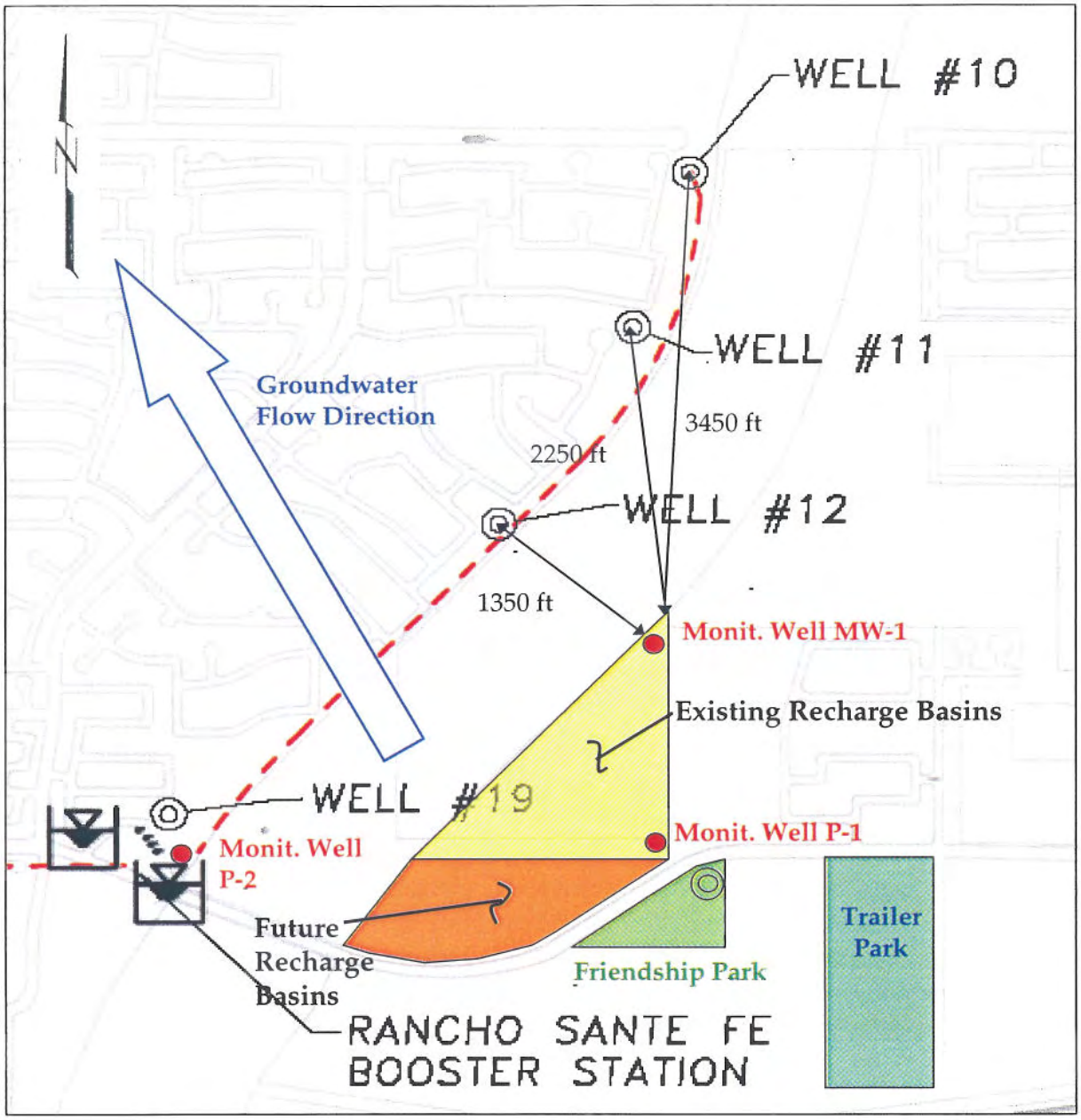
- Without additional filtration treatment and thus removal of additional particulate organic matter at the WWTP, the COA is concerned that chlorination of the current Class B+ effluent will create higher levels of Disinfection By-Products (DBPs), specifically Total Trihalomethanes (TTHMs), resulting from the long contact time the chlorine has with the WWTP effluent organic matter within the proposed 6½ mile pipeline from the City's WWTP to its recharge basin. Once recharged, these TTHMs could contaminate the groundwater and nearby potable water production wells. The COA would like to determine if treating to Class A+ at the WWTP would significantly reduce DBP levels in the recharge basins.
- Future regulations may require that all recharged water be at least Class A+ quality. The City is generally interested in the national and state regulatory environment regarding the recharge of WWTP effluent.
- The general public perception is that recharging Class A+ effluent is safer than recharging Class B+, even if that isn't necessarily true. The City is generally interested in the public perception of recharge programs on going in other municipalities in the Phoenix area.
- Given that there are other municipalities in the Phoenix area who recharge their WWTP effluent, the distance their potable water production wells are from their recharge basins and how such separation determinations were made is also of interest to the COA.

Site Description

The COA's recharge facility is located on the east side of the Agua Fria River and on the north side of McDowell Road, across from Avondale's Friendship Park. The COA meets its domestic water demands by pumping seven groundwater wells, five of which (Wells 10, 11, 12, 18, and 19) are located within one mile of the center of the recharge basins, as shown in Figure 1. Two wells, Wells 14 and 15 are located within one and a half miles of the recharge basins. In addition to the current groundwater wells that contribute to the City's potable water distribution system, the COA may choose to acquire an additional potable well located at Friendship Park. The well at Friendship Park is currently used for turf irrigation purposes only, and as part of the Master Plan the COA may elect to acquire this potable well from the City's Parks Department in exchange for supplying this facility with Class A+ reclaimed water.

The general groundwater gradient in this area is towards the northwest, as shown in Figure 1. Based on this gradient, the wells with the most potential to be influenced by the City's recharge facilities are Wells 10, 11, and 12. Well 12 is the closest of the three to the recharge basins, and is located approximately 1,500 feet from the edge of the current recharge basin

FIGURE 1
Recharge Basin Vicinity Map



boundary. Wells 10, 11, and 12 are described in more detail below. The hydrogeology of the area is discussed in more detail following the well descriptions.

Wells 10, 11, and 12

Wells 10, 11 and 12 are three of the top four producing wells in the COA, and comprise approximately 37-percent of the total available well pumping capacity. Information on each well was collected from the City and from public-domain information available on the Arizona Department of Water Resources' (ADWR) web site.

Well 10

Well 10 (Registration No. 608792) is the furthest of the three wells from the recharge basins, being located on the west side of the Agua Fria River approximately 4,000 ft to the north-northwest of the basins. This well was initially installed in 1977 and was originally documented as having an upper casing diameter of 20-inches (ground surface to 566 ft below ground surface) and a lower casing diameter of 12-inches with a total depth of 866 ft. The screen depth on this well was documented to start at 200 ft below ground surface (bgs) and extend down to the bottom. The COA acquired and re-drilled this well in 1995. The total depth of the well is now indicated as being 866 ft deep with a steel casing diameter of 20-inches from ground surface to 500 ft, and 12-inches from 500 ft down to 866 ft. The well casing is perforated from 255 ft to 495 ft, from 518 ft to 738 ft, and from 748 ft to 768 ft. The drilling logs also indicate that a 20-ft sanitary seal was also installed in 1995.

Well 10 has a design pumping capacity of 1,500 gpm, but well performance data provided in the City's *Water Infrastructure Master Plan* (RBF, 2002) indicate that this well has an average pumping capacity of approximately 2,070 gpm, making it the second most productive well in the COA.

Well 11

Well 11 (Registration No. 608791) is located approximately 3,000 ft to the north-northwest of the City's recharge basins, and similar to Wells 10 and 12, is located on the west side of the Agua Fria River. It was initially installed in 1933 and was originally documented as having a 20-inch diameter casing and a total depth of 250 ft. The City acquired this well in 1994, at which time it was re-drilled to a depth of 618 ft with a casing diameter of 18-inches. The depth to, and length of, the perforated section(s) of this well casing are not known.

Well 11 has a design pumping capacity of 1,500 gpm, but produces on average 1,640 gpm making it the fourth most productive well in the COA.

Well 12

Well 12 (Registration No. 608793) is the closest of the three wells to the recharge basins, being located on the west side of the Agua Fria River approximately 1,500 ft to the northwest of the basins. This well is very similar to Well 10, in that it was also initially installed in 1977 and was originally documented as having an upper casing diameter of 20-inches (ground surface to 539 ft bgs) and a lower casing diameter of 12-inches with a total depth of 867 ft. The well was originally rated at 3,000 gallons per minute. The screen depth on this well was documented to start at 200 ft bgs and extend down to the bottom. The COA acquired this well in 1994, but records do not indicate whether the well was re-drilled or verify the screening.

Well 12 has a design pumping capacity of 3,000 gpm, but produces on average 1,760 gpm making it the third most productive well in the COA.

Local Hydrogeology

A detailed description of the hydrogeology and geology of the entire Avondale area is provided in the *Water Resources Master Plan* (RBF, 2002). A detailed description of the hydrogeology in the vicinity of the COA recharge basins is provided in the Mounding

Study. Detailed descriptions of the local geology and hydrogeology are not repeated here. However, CH2M HILL has summarized a few of the more critical aspects of the hydrogeology.

The City's recharge basins are located within the West Salt River Valley (WSRV) sub-basin of the Phoenix Active Management Area. As previously mentioned, the groundwater gradient in this area is to the northwest, towards the Luke groundwater depression, the center of which is located in the vicinity of Luke Air Force Base in Litchfield Park. For modeling purposes, CH2M HILL used a groundwater model made publicly available by the City of Peoria, the model hereafter referred to as the Peoria Model. Incidentally, the Peoria Model was also used as the basis for the Mounding Study. Within the Peoria Model, the WSRV sub-basin is sub-divided into three hydrogeologic units: the Upper Alluvial Unit (UAU), Middle Alluvial Unit (MAU), and the Lower Alluvial Unit (LAU).

Based on CH2M HILL's review of the model in the vicinity of the COA's recharge basins, it appears that at a depth of approximately 300 ft bgs, the UAU is separated from the MAU by a layer of low-permeability. Although there is hydraulic connectivity between the UAU and MAU, the low-permeability separating layer limits vertical groundwater movement across this layer.

Recharge Basin Recharge Potential

CH2M HILL performed a qualitative assessment of the physical capacity of the City's existing recharge basins to accommodate reclaimed water for recharge in addition to current and projected SRP and CAP water allocations. Results presented in the Mounding Study were referenced to assist in CH2M HILL's qualitative analysis of the physical characteristics of the receiving aquifer and the affect of additional recharged reclaimed water on the local groundwater conditions. Additionally, CH2M HILL modified the Peoria Model to perform a preliminary investigation of the recharge area. The preliminary modeling effort conducted by CH2M HILL was primarily for the purpose of making a cursory evaluation of ground water flow travel time.

Anticipated Total Flows to Recharge Basins

As previously discussed, the City recently re-permitted their existing recharge facilities from 10,000 to 15,000 ac-ft/year. In 2004, the City recharged 9,826 ac-ft, and is expecting to surpass 10,000 ac-ft this year. The City's combined SRP and CAP allocations are expected to increase to approximately 15,000 ac-ft/year by 2030. Although the City currently recharges SRP and CAP supplied-water at its recharge facilities, the City plans to divert their SRP and CAP allocations in the future to other regional recharge facilities. The plan to divert CAP water is certain, and the City expects to begin diverting their CAP water to a regional recharge facility in the near future. The plan to divert SRP water is still being considered by the City, who may elect to continue recharging SRP water at the City's recharge basins.

Based on recommendations made in the Master Plan that is being conducted concurrent to this study, the most cost-effective use of reclaimed City water at this time is for the City to recharge all of their reclaimed water. Even if the City were to elect to directly reuse a portion of their reclaimed water for turf irrigation, they would still ultimately need to recharge more than 90-percent of their reclaimed water. Estimated long-term reclaimed

water flow projections were combined with and without SRP flows to determine total projected flows to the City's recharge basins over time to reflect the City's current options regarding the fate of their SRP water. These projections are presented in Table 1 below.

