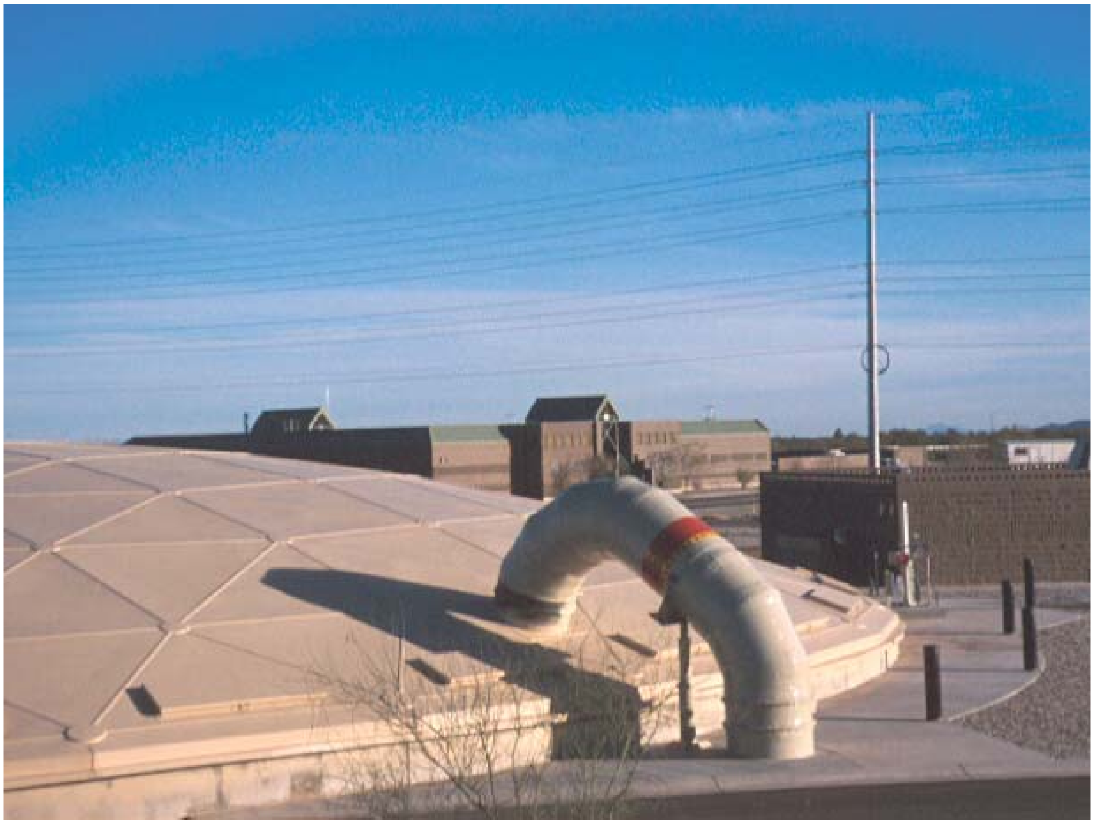
Appendix A – Cave Creek Water Reclamation Plant Study

CASS / CAVE CREEK WATER RECLAMATION SALINITY STUDY



WS90120017: CONTRACT NO: 110330
BROWN & CALDWELL

Prepared by:
TNT Technology Company

FINAL REPORT
February 24, 2006

ACKNOWLEDGMENTS

This report is complied from work conducted by various members of the City of Phoenix including: Peggy Parma who investigated rental equipment and laboratory testing costs and provided supervision and reporting of sampling activity; Roger Vial who investigated each manhole site, deployed the equipment and reported testing data results, and sampled the J.W. Marriott Softener backwash. Andy Terrey obtained zoning maps, aerial maps of each site, and with other staff members provided graphics and photos of CCWRP. David Perry of Arizona Water Quality Association provided information on residential water softener operation, softener salts and current exchange bottle marketplace intelligence. City personnel conducted the laboratory testing and others worked with Roger Vail to deploy, retrieve and clean the flow, conductivity and composite sampler equipment.

Thank you to City of Phoenix, Bureau of Reclamation and Brown & Caldwell personnel who provided oversight and review of the project, technical presentations and this report.

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CITY OF PHOENIX Contract No. 110330

BROWN & CALDWELL Project No. WS90120017

CASS / CAVE CREEK WATER RECLAMATION SEWER SHED SALINITY STUDY

Final Report
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1.0 Executive Summary

This document summarizes work conducted as part of the Cave Creek Water Reclamation Plant (CCWRP) Sewershed Salinity Study (City of Phoenix Contract# 110330).

1.1 Applicability

The results of this work are applicable to new and rapidly growing development areas within Central Arizona and any sewershed with significant water softener utilization.