TABLE 1
Projected Long-Term Total Flows to the Recharge Basins

Year	SRP (ac-ft/yr)	Reclaimed Water[1] (ac-ft/yr)	Total Recharge including SRP (ac-ft/yr)	Total Recharge without SRP (ac-ft/yr)
2005	4,410	5,380	9,790	5,380
2010	5,620	7,360	12,980	7,360
2015	6,830	9,170	16,000	9,170
2020	8,039	10,980	19,019	10,980
2025	9,249	12,690	21,939	12,690
2030	9,670	14,460	24,130	14,460

[1] Assumes City will recharge all of their reclaimed water at its recharge facilities.

As shown in Table 1, the total annual recharge volume is anticipated to surpass 15,000 ac-ft by approximately year 2013 if the City were to decide to continue recharging SRP water at their recharge facilities. At that time, the City may be unable to recharge as much of their effluent in the recharge basins as desired which may result in the need for supplemental recharge at another location.

Although unconfirmed, the *Water Resources Master Plan* (RBF, 2002) indicates that the City' recharge site has land available south of McDowell Road for future expansion which could include effluent recharge. If this information is correct and based upon the above, CH2M HILL recommends that the City acquire sufficient property south of McDowell Road to facilitate the potential future expansion of it's recharge facilities.

Contaminant Transport Potential

To address the COA's concerns regarding the potential for contamination of the COA production wells located in close vicinity to the recharge basins, the following evaluations were conducted:

- Adherence of recharging Class A+ and B+ reclaimed water to Aquifer Water Quality Standards and Federal Safe Drinking Water Standards;
- Potential for TTHM production and aquifer contamination due to chlorinating wastewater effluent if the City elects to treat to Class A+; and
- Contamination potential from currently unregulated contaminants, such as Pharmaceuticals and Personal Care Products (PPCPs) and Endocrine Disrupting Compounds (EDCs).

Each of these evaluations is discussed in more detail in the subsequent sections.

Adherence to Aquifer Water Quality and Safe Drinking Water Standards

Based on preliminary discussions between City personnel and the Arizona Department of Environmental Quality (ADEQ) personnel regarding the Aquifer Protection Permit (APP) requirements, including ADEQ's Wastewater Recharge and Reuse Unit Supervisor and a hydrogeologist in their Water Quality Division, ADEQ confirmed that they would permit the City's recharge facility for Class B+ effluent if the City can demonstrate it can meet the Aquifer Water Quality Standards and not degrade the aquifer.

Table A-1 in Appendix A compares the water quality data from the City's Class B+ wastewater effluent to the Aquifer Water Quality Standards. With the exception of coliforms, the Class B+ effluent from the City's WWTP exceeds the Aquifer Water Quality Standards for all constituents. The Maximum Contaminant Levels (MCLs) estimated to meet Federal Safe Drinking Water Standards are very similar to the Aquifer Water Quality Standards, and as shown in Table A-1, the City's Class B+ effluent also meets all of the Safe Drinking Water Standards with the exception of coliforms. There are some synthetic organic constituents that the City does not routinely sample for and thus will need to be addressed as part of the APP process.

Contamination Potential of Coliforms

There have been a large number of studies conducted that demonstrate the effectiveness of soil media to remove pollutants from wastewater. Systems that use soil media to treat wastewater are often referred to as Soil-Aquifer Treatment (SAT) systems. To summarize the general findings regarding removal of coliforms in SATs, the following excerpt from EPA Manual EPA 625/R-00/008, *Onsite Wastewater Treatment Systems* (EPA, 2002) is provided:

"Results from numerous studies have shown that SATs achieve high removal rates for most wastewater pollutants of concern (see chapter 3) with the notable exception of nitrogen. Biochemical oxygen demand, suspended solids, fecal indicators, and surfactants are effectively removed within 2 to 5 feet of unsaturated, aerobic soil (figure 4-2). Phosphorus and metals are removed through adsorption, ion exchange, and precipitation reactions. However, the retention capacity of the soil is finite and varies with soil mineralogy, organic content, pH, redox potential, and cation exchange capacity. The fate of viruses and toxic organic compounds has not been well documented (Tomson et al., 1984). Field and laboratory studies suggest that the soil is quite effective in removing viruses, but some types of viruses apparently are able to leach from SATs to the ground water. Fine-textured soils, low hydraulic loadings, aerobic subsoils, and high temperatures favor destruction of viruses and toxic organics."

In a study conducted by the Commission on Geosciences, Environment and Resources, *Ground Water Recharge Using Waters of Impaired Quality* (CGER, 1994), it was found that most fecal coliforms in non-chlorinated secondary treated municipal wastewater were removed in the top three feet of the vadose zone. Some did, however, penetrate the aquifer during flooding periods. This study also found that lateral movement of approximately 330 feet through the aquifer removed all detectable fecal coliforms for all cases investigated.

Based on the findings and extensive research conducted to date on this subject, there does not appear to be a risk of coliform contamination of the COA production wells if either Class A+ or B+ water were to be recharged at the COA recharge site. The City of Gilbert,

Arizona also recharges Class B+ water in infiltration basins (to be discussed later in this TM), and has complied with their fecal coliform requirements at all of their monitoring wells that surround their recharge site. With the anticipated removal of most, if not all, of the fecal coliforms in the vadose zone and further treatment ability in the saturated zone over relatively short distances, any recharged Class A+ or B+ effluent should be expected to meet all Aquifer Water Quality Standards and Federal Safe Drinking Water Standards at new monitoring wells placed between the recharge site and Wells 10, 11 or 12.

TTHM Production and Contamination Potential

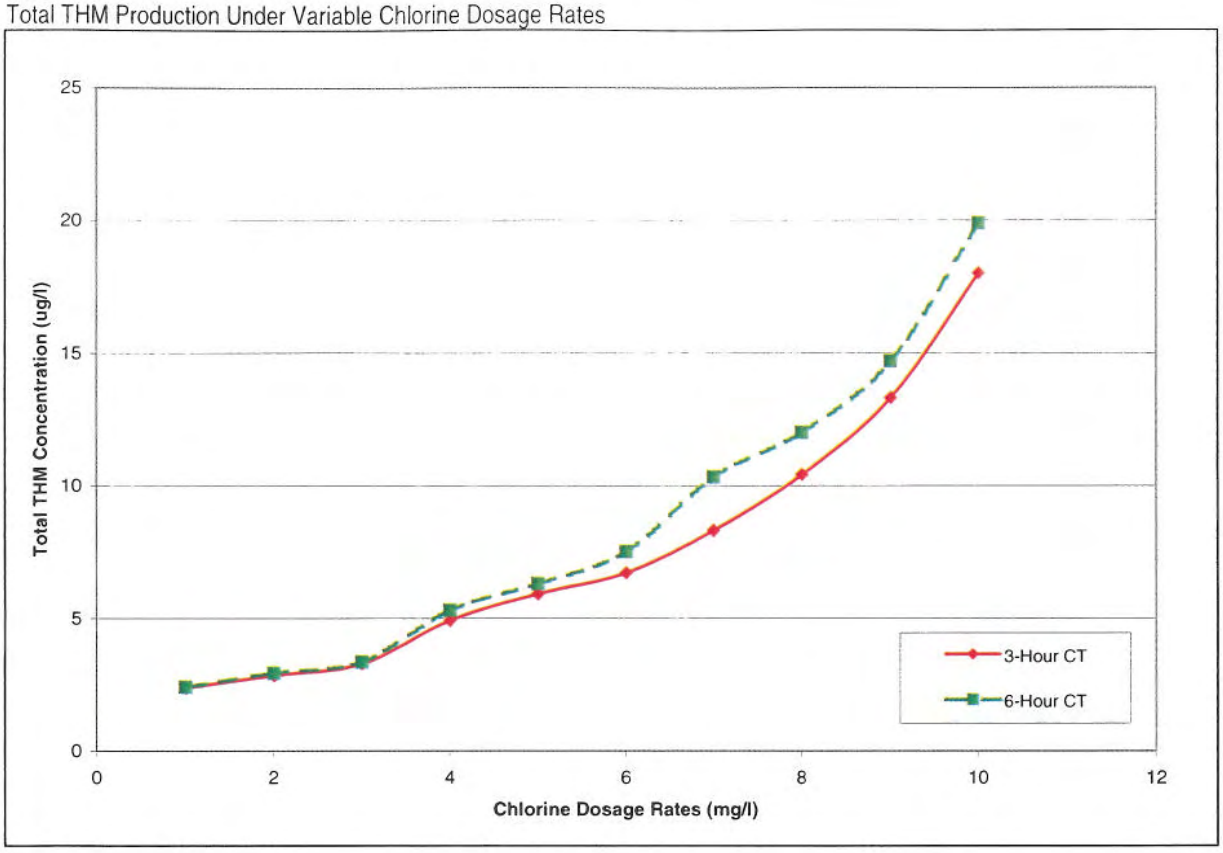
On March 17, 2005, CH2M HILL collected a sample of un-chlorinated WWTP effluent and sent it to CH2M HILL's Applied Sciences Laboratory for analysis. This unfiltered sample, that is indicative of current WWTP effluent quality, was tested to simulate TTHM production under various chlorine dosage rates and contact time scenarios. Specifically, the chlorine doses tested ranged from 1 mg/L to 10 mg/L, and the contact times tested were 3 hours and 6 hours. The contact times were selected based on CH2M HILL's understanding of the proposed reclaimed water conveyance system from the City's WWTP to the recharge basins. Water age analyses using an EPANET water model were conducted to determine the approximate contact time scenarios. A contact time of 6 hours corresponds to the earlier years of operation under average day conditions, when smaller effluent production rates and smaller pumping capacities result in longer conveyance times. A contact time of 3 hours corresponds to the conveyance time at ultimate build-out of the City, under average day conditions.

The Federal Safe Drinking Water Standards regarding TTHMs require that all municipalities using a chemical disinfectant comply with an MCL of 0.080 mg/L TTHM and 0.060 mg/L Haloacetic acids (HAA5). Between a pH of 5.0 and 9.4, the formation of TTHM and HAA5 are similar, and given that the pH of the COA WWTP typically ranges between 7.0 and 8.0, DBP formation may be characterized through TTHM analyses. The Aquifer Water Quality Standards have a higher MCL of 0.100 mg/L for TTHM, and do not regulate HAA5. Figure 3 shows the TTHM concentrations for both contact time scenarios under a variety of chlorine doses.

As shown in Figure 3, TTHM production increases to approximately 20 µg/L when dosing at 10 mg/L of chlorine. The effect of contact time on TTHM production appears to be greater at higher chlorine dosage rates. Based on conversations with the Environmental Services Manager/WWTP Superintendent for the COA, it is anticipated that the chlorine dosage rate required to achieve Class A+ reclaimed water would be 2.5 mg/L, assuming a goal of non-detect on total coliforms. For both contact case scenarios, this dosage rate would result in a TTHM concentration of approximately 3 µg/L, well below the Aquifer Water Quality Standards MCL of 0.10 mg/L (100 µg/L).

In regards to disinfection residuals, the Federal Safe Drinking Water Standards have an MCL of 4 mg/L for chlorine residual, whereas the Aquifer Water Quality Standards do not regulate chlorine residuals. If the City were to elect to treat their WWTP effluent to Class A+, assuming an anticipated chlorine dosing rate of 2.5 mg/L, the resulting Class A+ effluent would meet the DBP and disinfection residual standards for both the Federal Safe Drinking Water Standards and Aquifer Water Quality Standards. As such, based on the

FIGURE 3
Total THM Production Under Variable Chlorine Dosage Rates



anticipated chlorine dosing rate to achieve Class A+ effluent, no dechlorination would be required prior to discharging to the COA recharge basins. Similarly, if the City wanted to disinfect their Class B+ effluent prior to discharge, the estimated TTHM concentrations at the discharge point would be well below the Aquifer Water Quality Standards MCL, and no dechlorination would be required.

Contamination Potential Due to PPCPs and EDCs

In the past few years there has been an increasing awareness of, and concern with, the presence of PPCPs and EDCs in reclaimed water. EDCs are of particular concern since they can interfere with the natural actions of body hormones. There is evidence that specific populations of fish and other wildlife have already been adversely impacted by EDCs at some locations.

The above issues have opened new areas of regulatory concern and review. Studies performed to date indicate that many of these compounds are quickly removed from reclaimed water during its movement through an aquifer, but that some compounds are fairly persistent and capable of traveling for long times and distances (see, for example, Heberer and others, 2004). The fate of select EDCs during Aquifer Storage and Recovery (ASR) operations has been investigated under laboratory conditions with some positive results (Ying and others, 2004).

Based on a brief evaluation of recent literature regarding the fate of PPCPs and EDCs during the recharging of reclaimed water, CH2M HILL composed the following table for consideration by the COA.

TABLE 2
Fate of PPCPs and EDCs Due to Recharge of Reclaimed Water

Parameter	Secondary Treatment	Tertiary Treatment	Fate During Groundwater Recharge
Psychomotor stimulants e.g. caffeine	√	Removed	Effectively removed
X-ray contrast agents	√	Partial Removal	Partial removal
Lipid Regulators	√	Removed	Effectively removed
Antiepileptics	√	Partial Removal	Persist in anoxic and anaerobic conditions for longer than 8 years
Analgesic/anti-inflammatories	√	Removed	Effectively removed
Antibiotics	√	Partial Removal	Partial removal
Estrogenic steroids	√	Removed	Effectively removed
EDCs	√	Partial Removal	Partial removal

Based on CH2M HILL's literature review, it is likely that some PPCPs and EDCs present in the COA WWTP effluent will not be removed during tertiary treatment, if the COA elects to treat to Class A+, or during recharge and will likely migrate to those production wells located immediately down-gradient. It is likely that the resulting PPCP and EDC concentrations at these production wells will be low. However, it is impossible to say at this time what these concentrations will be and whether they will comply with future regulations. Many PPCPs and EDCs are known to be present in surface waters, albeit at lower concentrations than in wastewater, and may be present in the SRP and CAP water currently being recharged. As such, current surface recharge may have already contributed to background levels of PPCPs and EDCs at the COA production wells. Until PPCP and EDC samples are taken from the COA production wells, SRP and CAP water, and City WWTP effluent, it would be premature to try and estimate the extent of the PPCP and EDC contamination potential.

Regulatory Environment

Based on conversations between COA personnel and ADEQ personnel, it has been reported that ADEQ has had discussions internally regarding a minimum distance between recharge and recovery infrastructure, but have no established rules regarding it. The COA has expressed an interest in learning about other regulatory requirements, and in particular Title 22 regulations in California.

Based on the latest December, 2004 Title 22 Draft Regulations, the most pertinent excerpts are provided herein regarding the recharge of reclaimed water:

Section 60320.010. Control of Pathogenic Microorgansims.

(a) For each GRRP [Groundwater Recharge Reuse Project], *the wastewater shall be treated to meet the following*
(1) The definition of filtered wastewater, pursuant to Section 60301.320; and
(2) The definition of disinfected tertiary recycled water, pursuant to Section 60301.230.

(b) If the recycled water being used for surface spreading or subsurface injection has not been treated to meet the criteria in Sections 60301.230 and 60301.320, pursuant to Section 60321 (Sampling and Analysis), the GRRP shall:
(1) Suspend surface spreading or subsurface injection of the recycled water until the criteria is met; and
(2) Inform the Department [of Health Services] *and the RWQCB* [Regional Water Quality Control Board] *in the next monthly report.*

(c) For a surface spreading project, all the recycled water shall be retained underground for a minimum of six months prior to extraction for use as a drinking water supply, and shall not be extracted within 500 feet of any GRRP surface spreading area.

(d) For a subsurface injection project, all the recycled water shall be retained underground for a minimum of twelve months prior to extraction for use as a drinking water supply, and shall not be extracted within 2000 feet of any GRRP subsurface injection well.

There are other relevant Title 22 regulatory requirements, such as control of nitrogen compounds and other regulated contaminants, but it is believed that the COA would meet those requirements. The entirety of the Title 22 Draft Regulations is provided in Appendix C of this report. Of potential interest to the COA is Endnote 5 of Title 22, which recommends non-mandatory monitoring of specified EDCs *"as a diligent way of assessing and verifying recycled water characteristics, which can be useful in addressing issues of public perception about the safety of recharge projects."*

Limited water resource availability and high water demands have required California and Arizona to develop these types of regulations ahead of other states. As such, the ADEQ Aquifer Protection Permit (APP) requirements and the upcoming California Title 22 regulations are widely considered to be the most recent and thorough regulations in the United States regarding the recharge of reclaimed water. The recharge regulations in other states were not reviewed as part of this study.

Discussion on the Implications of Title 22

At this time, ADEQ has not indicated that it intends to adopt California's Title 22 regulations. However, there has been some speculation that some elements of Title 22, such of Section 60320.010 Control of Pathogenic Microorganisms, may be adopted by ADEQ because there are no specific provisions within the APP process that currently regulate pathogenic controls.

In the event ADEQ adopted Section 60320.010, the COA would be required to treat their WWTP effluent to Class A+ reclaimed water standards. The COA is already considering this option. In regards to underground retention time, and indicated earlier in this TM, CH2M HILL conducted a cursory travel time analysis using the Peoria Model. The model was run using an assumed annual recharge volume of 15,000 ac-ft/year at the recharge basins.

CH2M HILL verified that the Peoria Model properly accounted for groundwater pumping at all of the City's production wells in the vicinity of the recharge basins. Based on the model results, CH2M HILL was able to estimate that the approximate travel time, based on a particle tracking analysis, from the COA recharge basin to Well 12, the closest production well, was approximately 3 years. This approximate travel time is a rough estimate, and should be verified through further modeling. However, based on the approximated travel time, it appears that the COA would be able to comply with the Title 22 underground retention time requirements. Additionally, Wells 10, 11, and 12 are located further than 500 feet away from the boundary of the recharge basins and would comply with Title 22 distance separation requirements.

As previously discussed, the COA may elect to provide reclaimed water to the Parks Department at no cost, in exchange for acquiring a well located at Friendship Park that may be used as an additional COA production well. Although yet to be verified, it appears that the well at Friendship Park is located closer than 500 feet to the recharge basins and would not comply with the Title 22 separation distance requirements, if adopted by the ADEQ.

Discussion on the Implications of Upcoming EPA Regulations

The parameters listed in Table 2 represent some of the more commonly observed PPCPs and EDCs that are likely to be regulated by the EPA in the future. However, the full extent of PPCPs and EDCs is likely to be much more extensive than depicted in Table 2. The City should revisit this issue in the future as regulations regarding endocrine disrupters begin to take shape and the universe of contaminants and their MCLs are identified. CH2M HILL will also be closely monitoring regulatory activity in this field.

Based on future EPA regulations that may be promulgated in the next 10 to 15 years, the City may have to consider MCL reductions by ten to a hundred times for various EDC contaminants that are currently both regulated, such as atrazine, and un-regulated that may require additional treatment for organic compounds. Granular Activated Carbon (GAC) is currently the most appropriate treatment method for organics removal.

Recharging Reclaimed Water: Case Studies in the Phoenix Area

CH2M HILL contacted numerous municipalities in the Phoenix metropolitan area and conducted interviews with these municipalities regarding their reclaimed water recharge operations. The municipalities contacted included the following:

- Gilbert,
- Chandler,
- Glendale,
- Phoenix, and
- Mesa.

There are other municipalities in the valley that recharge reclaimed water that were not contacted, including Peoria and Scottsdale. Interview summaries for each of the

municipalities contacted are provided in Appendix B of this TM. Table 3 below identifies some of the key elements of the various recharge programs.

TABLE 3
Summary of Recharge Practices for Various Municipalities in the Phoenix Area

City	Effluent Quality	Length of Operation (yrs)	Recharge Capacity (ac-ft/yr)	Depth to Groundwater		Nearby Production Wells	
				Pre-Recharge (ft)	Post-Recharge (ft)	Horizontal Sep. (ft)	Vertical Sep. (ft)
Surface Recharge							
Avondale	B+	Future	15,000	100	30	1,350	660
Gilbert	B+	15	3,250	130		2,600	950
Mesa	B+	15	3,750	50	20-30	5,000+	
Glendale	A+	3	7,800	110	60	2,600	Hydraulic Separation
Wetlands Facility Recharge							
Gilbert	A+	6	4,500	150		<2,600	950
Chandler	A+	Future	2,250	100		5,000+	1000
Injection System Recharge							
Gilbert	A+	2	1,100	150			850
Chandler	A+	5	7,000	100	50	2,600	650
Phoenix	A+	Future	2,800	1000		5,000+	1000+

Surface Recharge Facilities

Based on the interviews conducted, both Gilbert and Mesa are permitted to recharge Class B+ reclaimed water at their surface recharge facilities. Similar to Avondale, Gilbert also has production wells located within a mile of their recharge facilities, though their production wells are somewhat deeper. Also similar to Avondale, the production wells in Gilbert are located in the Middle Aquifer Unit (MAU), the MAU being hydraulically connected to their Upper Aquifer Unit (UAU), though connected by a low-permeability layer that limits flows from the UAU from readily entering the MAU.

There is at least one surface recharge facility in the valley that has elected to recharge Class A+ reclaimed water, namely Glendale. Glendale originally treated to Class A+ to support an injection program that was eventually abandoned due to clogging. During their transition to a surface recharge program, Glendale continued to treat to Class A+, primarily to appease private water companies who owned production wells in the vicinity of the recharge facilities.

The surface recharge facilities at Gilbert and Glendale have remained in compliance with all APP requirements including Aquifer Water Quality Standards, based on samples collected at their monitoring wells. The City of Mesa routinely experiences positive fecal coliform samples at their monitoring wells that are located immediately adjacent to their recharge

facilities. Avondale's monitoring wells MW-1 and P-1 are similarly positioned in very close proximity to the COA recharge facilities and may experience similar problems. Mesa personnel believe their monitoring wells are located too close to the recharge facilities and are not suitable points of compliance monitoring. Their recommendation is to locate monitoring wells 300 - 400 feet away from the boundary of the recharge basins.

The presence of long-operating Class B+ surface recharge facilities in Mesa and Gilbert demonstrate that the COA has a good possibility of being permitted for similar activities if they choose not to treat to Class A+. However, the COA recharge facilities are located somewhat closer to their production wells than any of the municipalities interviewed. Additionally, the COA production wells appear to have less vertical separation from the recharge basins than other municipalities, with the exception of Chandler. The municipalities contacted, with the exception of Mesa, have clearly indicated that their City's production wells withdraw water from lower aquifers. In the case of Mesa, the person CH2M HILL contacted was unsure as to exactly how deep their production wells were, though their nearest production wells are located "several" miles away.

Injection and Wetlands Recharge Facilities

Other recharge methods, such as wetlands recharge, vadose zone injection, or direct injection, will require treating to Class A+ standards. In the case of wetlands recharge facilities, Class A+ is required from a regulatory standpoint, whereas in the case of injection, Class A+ treatment is required for operational reasons, i.e. to minimize the potential for clogging.

Gilbert has been very happy with their Class A+ wetlands recharge facility and routinely conduct tours for other Phoenix-area municipalities and are believed to have influenced Chandler's decision to implement a similar wetlands facility, currently under construction. The Class A+ wetlands recharge facility in Gilbert has been very popular with the public and with other environmentally-oriented organizations such as the Audubon Society.

Injection facilities are very popular in the Phoenix metropolitan area, primarily because they have small footprints and in many cases, lower operating costs. There has been a progression in the Phoenix area over several years from vadose zone injection to direct injection, the exception being the City of Phoenix who is currently constructing vadose zone injection wells at their Cave Creek WWTP (depth to groundwater is approximately 1,000 feet at this location). Previous vadose zone injection programs in Chandler and Glendale, for example, have all been abandoned due to clogging. Chandler transitioned to direct injection approximately five years ago and has had success with their direct injection program, as has Gilbert. Glendale's North Reclaimed Water Treatment Plant still maintains a direct injection program that is problematic, requiring Glendale to pull and replace their injection wells on an annual basis.