1.2 Key Findings

The key findings of this study are that:

- Total dissolved solids (TDS) increased 590-730 mg/L between potable water being delivered to City of Phoenix (COP) water customers in the vicinity of the CCWRP (650 mg/L), and wastewater being received at the CCWRP(1260-1380 mg/L).
- This increase exceeds those experienced at larger COP Wastewater Reclamation Plants (WRPs), as well as others (Gilbert and Scottsdale) within the Phoenix Metropolitan Area.
- Thirty to seventy percent of this additional TDS is in the form of sodium chloride (NaCl), and is generated by residential and commercial water softeners.
- Residential water softener market penetration is higher than expected (68% as opposed to 51%), and growing at a rate of 2% per year.
- Water conservation efforts have reduced wastewater flows from 86 gpcd (used in the mid-1990's for planning) to 62 gpcd, (actual after 2000) which increase the impact of water softener use on TDS.
- TDS from residential and commercial sources in CCWRP product is expected to increase to levels that will negatively impact the intended uses of the product. By 2025 the increase in TDS at CCWRP from fast growth in residential alone can reach 600-700 mg/L .
- J.W. Marriott resort is the largest single point source contributor of sodium chloride (over 500,000 pounds annually) and the resort's golf course (Wildfire) is the largest customer of CCWRP.
- Sodium content of CCWRP product water directly correlates with sodium levels measured in Wildfire golf course fairways.
- Individual restaurant contribution of softener salt varies from very small to large, but when clustered together in a large intense commercial development (such as Desert Ridge Marketplace) they can produce TDS concentrations greater than 1500 mg/L.
- Additional TDS and concentrations of sodium and chloride to CCWRP product water will occur when Lift Station 51 is repaired.

1.3 Additional Findings

Additionally, this study has:

- Characterized and prioritized the major salinity contributors to this sewershed,

Table 6.1 Prioritized TDS Discharges

PRIORITY	Description	Justification
1	**New residential**	This area can produce a TDS greater than 2000 mg/L, is showing 60% water softener utilization,and represents an increasing percentage of the sewershed.
2	**Resort/Large Hotels**	These facilities can deliver a TDS greater than 1700 mg/L, and represents 100% water softener utilization.
3	**Intense commercial, (restaurants, bars, data centers)**	These facilities can produce a TDS greater than 1500 mg/L, and represent significant softener use
4	**Hospitals**	TDS greater than 1100 mg/L, existing SIU
5	**Pre-2000 residential**	TDS greater than 1100 mg/L, may change with time
6	**Light retail, office, schools**	TDS greater than 1100 mg/L, expected to remain consistent

- Analytically quantified the 30% drop in gallons per capita per day (gpcd) after the year 2000 due to water conservation and residential water softener market penetration within this sewershed,
- Produced relevant slow and fast growth projections based on this lower gpcd,
- Summarized the key issues that will result from increased salinization within this sewershed,
- Projected TDS increases at CCWRP over the next twenty years,
- Quantified residential and commercial softener regeneration cycles by time, volume and salinity,
- Developed correlation curves for TDS and conductivity for wastewater samples, and
- Investigated technical, environmental and cost issues that favor sodium over potassium chloride for softener regeneration.

1.4 Recommendations

The following recommendations are made:

- Determine actual gpcd flows for this sewershed from residential and commercial developments since 2002.

- Verify the level of sodium and chloride that are toxic to Ceriodaphnia dubia through the on-going Toxicity Identification Evaluation.

- Continue diurnal study of conductivity spikes and the short-term impacts on CCWRP activated sludge process.

- Begin tracking groundwater quality in the vicinity of the CCWRP if this is not already being done.

- Compare and contrast salinity impacts at CCWRP to other high growth areas in Central Arizona.

- Develop an understanding of salt pool technology, to determine its potential for future salinity discharges to the sewershed.

- Speed up the development of an overall salinity management strategy for this sewershed.

2.0 Introduction

2.1 Purpose and Scope

This study was commissioned to characterize the CCWRP sewer shed, identify and quantify TDS sources, and attempt to project TDS changes over a 15 year planning horizon. As a small WRP with a consistent and steady source water TDS, this area represents an ideal study location to determine specific ion and overall TDS contributors of both residential and commercial sources. The Scope of Work for this project can be found in Appendix C.

This study focused on developing concrete measurements and calculations to identify the true nature of the sewer shed and the impact residential and commercial sources have on a small water reclamation plant, today and projected over the next 15 years.