Public Perception Issues

With the exception of Gilbert's Class A+ wetlands project, all municipalities interviewed reported little, if any, public objection to their recharge programs, even when recharging Class B+ reclaimed water. In the case of Gilbert, there were relatively few negative public perception issues with their Class B+ surface recharge facility. However, during the

construction of their Class A+ wetlands facility, the City of Gilbert did go through an extensive public outreach program during the construction phase. However, Gilbert personnel have indicated that this period of extensive public outreach was a very positive experience, and members of the public and the Audubon Society actually participated in the design of the facility. Furthermore, Gilbert continues to provide tours of their facilities to the public and also continues to maintain a strong public education program regarding recharge and reuse.

Study Summary and Recommendations

Based on the information provided herein, CH2M HILL has summarized and provided recommendations regarding the following key elements:

- The COA's existing recharge facility has adequate capacity to accommodate ultimate reclaimed water flows, provided that the City's SRP and CAP allotments are diverted to other regional recharge basins as planned. In the event that the City needs to continue to recharge SRP water at its facility (a possibility that has been raised), the existing recharge facility would have inadequate capacity to accommodate both SRP and City generated reclaimed water flows by Year 2013, and would require that the City find additional sites prior to 2013 to augment their recharge program.

- The COA's WWTP Class B+ effluent is of sufficiently good quality to meet the Aquifer Water Quality Standards at the existing recharge basins, with the exception of fecal coliforms. Given the well documented ability of soil aquifer treatment systems to remove fecal coliforms, it is believed the COA would be able to comply with all Aquifer Water Quality Standards by selecting new points of compliance, i.e. constructing new monitoring wells, to be ideally located 300 to 400 feet away from the boundary of the existing recharge facilities. There are similar ADEQ-permitted surface recharge facilities in the Phoenix area for Class B+ reclaimed water that suggest that the COA would also be able to permit their existing facility for Class B+ recharge. However, there is no guarantee that ADEQ will approve an APP permit. As such, it is recommended that the City begin the APP process immediately, prior to construction of the reclaimed water pump station and pipeline from the WWTP to the recharge basins.

- Based on a cursory model analysis of the COA recharge basin vicinity, a preliminary estimate is that the time of travel between the recharge basin and the nearest production well, Well 12, is approximately two to three years.

- Based on recent laboratory test results from effluent samples collected at the COA WWTP, disinfection using chlorine will not create high levels of TTHMs or other DBPs. Based on COA's anticipated chlorine dosage rate of 2.5 mg/L to achieve Class A+ standards, the estimated TTHM concentration at the recharge basin would be approximately 3 µg/L which is well below the Aquifer Water Quality Standards MCL of 100 µg/L. To address the COA's concerns, a) the disinfection of either Class A+ or Class B+ effluent would not produce TTHM's of sufficient concentration to violate the Aquifer Water Quality Standards, and b), the low chlorine dosage rates needed to achieve non-detect levels of total coliforms would not require the COA to de-chlorinate their reclaimed water prior to recharging.

- PPCP and EDC concentrations may be attenuated during tertiary treatment and during soil-aquifer treatment. However, there is still a strong likelihood that some currently un-regulated PPCP and EDC constituents will migrate from the recharge basins to the COA production wells located down-gradient. PPCP and EDC contamination risk may be minimized by additional treatment processes or by increasing the separation distance between recharge facilities and production wells, providing more opportunity for dilution.
- Reclaimed water recharge facilities in the Phoenix area have not experienced significant public opposition during their implementation, including Class B+ surface recharge facilities. This has been especially true when recharge facilities were constructed at existing wastewater treatment plant sites. It is anticipated that the COA will not experience strong public opposition to their recharging either Class A+ or Class B+ reclaimed water.
- There is no indication at this time that ADEQ intends to adopt California Title 22 regulations. However, in the event that ADEQ adopted portions of the California Title 22 regulations, the COA could expect to be required to treat their effluent to Class A+ prior to recharge. Additionally, Title 22-style regulations would require routine sampling for PPCPs and EDCs, although MCLs for these constituents have not yet been set.

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Appendix A

Water Quality Data Comparison

TABLE A-1
Water Quality Data Comparison

Constituent	Units	Water Quality Standards		WWTP Effluent	
		Safe Drinking	Aquifer	Avg	Max
Unregulated					
PH				7.3000	
TDS	mg/l			840.0	
Sodium	mg/l			150.0	
Calcium	mg/l			67.0	
Magnesium	mg/l			39.0	
Chloride	mg/l			260.0	
Phosphorus	mg/l			0.9700	
Sulfate	mg/l				
Coliforms					
Total		<5% samples coliform (+)	No repeat (+) samples		
Fecal		No repeat (+) samples	No repeat (+) samples	40 CFU	101 CFU
THMs					
Chloroform	mg/l				
Bromoform	mg/l				
Bromodichloromethane	mg/l				
Dibromochloromethane	mg/l				
Total	mg/l	0.08	0.08	0.0035	0.0100
Inorganics					
Antimony	mg/l	0.006	0.006	ND	ND
Arsenic	mg/l	0.05	0.05	0.0063	0.0066
Barium	mg/l	2	2	0.0633	0.0750
Beryllium	mg/l	0.004	0.004	ND	ND
Cadmium	mg/l	0.005	0.005	ND	ND
Chromium	mg/l	0.1	0.1	ND	ND
Copper	mg/l	1.3	1.3		
Cyanide	mg/l	0.2	0.2		
Fluoride	mg/l	4	4	0.3683	0.4200
Lead	mg/l	0.15	0.05	0.0008	0.0025
Mercury	mg/l	0.002	0.002	ND	ND

Constituent	Units	Water Quality Standards		WWTP Effluent	
		Safe Drinking	Aquifer	Avg	Max
Nickel	mg/l		0.1	ND	ND
Nitrate	mg/l	10	10		
Nitrite	mg/l	1	1		
Total N	mg/l	10	10	6.3600	8.2000
Selenium	mg/l	0.05	0.05	ND	ND
Thallium	mg/l	0.002	0.002	ND	ND
Synthetic Organics					
2,4-D	mg/l	0.07	0.07		
2,4,5-TP (Silvex)	mg/l	0.05	0.05		
Alachlor	mg/l	0.002	0.002		
Atrazine	mg/l	0.003	0.003		
Benzo(a)pyrene	mg/l	0.0002	0.0002	ND	0.000049
Carbofuran	mg/l	0.04	0.04		
Chlordane	mg/l	0.002	0.002		
Dalapon	mg/l	0.2	0.2		
Di(2-ethylhexyl) adipate	mg/l	0.4	0.4	ND	ND
Di(2-ethylhexyl) phthalate	mg/l	0.006	0.006		
Dibromochloro-propane	mg/l	0.0002	0.0002		
Dinoseb	mg/l	0.007	0.007		
Dioxin	mg/l	0.00000003	0.00000003	ND	ND
Diquat	mg/l	0.02	0.02		
Endothall	mg/l	0.1	0.1		
Endrin	mg/l	0.002	0.002		
Ethylene dibromide	mg/l	0.00005	0.00005		
Glyphosate	mg/l	0.7	0.7		
Heptachlor	mg/l	0.0004	0.0004		
Heptachlor epoxide	mg/l	0.0002	0.0002		
Hexachlorobenzene	mg/l	0.001	0.001	ND	ND
Hexachlorocyclopentadiene	mg/l	0.05	0.05	ND	ND
Lindane	mg/l	0.0002	0.0002		
Methoxychlor	mg/l	0.04	0.04		
Oxamyl	mg/l	0.2	0.2		
PCBs	mg/l	0.0005	0.0005		

Constituent	Units	Water Quality Standards		WWTP Effluent	
		Safe Drinking	Aquifer	Avg	Max
Pentachlorophenol	mg/l	0.001	0.001	ND	ND
Picloram	mg/l	0.5	0.5		
Simazine	mg/l	0.004	0.004		
Toxaphene	mg/l	0.003	0.003		
Volatiles					
Benzene	mg/l	0.005	0.005	ND	ND
Carbon tetrachloride	mg/l	0.005	0.005	ND	ND
Chlorobenzene	mg/l	0.1	NR		
o-Dichlorobenzene	mg/l	0.6	0.6	ND	ND
p-Dichlorobenzene	mg/l	0.075	0.075	0.0002	0.0007
1,2-Dichloroethane	mg/l	0.005	0.005	ND	ND
1,1-Dichloroethylene	mg/l	0.007	0.007	ND	ND
cis-1,2-Dichloroethylene	mg/l	0.07	0.07	ND	ND
trans-1,2-Dichloroethylene	mg/l	0.1	0.1	ND	ND
Dichloromethane	mg/l	0.005	0.005	ND	ND
1,2-Dichloropropane	mg/l	0.005	0.005	ND	ND
Ethylbenzene	mg/l	0.7	0.7	ND	ND
Styrene	mg/l	0.1	0.1	ND	ND
Tetrachloroethylene	mg/l	0.005	0.005	ND	ND
1,2,4-Trichlorobenzene	mg/l	0.07	0.07	ND	ND
1,1,1-Trichloroethane	mg/l	0.2	0.2	ND	ND
1,1,2-Trichloroethane	mg/l	0.005	0.005	ND	ND
Trichloroethylene	mg/l	0.005	0.005	ND	ND
Toluene	mg/l	1	1	ND	ND
Vinyl Chloride	mg/l	0.002	0.002	ND	ND
Xylenes	mg/l	10	10	ND	ND

Appendix B

Phoenix Area Recharge Facilities – Interviews

Gilbert

Contact: Mark Horn/Reclamation Superintendent (480-503-6420)

Treatment Facilities:
Gilbert currently has one wastewater treatment plant, the Neely Water Reclamation Plant, and will be expanding their capacity with the construction of a planned combined Gilbert/Mesa treatment facility. The Neely plant has a capacity of approximately 8 mgd and produces both Class A+ and Class B+ effluent. The Class A+ effluent is filtered and disinfected with sodium hypochlorite.

Recharge Facilities:.

a) City currently began an injection pilot program several years ago that has been very successful. They currently maintain 3 injection wells, approximately 90 feet deep, that have a total capacity of approximately 1 mgd, and they plan to construct two more injection wells in the near future. The injection wells are supplied from the Gilbert/Mesa facility and inject Class A+ water. The groundwater elevation in this area is approximately 150 feet bgs, and all production wells in the area are approximately 900 – 1,000 feet deep, drawing their water from a lower aquifer.
b) City has operated their Class B+ recharge facility for approximately 15 years at the Neely Wildlife Habitat Facility, a fenced in surface recharge area that has now become a well recognized bird watching site. The facility currently recharges approximately 3,300 ac-ft per year, and has numerous monitoring wells that surround the site. The horizontal separation between the recharge facility and the nearest production well is approximately ½ mile. Depth to groundwater at this site is approximately 130 ft.
c) The City maintains a wetlands recharge facility, the Riparian Preserves, for the purposes of surface recharging a portion of their Class A+ effluent from the Neely facility. The facility has a capacity of 4,500 ac-ft per year but will be expanding to 9,000 ac-ft per year in the near future. The depth to groundwater at this site is approximately 150 ft, and the horizontal distance to the nearest potable production well is less than ½ mile. The presence of THMs in their nearby potable protection wells does not appear to be a problem.

Public Perception:
As a part of their pre-design for the Riparian Preserves, the City conducted a large public involvement campaign and solicited opinions from a variety of stakeholders. These stakeholders were very supportive of the Riparian Preserves concept and were intimately involved throughout the design phase of the project, and even contributed towards the design itself. City has indicated that permitting and public perception issues were easier for the Class A+ facility than for the Class B+ facility. As part of their continued public outreach policy, City conducts tours of both facilities for the public.

Chandler

Contact: John Pinkston/WW Facilities Superintendent (480-782-3719)
Jim Phipps/Public Information Office (480-782-2225)
Greg Capps/Water Resources Manager (480-782-3585)

Treatment Facilities:
Tertiary treatment plant using advanced biological treatment with denitrification. WWTP flow is 9 mgd and effluent is classified as A+. They use sodium hypochlorite for disinfection, with 1 mg/L free chlorine in effluent. Turbidity of water is 0.1 to 0.5 NTU. TDS of the recycled water is 1,200-1,500 ppm.

Recharge Facilities:.

a) Five direct injection wells at "Tumble Weed" and 4 wells at "Ocotillo" operated since around 2000, with a total recharge capacity of approximately 7,000 ac-ft per year. Previous vadose-zone injection wells are being abandoned. Performance at the direct inject wells has been successful, and they are planning two additional injection wells. Lateral separation from potable wells used to be one mile, now one-half mile. They inject into "upper unit" while domestic water wells are in middle unit, approximately 1,000 ft deep. They inject in winter and take the water out in the summer. The wells are about 325 feet deep. Water levels are usually 110 feet below ground surface, and they don't let them get above 50 feet bgs. TTHMs are about 50 ppb. Monitoring wells are point of compliance, the nearest being about 300 feet away. Pharmaceutical issue has not been raised yet. They get ADWR recharge credits that they can use to pump water from the "middle aquifer unit" for water that they inject and store in the upper unit because it is assumed that the water will eventually travel vertically and recharge this lower zone.
b) Are planning a wetlands recharge facility for a portion of their effluent that they will combine with Class A+ effluent from the airport. In design phase right now, with limited infiltration capacity of approximately 2,240 ac-ft per year. The horizontal separation between the proposed wetlands facility and the nearest potable well is approximately 1-2 miles.

Public Perception:
City requires all new developments with turf areas of a certain size to use reclaimed water. Reclaimed water distribution system has only been extended into new developments, and new residents seem to have accepted reclaimed water use without complaint. Only a handful of the public typically attend public meetings regarding wastewater reuse. Most public comments have been regarding golf courses and parks...public education has been directed at dispelling perception that golf courses and parks are "wasting" water through over irrigation. Once informed that these facilities are actually using reclaimed water, then there is general acceptance.

Glendale

Contact: Larry Brotman/Water Reclamation Superintendent (623-930-4751)
Thomas Bullion/West Area Water Reclamation Plant Manager (623-930-4755)

Treatment Facilities:
The West Area Water Reclamation Plant (WAWRP) has Dynasand filter with UV and bleach backup. WWTP effluent classified as A+.

Recharge Facilities:.

a) The WAWRP used to operate eight injection wells total, but clogging was a major issue. Abandoned their well injection program in favor of surface recharge. The North Area Water Reclamation Plant (NAWRP) maintains small diameter direct injection wells that are highly prone to clogging. As a result, NAWRP pull and replace their injection wells on an annual basis.

b) For 3 years, they have been operating a 7,800 ac-ft/yr surface recharge facility located near their landfill that they use for recharging their wastewater effluent from their WAWRP. This recharge facility will be expanded to 11,200 ac-ft/yr over the next several years. There are no potable production wells nearby to be concerned about, although there are a number of wells within half a mile that are owned by private water companies. The nearby wells are located in a confined aquifer and are hydraulically separate from the upper aquifer unit impacted by recharging. To the City's knowledge, there are no potable wells in the vicinity of the recharge basins that withdraw from the upper aquifer unit. The depth to groundwater at the 40-acre recharge site was approximately 110 ft bgs prior to recharge activities, but has since mounded to 60 ft bgs. To date they are in APP compliance at all their monitoring wells that are located around the site. They are not planning to expand their site beyond 11,200 ac-ft/yr, but will contribute their future Class A+ effluent in excess of this amount to SRP's future New River Agua Fria Underground Storage Project (NAUSP) recharge facilities.

Public Perception:
During the pre-design phase of their surface recharge facility, they had a 30-day public announcement and comment period and received very little public comment. Majority of comments came from nearby private water companies who were satisfied that the quality of their effluent surpassed that of the local groundwater.

Phoenix

Contact: Andy Terry/Reuse Manager (602-256-3433)

Treatment Facilities:
The City of Phoenix has a very large reclaimed water direct reuse program, but is only now in the process of constructing their first pilot reclaimed water recharge facility. The pilot program will use effluent from their Cave Creek Treatment Plant. The Cave Creek plant has a capacity of approximately 2.5 mgd, and produces class A+ effluent that has been filtered and disinfected using UV, although sodium hypochlorite is regularly used as a backup.

Recharge Facilities:.
City is constructing a well recharge facility that will consist of 8 vadose-zone wells, approximately 150 feet deep. The total capacity of the wells has conservatively been estimated to be 2,800 ac-ft/yr. The depth to groundwater in this area is approximately 1,000 feet, and the horizontal separation between the facility and the nearest potable production well is more than a mile. All production wells in the area extract from below the 1,000 feet water level. The City has expressed concern about their ability to comply with the TTHM MCL. Additionally, previous City experience in recharging potable water through vadose zone wells has led to positive coliform counts at their monitoring wells, likely due to contamination through the vadose zone or during sampling. Anticipating similar problems with their reclaimed water recharge program.

Mesa

Contact: Ronny Lopez/WW Reclamation Superintendent (480-644-2483)

Treatment Facilities:
Mesa currently has two wastewater treatment plants, the Northwest Treatment Plant and the Southwest Treatment Plant. Additionally, Mesa will be expanding their wastewater capacity with the construction of a planned combined Gilbert/Mesa treatment facility. The Southwest Treatment Plant has a capacity of approximately 10 mgd and the Northwest Treatment Plant has a capacity of approximately 18 mgd. Both facilities have the capability to produce either Class A+ or Class B+ effluent, with the option of using both UV or sodium hypochlorite for disinfection. Typically, the City treats to Class A+ to meet their NPDES requirements for discharging their effluent to the Salt River or for direct reuse, but only treats to Class B+ for the purposes of recharging at their surface recharge facilities.

Recharge Facilities:.
City has operated their Class B+ recharge facility for approximately 15 years at the Southwest Treatment Facility. The facility currently recharges approximately 3,750 ac-ft per year, and has numerous monitoring wells that surround the site. The City discharges approximately two-thirds of their effluent into the Salt River, and are now in the process of building a pipeline to redirect this non-recharged portion of their effluent to a regional SRP recharge facility located upstream. The City's recharge basins have limited hydraulic capacity to recharge more than is currently recharged, and the low infiltration rates have been attributed to clay lenses located below the recharge basins.

The horizontal separation between the recharge facility and the nearest production wells is greater than one mile. Depth to groundwater at this site is approximately 50 ft given its proximity to the Salt River. The ADWR has assigned an alert level of 20 ft bgs for the recharge facility, and the City has had to suspend recharge operations in the past due to high groundwater levels. In response to CH2M HILL's question as to the rationale behind the 20 ft bgs alert level, the City responded that it was dictated by ADWR and that it was not governed by the presence of septic tanks in the area. Additionally, the City indicated that the Northwest Treatment Plant recharge basins, which are located on the Salt River Indian Reservation, also are used to recharge Class B+ effluent. The monitoring wells at the Northwest site routinely test positive for fecal coliforms due to their very close proximity to the recharge basins, i.e. they are located at the basin boundary. The recharge basins have continued to operate even under these circumstances because the ADEQ does not have jurisdiction over this site. However, in retrospect, City personnel would have preferred to locate their monitoring wells 300 to 400 feet away from the basins to prevent what they consider to be false positive samples for fecal coliforms.

Public Perception:
The City of Mesa has never had negative public outcry regarding their recharge program, even when the recharge program was first implemented. The City attributes this to the longevity of the plant (built in the 1940s) and a general public perception to accept City operations at this site. The City contrasted this to public perception issues in Gilbert that arose during the construction of a new facility. In numerous public forums where risk management has been discussed, including the recharge operations, there has been very little, if any, negative public comment.

Appendix C

California Title 22 Draft Recharge Regulations

These DRAFT regulations include citations to other draft regulations that have not yet been adopted, but are in the regulatory process. For example, Section 60320.080(d)(4)(B) of these DRAFT regulations refers to "Section 64533, chapter 15.5, title 22." The DHS regulations that include Section 64533 have not yet been adopted; however, a draft version is in future regulations [see Disinfection Byproducts, R-62-00].

This draft reflects the Department of Health Services' current thinking on the regulation of recharge of groundwater with recycled water. Any informal comments you might have on this draft can be emailed to Bob Hultquist, at bhultqui@dhs.ca.gov or to Jeff Stone, at jstone1@dhs.ca.gov

Title 22, CALIFORNIA CODE OF REGULATIONS
DIVISION 4. ENVIRONMENTAL HEALTH
CHAPTER 3. RECYCLING CRITERIA

December 01, 2004 version

ARTICLE 1. DEFINITIONS

Section 60301.080. 24-hour Composite Sample.

"24-hour composite sample" means a combination of no fewer than eight individual samples obtained at equal time intervals during a 24-hour period, such that the volume of each individual sample is proportional to the flow at the time of sampling.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.120. Aquifer.

"Aquifer" means a geologic formation, group of formations, or portion of a formation capable of yielding significant quantities of ground water to wells or springs.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.190. Diluent Water.

"Diluent water" means water that is not treated wastewater that is used to determine the RWC.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.370. Groundwater.

"Groundwater" means water below the land surface in a saturated zone.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.380. Groundwater Basin.

"Groundwater basin" means a subsurface structure having the character of a basin with respect to the collection, retention, and outflow of water or an aquifer or system of aquifers, whether basin-shaped or not, that has reasonably well defined boundaries and more or less definite areas of recharge and discharge.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.390. Groundwater Recharge Reuse Project (GRRP).

"Groundwater recharge reuse project (GRRP)" means a project that uses recycled water and has been planned and is operated for the purpose of recharging a groundwater basin designated in the Water Quality Control Plan [defined in Water Code section 13050(j)] for use as a source of domestic water supply, and that has been identified as a Groundwater Recharge Reuse Project by a RWQCB.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code.
Reference: Sections 13520, 13521, and 13050(j), Water Code.

Section 60301.610. Mound.

"Mound" means a localized, temporary elevation in a water table that builds up as a result of the localized downward percolation of waters that have been discharged to a spreading area.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.670. Project Sponsor.

"Project sponsor" means an agency or agencies that receives water recycling requirements for a GRRP from a RWQCB.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.680. Public Water System.

"Public water system" means a system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year. A public water system includes the following:

(a) Any collection, treatment, storage, and distribution facilities under control of the operator of the system which are used primarily in connection with the system.

(b) Any collection or pretreatment storage facilities not under the control of the operator that are used primarily in connection with the system.

(c) Any water system that treats water on behalf of one or more public water systems for the purpose of rendering it safe for human consumption.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 116275(h), Health and Safety Code.

Section 60301.690. Recycled Water.

"Recycled water" means water, which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13050, Water Code.

Section 60301.705. Recycled Water Contribution (RWC).

"Recycled water contribution (RWC)" means the quantity of recycled water applied at the GRRP spreading area or subsurface injection facility divided by the sum of the recycled water applied at the GRRP spreading area or subsurface injection facility and the diluent water.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.770. RWQCB.

"RWQCB" means Regional Water Quality Control Board.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.780. Saturated Zone.

"Saturated zone" means an underground zone in which all interstices in and between natural geologic materials are filled with water.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.810. Spreading Area.

"Spreading area" means an area where water is applied to the land surface for purposes of recharging the groundwater.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.840. Subsurface Injection.

"Subsurface injection" means the application of water to the groundwater basin by the controlled insertion of water below the ground surface.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.850. Surface Spreading.

"Surface spreading" means the controlled application of water to the spreading area resulting in the recharge of a groundwater basin.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301. 860. Total Nitrogen.

"Total nitrogen" means the sum of ammonia, nitrite, nitrate, and organic nitrogen concentrations, expressed as nitrogen.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60301.870. Total Organic Carbon (TOC).

"Total organic carbon (TOC)" means oxidizable organic carbon measured by an approved laboratory using a method designated by the Department.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60302. Source Specifications.

The requirements in this chapter shall apply only to recycled water of municipal wastewater origin.

NOTE: Authority cited: Section 13521, Water Code.
Reference: Sections 13520 and 13521, Water Code.