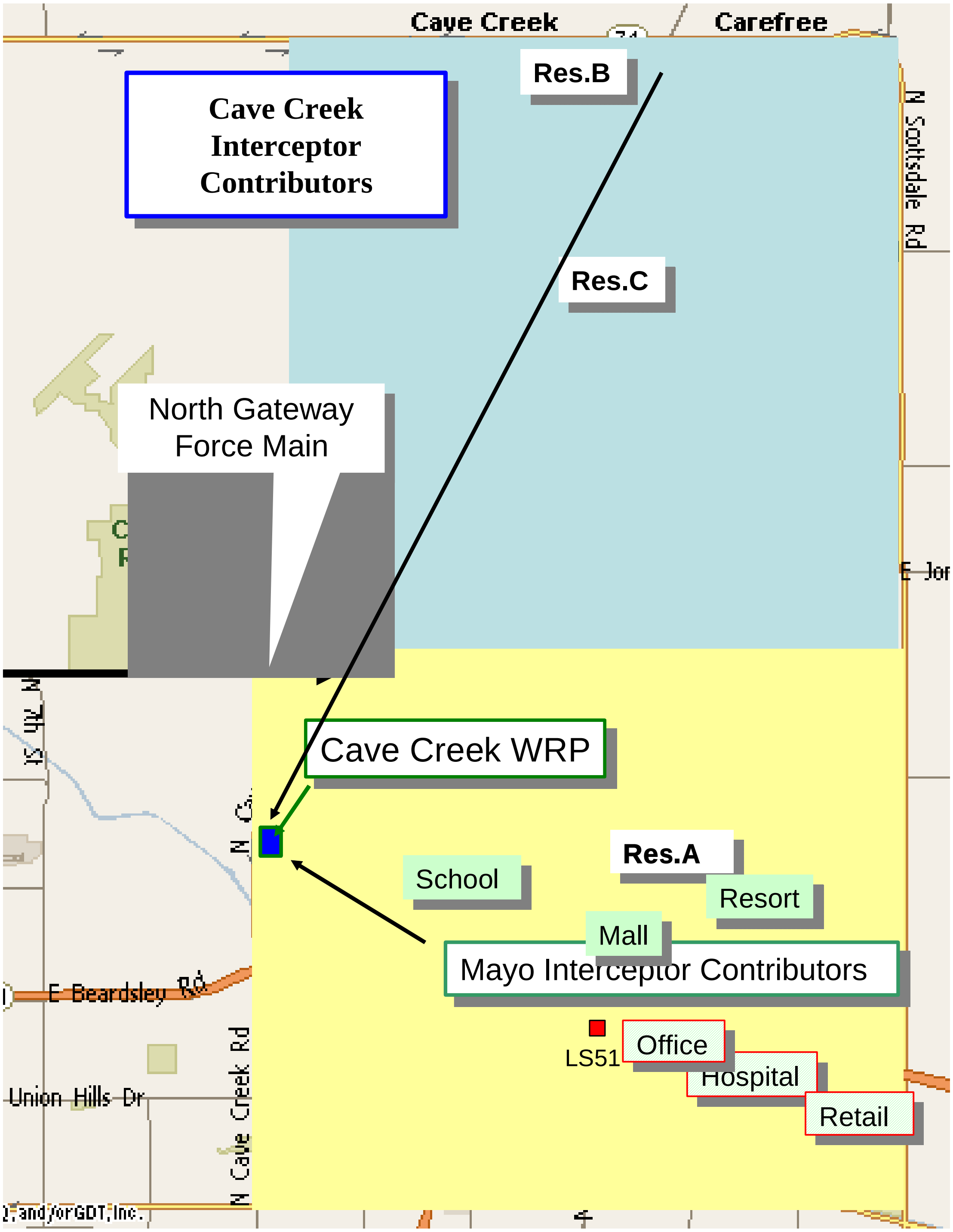
2.2 Sewershed Description

The CCWRP sewershed covers a 55 square-mile area in northeast Phoenix, Arizona, and is comprised of relatively new development. Two interceptor sewers collect wastewater from the sewershed for treatment at the CCWRP. The Mayo interceptor runs along the southern border of the sewershed, and transports wastewater from east to west. A majority of the discharges to this interceptor are from commercial developments. The Cave Creek interceptor runs along the western edge of the sewershed, and is dominated by a variety of residential developments, with limited commercial sites. This interceptor transports wastewater from north to south. Both interceptors serve the CCWRP.

CCWRP is an 8 MGD WRP which is currently treating an average daily flow of 2.6 MGD. At full build-out it will treat 32 MGD. CCWRP is ideal for this kind of study because of the consistent Central Arizona Project (CAP) water supply with a stable TDS level year round. Wells in this area were not in use during the sampling period. This reduced the number of variables in the study. It also has well-defined and easily isolated neighborhoods in a growth area. The impact of salt in this small sewershed is a microcosm of the larger wastewater treatment plants in Central Arizona. The product from this facility is utilized for large (>5 acres) irrigation and groundwater recharge, both of which are impacted by high salinity.

Figure 2.1 is a map of the CCWRP sewershed. The location of the CCWRP is identified and the areas of the sewershed that contribute to each of the interceptors are highlighted. The light blue area flows to the Cave Creek interceptor and the beige area flows to the Mayo interceptor. The North Gateway Forced Main will contain 87,875 gpd flows from Lake Pleasant Water Treatment Plant via the North Gateway Water Reclamation Plant starting in 2007. This flow will contain centrate, sanitary, wash and grey water. The general names of the sampling sites are identified by location. The boxes outlined in red indicate those sampling sites that are currently being diverted to 91st Avenue due to repairs at Lift Station 51 (LS 51). LS51 currently diverts 600,000 gpd.

Figure 2.1 CCWRP Sewershed



2.3 Background

The City of Phoenix operates two large Water Reclamation Plants (WRPs) (the 23rd Avenue WRP and the 91st Avenue WRP). The sewershed for these facilities transports wastewater from a complex mix of residential, commercial and industrial discharges. Reclaimed water from these facilities is utilized for large scale agricultural and cooling needs, as well as a constructed wetland operated by the City. City of Phoenix (COP) has previously determined that 27% of the TDS going to these facilities comes from residential, industrial, and commercial sources, while 73% is attributable to source water.

A growing trend within the Salt River Valley (SRV) has been to build smaller, localized WRPs such as the Cave Creek Water Reclamation Plant (CCWRP). This reduces the impact of growth related flow on older infrastructure, and allows reclaimed water to be utilized for irrigation and recharge within the WRP's service area. Data from the CCWRP shows that unlike COP's larger facilities, less than 50% of the TDS entering the CCWRP can be attributed to source water. This represents a significant increase in TDS over what had been expected, and impacts the City's reuse goals for this facility.

A second trend has been the increased use of point of use (POU) water treatment devices to improve water quality (predominately hardness). This trend has become so prevalent, that many new homes come equipped with technologies such as water softeners, which replace hardness causing ions (calcium and magnesium) with sodium or potassium. Nearly all water softeners in use today are sodium-based. Currently 9300 housing units are connected to the sewer and this figure is projected to potentially rise to 62,000 units by 2025. A high percentage of these homes have and use softeners.