ARTICLE 5.1. PLANNED GROUNDWATER RECHARGE REUSE PROJECTS

~~**Section 60320. Groundwater Recharge.**~~

~~(a) Reclaimed water used for groundwater recharge of domestic water supply aquifers by surface spreading shall be at all times of a quality that fully protects public health. The State Department of Health Services' recommendations to the Regional Water Quality Control Boards for proposed groundwater recharge projects and for expansion of existing projects will be made on an individual case basis where the use of reclaimed water involves a potential risk to public health.~~

~~(b) The State Department of Health Services' recommendations will be based on all relevant aspects of each project, including the following factors: treatment provided; effluent quality and quantity; spreading area operations; soil characteristics; hydrogeology; residence time; and distance to withdrawal.~~

~~(c) The State Department of Health Services will hold a public hearing prior to making the final determination regarding the public health aspects of each groundwater recharge project. Final recommendations will be submitted to the Regional Water Quality Control Board in an expeditious manner.~~

Note: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code.
Reference: Section 13520, Water Code.

Section 60320. General Requirements.

(a) All recycled water used for a GRRP shall be from a wastewater management agency that administers an industrial pretreatment and pollutant source control program that includes contaminants specified by the Department based on a review that includes the engineering report and other available data on potential groundwater contaminants. The source control program shall include:

(1) An assessment of the fate of the specified contaminant compounds through the wastewater and recycled water treatment systems.

(2) A source investigation and monitoring program focused on the specified contaminants.

(3) An outreach program to industrial, commercial and residential communities within the sewage collection agency's service area to manage and minimize the discharge of compounds of concern at the source.

(4) A program for maintaining an inventory of compounds discharged into the wastewater collection system so that new compounds of concern can be evaluated rapidly.

(b) Prior to the onset of operation for new GRRP's, or during the first year of operation after the effective date of this section for existing GRRP's, each GRRP shall have in place an approved plan providing for an alternative source of domestic water supply, or Department approved treatment mechanism, to any user whose producing well is found to violate California drinking water standards as a result of the GRRP, or when the Department finds that the groundwater has been degraded to the degree that it is no longer a safe source of drinking water as a result of the GRRP.

(c) The State Department of Health Services will hold a public hearing for each GRRP prior to submitting its recommendations for the initial permit to the RWQCB, and at any time an increase in RWC has been proposed.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.010. Control of Pathogenic Microorganisms.

(a) For each GRRP, the wastewater shall be treated to meet the following:
(1) The definition of filtered wastewater, pursuant to section 60301.320; and
(2) The definition of disinfected tertiary recycled water, pursuant to Section 60301.230.

(b) If the recycled water being used for surface spreading or subsurface injection has not been treated to meet the criteria in sections 60301.230 and 60301.320, pursuant to section 60321 (Sampling and Analysis), the GRRP shall:
(1) Suspend surface spreading or subsurface injection of the recycled water until the criteria is met; and
(2) Inform the Department and the RWQCB in the next monthly report.

(c) For a surface spreading project, all the recycled water shall be retained underground for a minimum of six months prior to extraction for use as a drinking water supply, and shall not be extracted within 500 feet of any GRRP surface spreading area. *(Also, see Section 60320.095. Alternatives)*

(d) For a subsurface injection project, all the recycled water shall be retained underground for a minimum of twelve months prior to extraction for use as a drinking water supply, and shall not be extracted within 2000 feet of any GRRP subsurface injection well. *(Also, see Section 60320.095. Alternatives)*

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.020. Control of Nitrogen Compounds.

(a) To demonstrate control of the nitrogen compounds in the recycled water, each GRRP shall comply with either subsection (a)(1), (a)(2), or (a)(3). (See ENDNOTE 7)

(1) The GRRP shall:
(A) Each week, at least three days apart, collect two grab or 24-hour composite samples of recycled water, or the blend of recycled water and diluent

water, prior to surface spreading or subsurface injection, or prior to its reaching the regional groundwater table if the GRRP has been approved for vadose zone or mound monitoring, pursuant to section 60320.050.

(B) Have the samples analyzed for total nitrogen and require the laboratory to complete each analysis within 72 hours and, if the result of any single sample exceeds 5 mg/L, report the result to the GRRP within the same 72 hours.

(C) If the average of two consecutive samples exceeds 5 mg/L total nitrogen, investigate the cause, take appropriate actions to reduce the total nitrogen levels, and notify the Department and the RWQCB within 24 hours of being notified by the laboratory. If the average of all samples collected during the ensuing two weeks exceeds 5mg/l, suspend the surface spreading or subsurface injection of recycled water. Surface spreading or subsurface injection shall not recommence until appropriate corrections are made to reduce total nitrogen levels to below 5 mg/l.

(D) If more than 25% of the samples collected in any two-week period exceed a total nitrogen of 10 mg/L as nitrogen, suspend surface spreading or subsurface injection of recycled water until appropriate corrections are made to reduce total nitrogen levels to below 5 mg/L.

(2) The GRRP shall:

(A) At the frequency specified in the engineering report prepared pursuant to Section 60320.080, collect grab or 24-hour composite samples of recycled water, or the blend of recycled water and diluent water prior to surface spreading or subsurface injection, or prior to its reaching the regional groundwater table if the GRRP has been approved for vadose or mound monitoring pursuant to section 60320.050. Have the samples analyzed for total nitrogen, nitrate, nitrite, ammonia, organic nitrogen, and DO in excess of BOD as described in the engineering report.

(B) As specified in the engineering report prepared pursuant to Section 60320.080, collect and analyze for DO in the groundwater.

(C) Require the laboratory to complete each analysis within 72 hours and report the result to the GRRP within the same 72 hours if the results indicate:

1. Total nitrogen at a level greater than 10 mg/L, and/or
2. Any constituent listed in Paragraphs (A) or (B) at a level greater than a limit identified in the engineering report.

(D) If the average of two consecutive samples is out of compliance with the 10 mg/L total nitrogen limit or a limit identified in the engineering report for another constituent, investigate the cause, take appropriate actions to achieve compliance, notify the Department and the RWQCB within 24 hours of being notified by the laboratory, and suspend surface spreading or subsurface injection of recycled water until an average of two consecutive samples is in compliance.

(3) The GRRP shall:

(A) In the engineering report prepared pursuant to Section 60320.080, provide evidence that over a period of at least 10 years, local surface spreading

or subsurface injection of water containing nitrogen levels at least 75 percent of those existing or projected for the GRRP, has not resulted in nitrate or nitrite levels in the groundwater in excess of MCL's, and that it will be possible to track the movement of water applied by the GRRP at the surface spreading or subsurface injection facility to the downgradient extraction point.

(B) Each month collect two samples of groundwater at each sampling location downgradient of the GRRP spreading area or subsurface injection facility and analyze for nitrite and nitrate.

(C) Require the laboratory to complete each analysis within 72 hours and, if the results indicate nitrate or nitrite at a level greater than the MCL, report the result to the GRRP within the same 72 hours.

(D) If the average of two consecutive samples exceeds an MCL at any sampling location, notify the Department and RWQCB, and either demonstrate compliance has been achieved or suspend the surface spreading or subsurface injection of recycled water.

(b) Each GRRP shall monitor diluent water quarterly for nitrate and nitrite. Within 48 hours of being informed by the laboratory of a nitrate and/or nitrite result greater than an MCL, the GRRP shall collect a confirmation sample. If the average of the two samples is greater than an MCL, the GRRP shall notify the Department and the RWQCB within 48 hours of receiving the confirmation sample result and:

(1) Investigate the causes and make appropriate corrections;

(2) Each week collect and analyze two grab or 24-hour composite samples at least three days apart; and

(3) If the average of all samples collected over the ensuing two-week period exceeds the applicable criterion, suspend surface spreading or subsurface injection of the diluent water until appropriate corrections are made.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.030. Control of Regulated Chemicals and Physical Characteristics.

(a) The recycled water shall be in compliance with the following:

(1) Primary maximum contaminant levels specified in chapter 15: Inorganic chemicals in table 64431-A (except for nitrogen compounds); radionuclides in table 4, section 64443; organic chemicals in table 64444-A (See Endnote 1)

(2) MCLs for disinfection byproducts in section 64533, chapter 15.5;

(3) Action levels for lead and copper in section 64678, chapter 15:

(4) Secondary MCLs for the constituents and characteristics in tables 64449-A and B ("Upper" levels), chapter 15, with the exception of color.

(b) On a quarterly basis at regular intervals, the GRRP shall collect 24-hour composite or grab samples of the recycled water to determine compliance with paragraphs (a)(1), (2), and (3). The GRRP shall determine compliance on the basis of a running-quarterly average, calculated each quarter using the previous four quarters of data. If the recycled water is out of compliance, the GRRP shall submit a report to the Department and the RWQCB that describes the reasons and the corrective actions taken.

(c) Each year, the GRRP shall collect a representative grab sample of the recycled water to determine compliance with subsection (a)(4); if the single sample result (or average of samples collected during the year, if more than one) exceeds a secondary MCL, the GRRP shall inform the Department and RWQCB and describe the reasons and the corrective actions taken in the next monthly report.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.040. Control of Nonregulated Chemicals.

(a) The TOC in any portion of the filtered wastewater that is not subsequently treated with reverse osmosis shall:

(1) Not exceed 16 mg/L for more than two consecutive samples; if the TOC fails to comply with this criteria, the GRRP shall suspend surface spreading or subsurface injection of recycled water until the TOC is reduced to 16 mg/L or less; and

(2) Be monitored as follows:

(A) For one year after initial startup, the GRRP shall collect and analyze a 24-hour composite sample twice a week;

(B) Subsequently, the Department may allow the GRRP to collect and analyze weekly 24-hour composite samples, based on its review of the first year of data.

(b) The Department will specify a maximum average RWC for each GRRP based on its review of the GRRP's engineering report (section 60320.080) and information presented to the Department during hearings on the GRRP.

(1) Once a month, the average RWC shall be calculated by dividing the total volume of recycled water applied at the GRRP spreading area or subsurface injection facility during the preceding 60 calendar months by the sum of the total volume of recycled water applied at the GRRP spreading area or subsurface injection facility and the diluent water applied during that period. If the average RWC exceeds the maximum average RWC, the GRRP shall notify the Department and RWQCB within 7 days and submit a report to both within 60 days describing the reason and corrective actions taken to avoid future occurrences.

(2) The surface spreading or subsurface injection of recycled water shall be distributed over the surface spreading or subsurface injection facilities and over time in such a manner that the maximum RWC will not be exceeded as an average over any 60 month period in any individual aquifer recharged by the GRRP.

(3) Any GRRP that is initiating surface spreading or subsurface injection with recycled water where the groundwater basin had been recharged with diluent water any time during the prior 60 months, may be credited with this diluent water in determining the RWC pursuant to Section 60320.040 (b)(2) provided that:

(A) The GRRP has demonstrated that the diluent water quality used in the calculation has been characterized in accordance with Section 60320.080 (d)(5) and meets all applicable water quality criteria outlined in Sections 60320.020(b), 60320.030 and 60320.040(f)(1)(a).

(B) Documentation of historical diluent water quality and quantity is addressed in the engineering report required pursuant to Section 60320.080.

(C) The GRRP has accurate records of the volume of diluent water applied during the period used in the RWC calculation.

(D) A source water assessment for the diluent water has been conducted.

(c) Any existing GRRP with its existing Department-specified maximum average RWC shall not exceed a TOC level specified by the Department based on its review of the GRRP's historical TOC data and other operational data. The TOC shall be measured as follows:

(1) In the recycled water; or

(2) For a surface spreading project approved for vadose zone or mound monitoring pursuant to section 63020.050, in the recycled water in the vadose zone or mound. *(Also, see Section 60320.095. Alternatives)*

(d) Any new GRRP and any existing GRRP with an increased Department-specified maximum average RWC shall not exceed a TOC level of 0.5 mg/L divided by the Department-specified maximum average RWC, or the recycled water shall be treated by reverse osmosis to do so. For a GRRP using direct subsurface injection, the entire wastewater stream shall be treated with reverse osmosis. The TOC shall be measured as follows:

(1) In the recycled water; or

(2) For a surface spreading project approved for vadose zone or mound monitoring pursuant to section 63020.050, in the recycled water in the vadose zone or mound.