Taken together, these two developments have had the effect of increasing the concentrations of salt entering localized WRPs, and negatively impacting the quality of their product.

2.4 Study Approach

The study began by identifying specific classes of dischargers to the sewershed that would represent changes in residential development ages, as well as various commercial contributors to the sewershed. These classes of dischargers are summarized in **Table 2.1**.

Table 2.1 - Classes of Dischargers	
Development Type / Class	**Site**
Large commercial	Desert Ridge Marketplace
Large resort	JW Marriott Desert Resort & Spa
Large school	Pinnacle High School
Typical office complex	American Express
Medium-sized hospital	Mayo Hospital
Mid 1990's residential area	Desert Ridge
Late 1990's residential area	Dove Valley
Early 2000's residential area	Tatum Ranch/Desert Willow
Mixed commercial/residential	Scottsdale /101; Triangle Bell
High % residential inflow	CCWRP Mayo Interceptor
High % commercial inflow	CCWRP Cave Creek Interceptor
Reuse water	CCWRP Treated Effluent

The second step in this study was to locate sampling sites that represent each of those classes. These were determined in conjunction with COP staff using aerial photographs and site visits. The consultant then identified water quality parameters that would be relevant to the project, and developed a sampling plan to collect the samples and data. Both the sample locations and sampling plan are discussed further in **Section 3**.

Finally, the data was compiled and analyzed to determine the impact of each of the development classes on the CCWRP. The results of this analysis can be found in **Section 5**.

3.0 Sampling Plan and Site Descriptions

This sampling plan was structured to identify and quantify significant salinity contributors the CCWRP sewer shed, due to unanticipated levels of TDS found at the WRP. Sampling sites were chosen to represent the various types of discharges to the CCWRP sewershed which were believed to contribute to the total salinity at the treatment plant. Commercial sampling sites were selected to reflect the range of commercial activity within the sewershed. Residential development was grouped by age of the home, since other studies have indicated that a greater proportion of new homes utilize water softeners, and can be a significant source of TDS. Mayo Hospital is designated as a significant industrial user (SIU) within the COP. Hospital data was incorporated into the commercial sampling sites.

3.1 Site Descriptions

Table 3.1 lists the sample location name, quarter section, manhole designation and analysis code number.

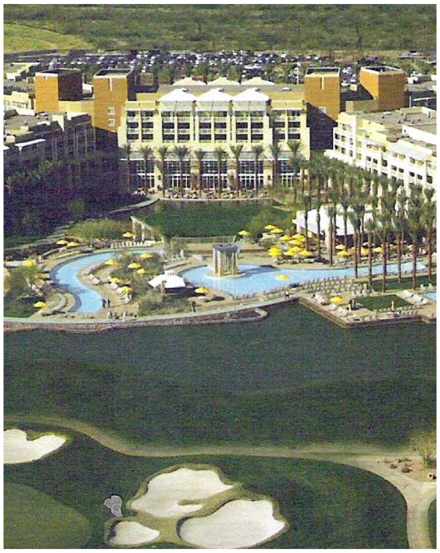


Figure 3.1 J.W. Marriott Resort

Table 3.1 Sample Location Designations

Site Name	QS	Manhole	C
Desert Ridge Marketplace	41-39	219	
JW Marriott Desert Resort	43-40	302	
American Express - East Bldg	39-40	401	
American Express - West Bldg	39-40	402	
Mayo Hospital	39-41	Vault	5
Residential A - Desert Ridge	43-39	407	
Residential B - Dove Valley	56-37	213	
Residential C - Tatum Ranch/Desert Willow	54-37	104	
East of Mayo (Scottsdale 101/Triangle Bell)	39-41	102	
CCWRP Mayo Interceptor	43-33	206	
CCWRP Cave Creek Interceptor	43-33	201	
CCWRP Treated Effluent (Reservoir)	43-33		
JW Marriott Resort supply water	43-40		2
JW Marriott Resort Softener effluent	43-40		216
Tatum Ranch Well			V

3.1.1 Commercial Sampling Sites

3.1.1.1 J.W. Marriott Desert Ridge Resort & Spa

The JW Marriott Desert Ridge Resort & Spa is a 950-room mega-resort situated on 316 acres with two 18-hole golf courses and 4 acres of pools and ten restaurants. Occupancy rates are a fairly consistent 90% summer and winter. As an up-scale resort with all the amenities mentioned, the quality of water is highly important for maintaining the landscaping, the fixtures in guest rooms, shower facilities in the guest rooms and spa, kitchen facilities for the restaurants as well as for turf irrigation.

The dramatic difference in water use summer to winter tells the story of how much water is evaporated from the cooling towers and pools and how much additional water the vegetation demands in the summer. Both periods represent similarly high occupancy rates for the resort. The director of engineering provided the details in **Table 3.2**.

Table 3.2 J.W. Marriott Water Use (gallons)

Period of Use	Irrigation	Cooling towers, pools, guest and kitchen facilities
7/17-8/13/04	6,830,900	9,827,000
1/1-2/1/04	2,000,000	752,800

Figure 3.2 Commercial Water Softener

All water on the site is softened and then blended back to achieve 4 grains of hardness. The custom softener system consists of three 50 cubic foot vessels, each of which is capable of providing 1.5 million grains of softening. Two are on-line at all times with the third on stand-by. Regeneration of each vessel is set at 45,000 gallons treated. All three discharge into one sump which allowed for easy sampling and analysis of the conductivity of a typical regeneration cycle. **Figure 3.2** shows the three large softener resin containers and the 700 gallon brine tank that serves all three. A complete 82-minute regeneration cycle was observed and sampled. The backwash (brine draw), slow rinse and fast rinse generated approximately 2000 gallons and used nearly 700 gallons of concentrated brine.

Figure 3.3 American Express

The Marriott purchases sodium chloride salt from Salt Works for $.08125 per pound and the resort consumed 518,501 pounds from Sept. 2003 to Sept. 2004. A portion of that salt was used in the cooling towers in 2003 during a trial to determine if the economics favored use of salt to increase cycles of concentration to 5.0. The salt use was discontinued because the cost was not justified by water and chemical savings.

3.1.1.2 American Express

The American Express operates a data center at the facility selected for this sampling. The campus currently has 2 office buildings with three floors each comprising 360,000 sq. ft and serving 2500 people. The site was originally planned to have six buildings in order to centralize American Express operations in Arizona. After the terrorist attack on September 11th, those plans were changed and at this time, no further expansions are planned. The site uses water from the Union Hills WTP, and also has two wells on-site as a backup supply. OB1, the east building only has bathrooms for water use and sewer discharge. OB2, the west building, houses the data center, central cooling plant with two, 1000-ton cooling towers, and a cafeteria. The cooling towers are operated at 3.1 cycles, and staff reports water quality issues resulting from rapid changes in source water. The cafeteria has a commercial water softener that is regenerated on-site using approximately 4500 pounds of salt per year. No accurate flow data could be obtained from this site.

3.1.1.3 Mayo Hospital

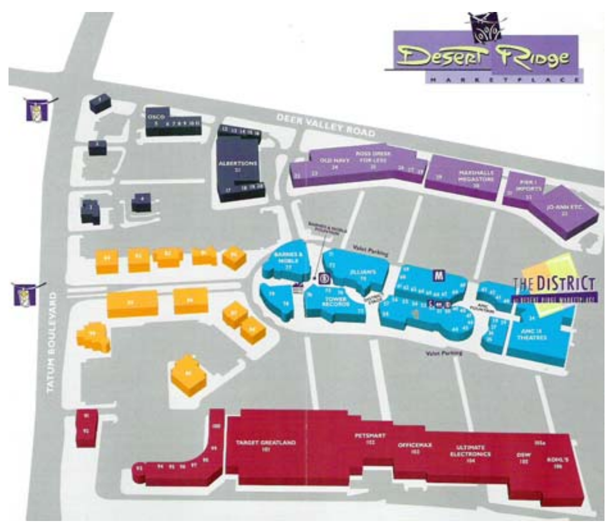
Figure 3.4
Mayo Hospital

The Mayo Hospital campus is currently expanding. An additional building, a specialty treatment center, is being erected adjacent to the central plant (**Figure 3.4**). Hospitals are regulated dischargers to the sewer system. All testing of the wastewater was done at the sampling vault. During the time of the testing, a large flow of black solids was found in the vault, which might be coming from the on-site water treatment system – carbon solids are used to remove chlorine before water is treated in a reverse-osmosis system. Hospital central plants have cooling towers, large commercial softening systems, reverse osmosis and deionization systems. Water used for boiler feed, steam sterilization and other instrument cleaning needs to be of a very high purity. Mayo Hospital is related to the Mayo Clinic located on 136th Street and Shea in Scottsdale, which is a smaller facility.

The two-resin bed softener system is run in series and regenerates two to three times per week or every 200,000 gallons. The fast rinse rate is 365 gpm according to the facilities person who started up and ran the system before being transferred to Mayo Clinic. He estimated that 1400 pounds of salt were used per regeneration and that 26-50% of the salinity is in the first part of the cycle; namely the backwash. Additional softeners polish boiler feedwater. These regenerate every 35,000 gallons or once every six months. Flows from American Express and Mayo Hospital are currently diverted to 91st. Avenue due to repairs at LS-51.

3.1.1.4 Desert Ridge Marketplace

Figure 3.5 Desert Ridge Marketplace



Desert Ridge Marketplace is one of the largest outdoor retail developments in the north Phoenix area, located just north of the 101 on Tatum Boulevard. It has 1.15 million sq. feet of retail, restaurants and entertainment. Thirty restaurants range in size from a coffee shop, Starbucks to a large dining and bar operation like Bahama Breeze. Nearly every restaurant uses softeners. Each tenant building (except Albertson's grocery store) and the shared buildings have packaged roof-top air conditioning systems so no cooling towers are present on this site. This is in contrast to the large enclosed malls, which use cooling towers to achieve higher efficiency cooling and lower operating costs. No flow data was obtained from this site after extensive site investigation to find the manholes.

Fourteen of the 30 restaurants on site were interviewed to determine softener use and obtain estimates of salt use. Those restaurants that have a large bar business use the most salt, ranging from 10,400 to 15,600 pounds per year. The smaller restaurants or ones that primarily serve meals use less salt – about 2400 pounds per year. Even Starbucks uses a small softener to keep the steam systems from corroding. The 61,583 pounds of annual salt use for the 14 restaurants represents a sizeable load into the CCWRP. Each restaurant manager / owner was encouraged by the City's interest in the water quality issues faced by water users and the overall water supply and reuse issue.