(e) To determine compliance with subsections (b) and (c),

(1) Each week during which the GRRP is recharging the groundwater basin, the GRRP shall collect a 24-hour composite sample, except that if it can be demonstrated that a grab sample is representative of the water quality

throughout a 24-hour period, or if 100 per cent of the wastewater stream is treated by reverse osmosis, the GRRP may collect a grab sample;

(2) Each month, the GRRP shall determine whether the average of the most recent 20 TOC samples exceeds the applicable criterion;

(A) If the criterion is exceeded, the GRRP shall suspend surface spreading or subsurface injection of the recycled water until the criterion are met and, within 7 days of the suspension, notify the Department and the RWQCB;

(B) New GRRPs shall begin determining compliance as soon as 4 samples have been collected, averaging all available samples up to 20;

(3) If the average of the last four samples exceeds the applicable criterion, the GRRP shall submit a report to the Department and RWQCB within 60 days that describes the reasons and the corrective actions that have been taken to avoid future occurrences.

(f) The GRRP shall conduct the following monitoring (See Endnote 2) and report any detections to the Department and the RWQCB in the next monthly report:

(1) Each quarter during the first year of operation the GRRP shall sample and analyze the recycled water for:

(A) Unregulated chemicals in table 64450, chapter 15;

(B) Priority Toxic Pollutants [chemicals listed in the Water Quality Standards, Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California, and 40 CFR Part 131, Federal Register 65(97), May 18, 2000, p. 31682];

(C) Chemicals with state notification levels that the Department has specified (see Endnote 3), based on a review of the GRRP engineering report and the affected groundwater basin(s); and

(D) Other chemicals that the Department has specified (See Endnote 4) based on a review of the GRRP engineering report and the affected groundwater basin(s).

(2) Subsequently, the Department may allow monitoring to be reduced to annually for the chemicals in paragraphs (1)(A, B, C and D) based on initial sample results.

(3) Annually, the GRRP shall monitor the recycled water for pharmaceuticals, endocrine disrupting chemicals and other chemical indicators of municipal wastewater presence specified by the Department (See Endnote 5), based on a review of the GRRP engineering report and the affected groundwater basin(s).

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.050. Vadose Zone and Mound Monitoring for TOC and Nitrogen Compounds.

To obtain approval for vadose zone or mound monitoring in a surface spreading project, a GRRP shall demonstrate the following to the Department:

(a) For TOC monitoring, that vadose zone or mound samples are representative of undiluted recycled water or that the TOC sample can be used to determine the degree of recycled water TOC reduction through the soil treatment;

(b) For the nitrogen compound monitoring, that vadose zone or mound samples are representative of recycled water and diluent water applied at the GRRP spreading area or subsurface injection facility; and

(c) That the vadose zone or mound monitoring is representative of conditions throughout the spreading area.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.060. Department-Specified Maximum Average RWC Greater than 0.50.

(a) A GRRP may apply to increase the Department-specified maximum average RWC for a GRRP to greater than 0.50 by submitting a proposal to the Department. The proposal shall include a comprehensive report prepared and signed by an engineer registered in California and experienced in the fields of wastewater treatment and public water supply; the report shall include, but not be limited to:

(1) GRRP operations, monitoring, and compliance data;

(2) A demonstration that the water applied at the GRRP spreading area or subsurface injection facility with an average RWC of at least 0.4 has reached at least one GRRP monitoring well for at least one year and the GRRP has been in compliance with the existing Department-specified maximum average RWC,

(3) A demonstration that the water quality data collected at the monitoring well used in the demonstration in subparagraph (2) meets all the primary drinking water standards for the parameters specified pursuant to section 60320.070(b)(2.

(4) Any additional analytical and/or treatment studies requested by the Department to make the determination in subsection (b);

(5) Validation of appropriate construction and siting of monitoring wells;

(6) Scientific peer review by an advisory panel that includes, as a minimum, a toxicologist, a registered engineering geologist or hydrogeologist, an engineer registered in California and experienced in the fields of wastewater treatment and public water supply, a microbiologist, and a chemist; and

(7) An updated engineering report.

(b) Prior to the GRRP's proceeding with an increase in the RWC,

(1) The Department will determine and specify the increment(s) for the increase based on its review of the Engineering Report submitted under subsection (a); and

(2) The project sponsor shall obtain written approval from the Department and the RWQCB.

(c) A GRRP with a Department-specified maximum average RWC greater than 0.50 shall:

(1) Provide advanced oxidation treatment subsequent to any reverse osmosis membrane treatment provided to achieve at least a 1.2 log reduction of NDMA and at least a 0.5 log reduction of 1-4 Dioxane (See Endnote 6); and

(2) Conduct a Tentatively Identified Chemicals (TIC) analysis of the recycled water every year.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.065. Operation Optimization.

(a) During the first year of operation for new GRRP's, or during the first year of operation after the effective date of this section for existing GRRP's, operation of all treatment processes shall be optimized to reduce contaminant levels, including:

(1) regulated contaminants identified in Section 60320.030, and

(2) nonregulated contaminants identified in Section 60320.040.

(b) Each GRRP shall update the operations plan developed pursuant to Subsection 60320.080(a) to include the procedures identified pursuant to Subsection 60320.065(a).

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.070. Monitoring Between GRRP and Downgradient Drinking Water Supply Wells.

(a) Each GRRP shall site and construct monitoring wells, as follows:

(1) At a location between one and three months travel time from the surface spreading or subsurface injection area and at an additional point or points between the surface spreading or subsurface injection area and the

nearest downgradient domestic water supply well as specified pursuant to Section 60320.080(d)(10); and

(2) Such that samples can be obtained independently from each aquifer potentially conveying the water that was recharged by the GRRP.

(b) Monitoring shall be conducted and reported as follows:

(1) Each quarter, at a minimum, samples shall be collected at each monitoring well;

(2) Each sample shall be analyzed for TOC, total nitrogen, nitrate, nitrite, constituents and characteristics in tables 64449-A and B, total coliform levels, and any water quality constituents specified by the Department based on the results of the recycled water monitoring conducted pursuant to this chapter; and

(3) If any of the monitoring results indicates that an MCL has been exceeded or that coliforms are present, the GRRP shall notify the Department and the RWQCB within 48 hours of receiving the result.

(4) All monitoring results shall be noted in the monthly report to the Department and the RWQCB.

(c) Analytical results for chemicals shall be reported directly to the Department and the RWQCB, as follows:

(1) Analytical results of all analyses completed in a calendar month shall be reported to the Department and the RWQCB no later than the end of the following month.

(2) Analytical results shall be reported to the Department electronically using the Electronic Deliverable Format as defined in The Electronic Deliverable Format (EDF) Version 1.2i Guidelines & Restrictions dated April 2001 and Data Dictionary dated April 2001.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.080. Engineering Report.

(a) Any project sponsor proposing a GRRP shall submit an engineering report that includes an operations plan to the RWQCB and the Department. This report shall be prepared by an engineer registered in California and experienced in the fields of wastewater treatment and public water supply, in conjunction with a geologist experienced in hydrogeology and registered in California.

(b) GRRPs shall not spread or inject recycled water until the project sponsor submits a complete engineering report to the RWQCB and the Department and receives a permit from the RWQCB.

(c) For a GRRP with a permit from the RWQCB as of the effective date of this regulation, the project sponsor shall submit an engineering report pursuant to this section to the RWQCB(s) and the Department within two years.

(d) The engineering report shall consist of a comprehensive investigation and evaluation of the GRRP, impacts on the existing and potential uses of the impacted groundwater basin, and the proposed means for achieving compliance with sections 60320.010 through 60320.050 and sections 60325 through 60355. The engineering report shall include, but not be limited to, the following:

(1) A description of the proposed GRRP, including the anticipated TOC level and proposed RWC;

(2) An engineering plan of the recycling plant, transmission facilities, spreading basins/subsurface injection wells, and monitoring wells;

(3) A hydrogeologic study on the impacted groundwater basin that addresses the following:

(A) Impact of the GRRP on domestic groundwater sources;

(B) Description of any other existing or proposed GRRPs that could impact the groundwater basin, and an estimate of the cumulative impact on water quantity and quality with and without the proposed GRRP;

(C) Sources of groundwater basin recharge water, areas of surface spreading or subsurface injection, groundwater quantity, quality, and flow patterns for all aquifers in all impacted groundwater basins;

(D) The horizontal and vertical extent of the underground zone within which the recycled water has not been retained for the period of time or distance specified in subsection 60320.010(c) or (d), as applicable;

(E) For new projects, a description of the pre-project groundwater quality in the impacted groundwater basin;

(F) For all wells that will be impacted by the proposed project

1. Use of each;
2. Identification of well(s) subject to the maximum average RWC; and
3. The estimated or measured shortest recycled water retention time underground and horizontal separation, along with the methods for obtaining these;

(G) Quantitative descriptions of the aquifer transmissivity, groundwater movement, historic depth-to-groundwater, safe yield of the basin, influence of localized pumping, and usable storage capacity of the groundwater basin; and

(H) Description of any existing or anticipated flows into, or recharges of, the basin that could affect the quality of water in the monitoring wells or drinking water wells downgradient of the GRRP.

(4) For the wastewater, treated wastewater, or recycled water proposed for use by the GRRP, the results of one year of quarterly monitoring for:

(A) TOC, BOD, SS, total coliforms, and total nitrogen;

(B) All regulated and unregulated chemicals listed in sections 64431, 64439, 64441, 64443, 64444, 64449, and 64450, chapter 15, and section 64533, chapter 15.5, title 22;

(C) Lead and copper;

(D) Priority Toxic Pollutants [chemicals listed in the Water Quality Standards, Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California, and 40 CFR Part 131, Federal Register 65(97), May 18, 2000, p. 31682]; and

(E) Chemicals that have state notification levels that have been specified by the Department on the basis of vulnerability.

(5) For any diluent waters proposed for use by the GRRP, a source water assessment, and a quantitative and qualitative characterization of the water quality, including temporal variations (e.g. stormwater quality) shall be conducted;

(6) Identification of the agency responsible for preventing the use of groundwater for drinking water within certain areas pursuant to paragraphs (d)(3)(D) and subsection 60320.010(c) and (d), and the mechanism that will be used;

(7) A contingency plan for diversion of recycled water when required pursuant to sections 60320.010(b)(1), 60320.020(a)(1)(C&D), (2)(D) and (3)(D), and 60320.040(a)(1) and (e)(2)(A);

(8) A description of how the data will be obtained and a sample calculation for RWC;

(9) Identification of the maximum average RWC proposed by the project sponsor for the GRRP, pursuant to section 60320.040(e);

(10) A plan for monitoring groundwater flow and water quality in the impacted groundwater basin, including a map of the locations of monitoring wells in the spreading basin and groundwater basin, details on their construction, and a rationale for their siting;

(11) For GRRP's monitoring in the vadose zone or the mound, a description of how compliance with Sections 60320.020 (a)(1) or (2) and 60320.040(c) or (d) will be achieved.

(12) A water quality monitoring plan for the recycled water, diluent water, water in the vadose zone as necessary, water in the mound as necessary and monitoring wells;

(13) A description of the industrial pretreatment and pollutant source control program, pursuant to section 60320(a);

(14) A list of endocrine disrupting chemicals and pharmaceuticals identified in the wastewater, as well as data on the levels where measurable;

(15) For GRRPs using vadose zone or mound monitoring, a description of the vadose zone or mound monitoring program, including the demonstration in section 63020.050; and

(16) An analysis of the GRRP impact that includes a determination of the possible violations or situations that could occur that might pose a risk to public health and a plan with associated costs for mitigating each along with the

financial assurance mechanism that would be utilized. Such violations or situations include, but shall not be limited to:

(A) RWC;

(B) Minimum retention time; and

(C) MCL exceedance or microbiological problem in a drinking water supply well.

(17) An explanation of how the recycled water and diluent water will be distributed over the surface spreading or subsurface injection area and over time to prevent the recycled water fraction in any aquifer from exceeding the maximum RWC.

(e) The operations plan shall include, but not be limited to, the following:

(1) A description of the operational and management personnel, their qualifications, experience, and responsibilities;

(2) If RO membrane technology is used, the routine testing procedures for the integrity of the RO membranes and the RO membrane replacement schedule;

(3) Routine maintenance and performance monitoring for the disinfection system;

(4) Maintenance and calibration schedules for all monitoring equipment, process alarm set points and response procedures for all alarms;

(5) Water blending plan, as applicable;

(6) Maintenance of injection and monitoring wells, and spreading basins;

(7) Vector control activities related to the GRRP;

(8) A description of how the GRRP will measure the retention time to demonstrate compliance with subsection 60320.010(c) or (d);

(9) A list of the pesticides and herbicides used in the spreading facilities; and

(10) The procedures used to operate for compliance with subsections 60320.040 (b) and (c) or (d)).