3.1.1.5 Developments East of Mayo Hospital

The area east of Mayo Hospital to Scottsdale Road and bordered on the north by the 101 Freeway and on the south by the CAP canal is zoned for primarily commercial development, with some residential. Currently there are several retail developments with another very large one planned that will be larger than Desert Ridge Marketplace. Currently all of the wastewater flow from this area is diverted to the 91st Avenue WWTP because Lift Station 51 is not operating. The salinity from these sites and the developments in the area will have a direct impact on the CCWRP.

Scottsdale/101 is a retail development just south of the 101 freeway, and was under construction during this study. It contains 600,000 sq. feet of space with several very large box retailers and about 10 restaurants. More pads are evident that may add restaurants and therefore increase the salinity discharge from this site. It is estimated based upon the size of the restaurants that approximately 26,000 pounds per year of salt will be contributed to CCWPR when LS51 is repaired.

Further south on Scottsdale Road, across from the Scottsdale Princess Resort is a large auto mall with large dealerships for Porche, BMW, Audi, Land Rover, Jaguar, Volvo, Acura, Lincoln and VW which are all part of United Auto Group. A Danny's Car Wash is located behind this group of dealerships that will likely have a softener for rinsing vehicles. An apartment complex – Desert Club – is located on the western end of this plot of land with nearly 500 units, pool and spa. According to the manager, no softeners are used on site. No cooling towers were evident on any of the structures.

Triangle Bell is a small, tightly packed development is on a county island bordered by Bell Road, Scottsdale Road and the CAP canal. Two restaurants, two Marriott hotels and a luxury apartment complex dominate this development with a few small retail shops. The restaurants and the hotels contribute approximately 89,000 pounds of salt on an annualized basis.

3.1.2 Residential Sampling Sites

3.1.2.1 Residential A

Residential A is an area behind the JW Marriott Resort. It consists of 503 accounts and the homes were built in mid-1990's (1995-1997).

Figure 3.6 Residential Sampling Location

3.1.2.2 Residential B

Residential B is an area immediately south of Carefree Highway and west of Cave Creek Road, on the western edge of development in that region. It consists of 1015 accounts and the homes were built in the early 2000's (1999-2003).

3.1.2.3 Residential C

Residential C is an area that bridges Cave Creek Road between 40^{th} and 51^{st} Streets. The 865 houses were built in the early 1990's (1989-1992) with some small pockets of home built in 1994 and 1996.

3.2 Sampling Plan

The sampling plan consisted of a combination of on-line monitoring and laboratory analysis. On-line monitoring was conducted for a period one week at each site. Composite samples were collected in conjunction with on-line monitoring. The COP's water quality laboratory provided all analytical services for this project. COP also rented the continuous conductivity and flow measurement devices (Troll 9000 from Insitu Inc.) for the sampling events. Two units were rented, so two sites were tested at any one time.

COP personnel assisted with identifying locations for the sampling event. **Table 3.1** identifies the sampling points for each site selected for this sampling effort. Staff identified manholes that would segregate the target contributor from other flows. In some cases, alternative manholes were needed due to problems with access (gated residential communities; manholes buried under 18 inches of parking lot fill and asphalt; multi-sewer connections in one place, etc.) In some cases, flow data could not be collected due to a.) depth of the manhole exceeded the cable length; b) excessive debris; or c.) inability to shield or set the probe for reliable data collection.

The Union Hills WTP provided the annual water quality data that was used to document background TDS coming from the source water. To verify the source water salinity as measured by both TDS and conductivity, several sites were tested, namely: J.W. Marriott Desert Resort & Spa, Union Hills WTP, Tatum Ranch well #285. Wells were not active during the days of testing.

COP also provided salt use data for its on-site chlorine generators.

Pinnacle High School was not sampled. Maintenance staff indicates that water softeners are not utilized. City personnel supplied water meter reading data to assist in determining the impact of specific commercial / industrial sites; namely, Pinnacle High School, American Express and Mayo Hospital.

3.2.1 Analyte Selection and Analytical Methods

Analytes (ions or constiuents being analyzed) were selected that would represent the impact of activities such as water softening, evaporative cooling, and salt concentrating technologies such as nanofiltration and reverse osmosis. These analytes, along with the analytical methods used by the COP water quality laboratory, are listed in **Table 3.3.**

Table 3.3 – Analytes and Methods

Parameter Name	Analysis Method	Units of Measure	Sample Type
Hardness – Total	SM19 2340B	mg/L	Composite
Selenium	EPA 200.8	ug/L	Composite
Molybdenum	EPA 200.7	mg/L	Composite
Sodium	EPA 200.7	mg/L	Composite
Potassium	EPA 200.7	mg/L	Composite
Calcium	SM19 2340B	mg/L	Composite
Calcium Harness	SM19 2340B	mg/L	Composite
Magnesium	SM19 2340B	mg/L	Composite
Chloride	EPA 300.0	mg/L	Composite
Sulfate	EPA 300.0	mg/L	Composite
Total Dissolved	EPA 160.1	mg/L	Grab/Composite
Conductivity	SM19 2510B	mg/L	Grab & online

4.0 Water Softeners

4.1 Overview

Water softeners are utilized to remove hardness, which is caused by calcium and magnesium ions in the water. Both surface water sources in Arizona (the Salt River and the Colorado River) contain very hard water. These ion cause scale to form within pipes and appliances, and require increased detergent use. Hardness is reported as its calcium carbonate equivalent using the following formula.

$$\textbf{Hardness} = 2.497 * \textbf{Ca (mg/L)} + 4.118 * \textbf{Mg (mg/L)}$$

Hardness is also reported as grains per gallon. One grain per gallon equals 17.1 mg/L. Typical hardness ranges are presented in **Table 4.1.** Local water sources are included for comparison.

Table 4.1 Water Hardness Values vs. Surface Supply

Water Designation	Hardness in mg/L	Grains per Gallon
Soft	Under 17.1	1
Slightly Hard	17.1 - 60	1-3.5
Moderately Hard	60 – 120	3.5 – 7
Hard	120 – 180	7 – 10.5
Very Hard	**Over 180**	**Over 10.5**
Salt River	190	10.8
Colorado River	270	15.8

4.2 Equipment and Process of Softening

Figure 4.2 Residential Water Softener Schematic Drawing

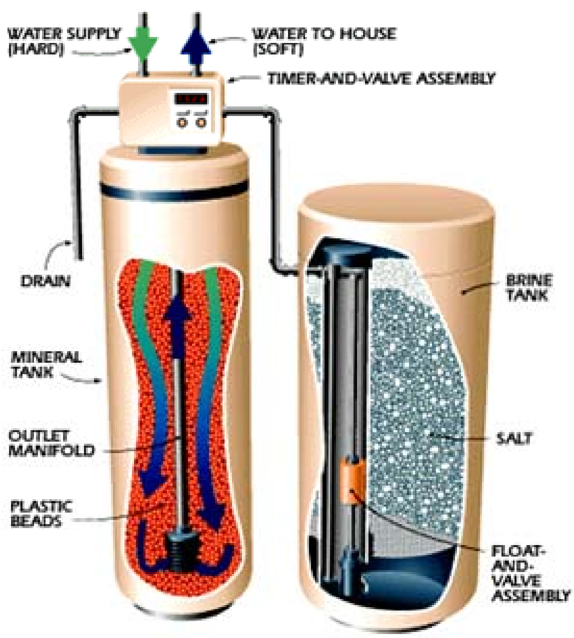
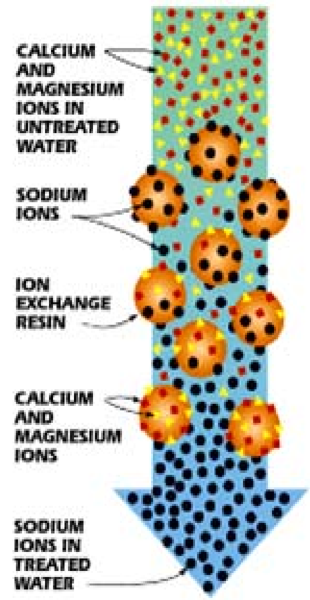


Figure 4.1 Ion Exchange



Water softeners chemically exchange sodium ions for calcium and magnesium ions (**Figure 4.1**). **Figure 4.2** shows a schematic of a typical household water softener. A “mineral or resin tank” contains negatively charged ion exchange resin beads. These beads are made of a polymer with specific chemical functional groups selected for the purpose. The functional group has a negative charge and chemically attracts positive ions such as sodium. As hard water passes along the resin beads, the more positively charged (+2) calcium and magnesium ions displace the less positively charged (+1) sodium ions on the resin. The sodium goes into the water that supplies the house. This softened water eliminates white hard water stains on faucets, corrosion of pipes and porcelain appliances and extends the life of water heaters. The one disadvantage of softened water is that it feels slippery on the skin. The resin becomes saturated with calcium and magnesium as the softening process progresses, and must be replenished with sodium in a process called regeneration.

Next to the mineral or resin tank is a brine tank. The brine tank holds salt (sodium chloride) pellets and about 3 gallons of water, resulting in a saturated brine solution. A meter, at the top of the resin tank, regulates the regeneration cycle. At that time, the brine solution is pulled into and flushes the resin tank, forcing the calcium and magnesium ions off the resin bead and replacing them with sodium.

Most houses have softeners that operate simply on a timer, and are set to regenerate at some period during each day. The more expensive water softeners are based upon actual flow. The timer and valve assembly is set based upon the hardness value for the water in grains per gallon. Many homes do not use the most efficient settings and are therefore using more salt than necessary to soften their water supply. During the regeneration cycle, the calcium and magnesium, along with the saturated brine, are flushed down the drain to the sewer. Timer-based softener systems are not typically set to the most efficient regeneration cycles, therefore the amount of calcium, magnesium, sodium and chloride going to the sewer is higher than necessary.