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.090. Annual and Five Year Reports.

(a) Every year, the project sponsor shall provide to the RWQCB, the Department, and all downgradient public drinking water systems a report prepared by an engineer registered in California and experienced in the fields of wastewater treatment and public water supply that includes the following:

(1) Summary of compliance with the monitoring requirements and criteria in sections 60320.010, 60320.020, 60320.030, 60320.040, and 60320.050;

(2) Summary of any corrective actions taken as the result of violations and any suspensions of surface spreading or subsurface injection of recycled water; including a schedule for making needed improvements.

(3) Any detections of monitored constituents and any observed trends in the monitoring wells,

(4) Information related to travel of waters applied at the GRRP spreading area or subsurface injection facility, i.e., the leading edge of the recycled/diluent water plume,

(5) A description of any changes in the operation of any unit processes or facilities, and

(6) A description of any anticipated changes, along with an evaluation of their expected impact on subsequent unit processes.

(b) Every five years, the project sponsor shall update the engineering report to address any project changes and submit it to the RWQCB and the Department. The update shall include, but not be limited to, a demonstration:

(1) That the maximum RWC pursuant to subsection 60320.040(b) will not be exceeded,

(2) That the minimum retention time underground pursuant to subsection 60320.010(c) or (d) will be met, and

(3) Any inconsistencies between groundwater model prediction and observation and/or measurement and how they are being dealt with.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

Section 60320.095. Alternatives.

(a) The project sponsor may apply to the Department to reduce the distance in subsection 60320.010(c) or (d), if the sponsor can demonstrate with tracer test results and monitoring facilities that the required retention time will be achieved at the proposed alternative distance and can demonstrate compliance with Section 60320.070 (a).

(b) The project sponsor may apply to the Department to use one or more wastewater constituents as a surrogate for nonregulated contaminants (section 60320.040) in place of TOC. Department approval of the alternative will be based on:

(1) Ability to quantify the constituent(s) in the wastewater, recycled water and groundwater samples;

(2) The effect of the engineered and natural treatment systems on the constituents is similar to the effect of the systems on the potential harmful nonregulated components of the organic material in the wastewater and recycled water; at least one of the constituents shall be present in the treated water at a level that enables a determination of constituent reduction through the treatment process; and

(3) Identification of treatment performance standards for the constituent(s) that are as protective of public health as the TOC criteria in section 60320.040.

~~(c) The project sponsor may apply to the Department to modify the responses to exceeding the total nitrogen limit in subsections 60320.020, if it can demonstrate that it can track the volume of water applied at the GRRP facilities containing high nitrogen levels as it moves from the surface spreading or subsurface injection area to drinking water wells, and that, based on sufficient data from pertinent monitoring, it can ensure that the nitrate-N or nitrite-N MCLs have not been and will not be exceeded at any time in drinking water supply wells.~~ NOTE: THE 3 OPTIONS OUTLINED IN 60320.020 NOW ADDRESS THIS ALTERNATIVE

(c) The project sponsor may apply to the Department to use groundwater flow or other potential sources as diluent water for the purpose of calculating the RWC.

NOTE: Additional language is required in this subsection to clarify that the GRRP would have to quantify the additional diluent water with measurements to ensure that the intent of the regulations to control non-regulated chemicals (e.g. TOC) at drinking water wells is achieved on a five-year running average, and ensure that all aquifers are adequately protected.

NOTE: Authority cited: Section 100275, Health and Safety Code and Section 13521, Water Code. Reference: Section 13520, Water Code.

ENDNOTES
These endnotes are not part of the draft regulations, but are included to provide readers with additional information and guidance about the intended application of the draft regulations, and the specific contaminants that are or may be involved.

ENDNOTE 1. New state and federal MCLs will be added as they are adopted (e.g., arsenic, radon, perchlorate, chromium-6)

ENDNOTE 2. GRRPs should select methods for nonregulated chemicals according to the following approach:

- *Use drinking water methods, if available.*
- *Use DHS-recommended methods for chemicals in subsection (f) (e.g., 1,2,3-TCP, NDMA).*
- *If there is no DHS-recommended drinking water method for a chemical, and more than a single EPA-approved method is available, use the most sensitive of the EPA-approved methods.*

- *If there is no EPA-approved method for a chemical, and more than one method is available from the scientific literature (e.g., peer-reviewed journals), after consultation with DHS, use the most sensitive method.*
- *If no approved method is available for a specific chemical, the GRRP's laboratory may develop or use its own methods and should provide the analytical methods to DHS for review. Those methods may be used until DHS-recommended or EPA-approved methods are available.*
- *If the only method available for a chemical is for wastewater analysis (e.g., a chemical listed as a priority pollutant only),sample and analyze for that chemical in the treated wastewater immediately prior to reverse osmosis treatment to increase the likelihood of detection. Use this approach until the GRRP's laboratory develops a method for the chemical in drinking water, or until a DHS-recommended or EPA-approved drinking water method is available.*

ENDNOTE 3. These chemicals are selected from DHS' chemicals with notification levels; chemicals already included in analysis required under subsections (f)(1)(A) or (B) are not included here. These chemicals have either been detected at least once in drinking water supplies, or if not detected, they are of interest for some specific reason [e.g., formaldehyde is of interest because in may be a byproduct of certain treatment processes]. The chemicals are: n-butylbenzene, sec-butylbenzene, tert-butylbenzene, carbon disulfide, chlorate, 2-chlorotoluene, diazinon, 1,4-dioxane, formaldehyde, isopropylbenzene, n-propylbenzene, 1,2,4 -trimethylbenzene, and 1,3,5-trimethylbenzene.

ENDNOTE 4. N-Nitrosodiethylamine (NDEA) and N-Nitrosopyrrolidine are the only two that would be specified by DHS. Monitoring for these nitrosoamines is desired, because of the DHS' experience with N-nitrosodimethylamine (NDMA), a Priority Pollutant and one for which DHS has established a notification level.

ENDNOTE 5. DHS has specified the following endocrine disrupting chemicals, pharmaceuticals and other chemicals for monitoring:

- *Hormones: Ethinyl estradiol, 17-B estradiol, estrone*
- *"Industrial" endocrine disruptors: bisphenol A, nonylphenol and nonylphenol polyethoxylate, octylphenol and octylphenol polyethoxylate, polybrominated diphenyl ethers.*
- *Pharmaceuticals and others substances: acetaminopen, amoxicillin, azithromycin, caffience, carbamazepine, ciprofloxacin, ethylenediamine tetra-acetic acid (EDTA), gemfibrozil, ibuprofen, iodinated contrast media, lipitor, methadone, morphine, salicylic acid, and triclosan.*

These samples are being collected for information purposes; there are no standards for the contaminants listed below and no standards are anticipated at this time and analytical methods may not be widely available (See Endnote 2).

Some interested parties have asked for some clarification of what would happen if any of these contaminants are found. In response, we offer this: Monitoring for these chemicals is viewed as a diligent way of assessing and verifying recycled water quality characteristics, which can be useful in addressing issues of public perception about the safety of recharge projects. Further, should there be a positive finding, the recharge agency and DHS can give the result due consideration as to whether it is of concern or not. Just what such consideration might entail would depend on the knowns and unknowns of the particular chemical, including its potential health effects at the given concentration, the source of the chemical, as well as possible means of better control to limit its presence, treatment strategies if necessary, and other appropriate actions.

Again, we stress that such monitoring is not for compliance purposes, but for informational use only.

The specific contaminants targeted for monitoring may vary among GRPPs, depending on their individual engineering reports and groundwater basins. If a GRPP has additional reports for its own project using prior data that address chemicals identified below, or reports for its own project using data on other chemicals addressing the effectiveness of the treatment processes in limiting the release of endocrine disruptor chemicals into recharge water, those reports should be made available to DHS to assist in developing a list of chemicals that would build upon or supplement the already available information. A GRPP that has little monitoring information should plan on collecting more analytical data related to endocrine disrupting chemicals and pharmaceuticals in its recharge water. A GRRP that can demonstrate a history of prior sampling, analysis, and related research, as well as an on-going program on endocrine disrupting chemicals and pharmaceutical in its recharge water will likely have fewer contaminants specified by DHS for analysis under this section.

GRPPs will not be required to conduct an ongoing monitoring program for contaminants under this section, unless good indicator chemicals can be identified through this monitoring. Depending on the results of analyses and other information discussed above, required monitoring may be of short duration (e.g., twice a year for two or three years). If good indicator chemicals can be identified, requirements for their monitoring will be considered. This notwithstanding, DHS recommends an ongoing monitoring program for these types of chemicals.

ENDNOTE 6. The current draft proposes establishing log reduction of targeted chemicals rather than specifying a specific treatment scheme and/or dosage for achieving advanced oxidation. However, DHS is considering how to implement a requirement for achieving advanced oxidation that would be effective. DHS continues to seek ideas on how this should be regulated.

ENDNOTE 7. Table summarizing text of Section 60320.020 (Control of Nitrogen Compounds)

	Option (a)(1)	(a)(2)	(a)(3)
Compliance point	Recycled water, or a blend of recycled water and diluent water, in or above the mound	• Recycled water, or a blend of recycled water and diluent water, in or above the mound for total N • Recycled water, or recharge water in or above the mound, for ammonia, organic nitrogen, nitrite, and DO in excess of the BOD as required • Groundwater down-gradient of the recharge area for DO as required	Groundwater down-gradient of the recharge area
Standard(s)	• 5 mg/L total N as an average • 10 mg/L total N at a maximum frequency	10 mg/L Total N As established by the engineering report for: • Total N at some level <10 mg/L when used as part of a comprehensive nitrogen control scheme • Ammonia, nitrite, and/or organic nitrogen • Minimum DO in excess of BOD • Minimum DO	MCLs for NO_2 and NO_3
Frequency of sampling	2/wk.	As established by the engineering report	2/mo.
Engineering report	Monitoring plan	• Identification of chemical or surrogate concentrations that will ensure that the NO2 and NO3 MCLs are not exceeded in groundwater down-gradient of the recharge area • Identification of the criteria for suspending recharge • Baseline monitoring and operations plan • Monitoring plan	• Evidence that local recharge of water containing similar nitrogen levels over at least 10 years has not caused a problem and that recharge water can be tracked • Monitoring plan
Consequence of failure	Investigate, correct and notify based on average of two consecutive samples >5 mg/L and suspend recharge of recycled water based on an average of all samples collected during the ensuing two week >5 mg/L. Suspend recharge if more than 25% of samples collected in any two week period exceed 10 mg/L.	Investigate, correct and notify based on an average of two consecutive samples over the total N standard, any standard for another form of nitrogen, or under the DO - BOD or DO level. Suspend recharge of recycled water based on an average of a number of consecutive samples over the total N standard, any standard for another form of nitrogen, or under the DO - BOD or DO level, identified and justified in the engineering report	Notify, and either demonstrate compliance with (a)(1) or (a)(2) or suspend recharge of recycled water, based on average of two consecutive samples over an MCL.

Rationale	Option relies on such a low limit for the total N in the recycled water that the chance that the NO_2 or NO_3 MCL could be exceeded is minute.	Option relies on: 1. A low enough limit for the total N in the recycled water that the chance that a NO_2 or NO_3 MCL could be exceeded is low, combined with 2. Some set of limits determined for the specific GRRP and explained in the Engineering Report for nitrite, organic nitrogen and /or ammonia necessary to limit oxidation to NO_2 or NO_3, and some set of minimum levels for an excess DO over BOD requirement in the recycled water and/or a DO requirement in the groundwater as necessary to prevent reduction of NO_3 to NO_2	Option relies on: 1. A demonstration that historic recharge with water containing comparable levels of nitrogen has not caused a problem, 2. Evidence that recharge water can be tracked and monitored throughout the flow path, and 3. Monitoring to show that the MCLs in for NO2 and NO3 are met in the groundwater. Relatively frequent monitoring at locations between the recharge area and down gradient domestic wells is required.