4.3 Residential Softeners

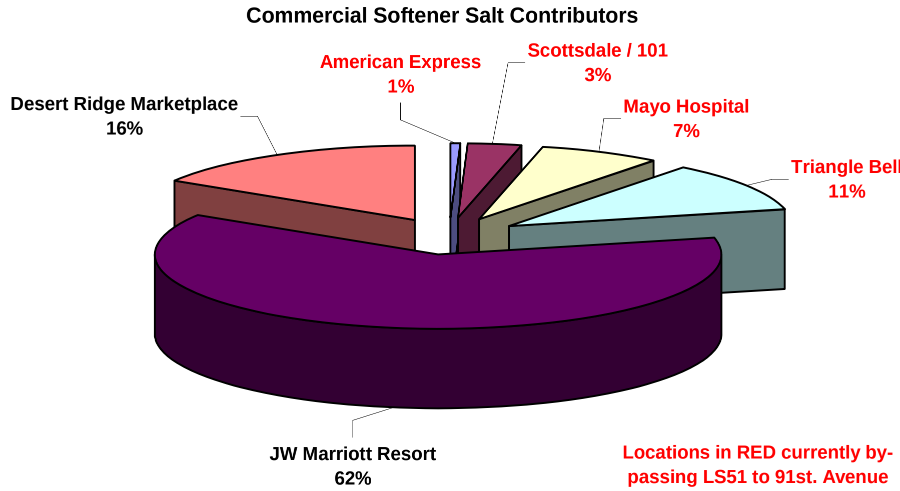
There are a wide range of residential water softeners on the market today. A typical 2-3 person household water softener contains 1 cubic foot of resin and has a rated capacity of up to 30,000 grains of hardness. It will process about 1000 gallons of Phoenix-area water (17 grains hardness) before needing to regenerate. Each 100-minute regeneration cycle discharges approximately 30 gallons of brine and uses 9-10 pounds of sodium chloride. This results in a discharge of up to 35,000 mg/L NaCl to the wastewater collection system. Both the BOR softener study, and the Water Quality Association (WQA) confirmed that approximately 40 pounds of salt is used each month in a residential water softener.

4.4 Commercial Softeners

Since commercial systems vary so widely, there is no “typical” size or regeneration frequency. Data gathered from restaurants, the resort and the hospital indicate that these systems are managed based upon an assumed hardness of the supply water and computer-controlled regeneration is based upon the total number of gallons processed. For the JW Marriott Resort, an 86-minute cycle generated 1840 gallons of waste and a peak conductivity of 84,200 mS/cm. This system regenerates one of three large resin tanks every 45,000 gallons. By contrast, the system at the Mayo Hospital regenerates every 200,000 gallons.

Figure 4.3 shows the percent contribution by the commercial sites to the 826,084 pounds of annual softener salt use. The sites in red are those that would normally go to Lift Station 51 and enter the Mayo Interceptor to CCWRP. A total of 600,000 gallons is currently being by-passed to the 91st Avenue WWTP until repairs to LS51 are completed.

Figure 4.3 - Commercial Softener Salt Contributors to CCWRP – Mayo Interceptor



4.5 Potassium vs. Sodium Chloride Salt for Regeneration

Either potassium or sodium chloride can be used to regenerate ion exchange resins. The primary difference between the two is cost, and the behavior of the two salts in the brine tank. Sodium salt is by the far the most common salt used because the largest and local Central Arizona supplier – Morton Salt – promotes this as the least expensive and most convenient. On occasion, the local newspaper will have a $1.00 Off coupon for two or three bags. Salt is typically purchased by home owners at Home Depot or Costco for $4.00 per 50-pound bag.

Excessive amounts of sodium are known to cause problems when irrigating turf. Soils with high clay content (common in the desert southwest) breakdown in the presence of excess sodium, impeding good drainage. Potassium does not cause this problem, and in fact, is a plant nutrient. A literature and internet search revealed much discussion and many papers given at various symposia which tout the benefits of potassium chloride over sodium chloride. In one case, a Canadian golf course was cited as benefiting from the potassium salt.

The following classification is used by the U.S. Department of Agriculture to indicate the degree of hazard of saline soils to food crops. It is based on conductivity and salinity hazard. (Conductivity can be converted to approximate mg/L dissolved solids).

USDA Salinity hazard ratings:

Low:	70	-	175	mg/l
Medium:	176	-	525	mg/l
High:	526	-	1,575	mg/l
Very high:			more than	1,575 mg/l

A number of studies, including a 1992 Transportation Research Board Special Report about deicing salt, confirm that the environmental effects of elevated chloride levels are highly site specific. Other factors that affect the degree of salinity hazard are: soil texture, soil permeability, drainage, quantity of water applied and the salt tolerance of the vegetation.

There are several reasons why potassium has not been widely applied to residential or commercial softening systems. They are:

A. Potassium chloride is not as prevalent in as sodium chloride. Sodium chloride occurs naturally in many parts of the world. In fact, sodium chloride is mined in the western portions of the Phoenix Metropolitan Area.
B. There is only one commercial source of potassium chloride and one mine located in Canada. This results in a doubling of the price per pound. The Home Depot price of $6.97 for 40 pounds or $0.174/ pound vs. $0.08/pound for sodium chloride.
C. Potassium chloride bridges in the brine tank. If the tank is not flushed frequently, the resulting cake cannot be broken up and requires the replacement of the brine tank. There are systems on the market that use potassium, and have engineering solutions to the bridging issue.
D. The EPA has identified a higher toxicity for potassium chloride, while various independent consultants have proposed improved health benefits from drinking water containing potassium over sodium.
E. Potassium chloride as a substitute may lower the chloride levels but the total dissolved solids issue is remains unaddressed

4.6 Non-Salt Regeneration (Demineralization)

Jay Miers, Manager of Business Development for Rohm & Hass, a supplier of ion exchange resins, provided the following information regarding non-salt regeneration of ion exchange for partial water softening. This method of softening has been used in Europe and may or may not prove to be economical here due to limitations on such systems. Dave Perry, Executive Director of the Arizona Water Quality Association provided insight into these limitations and identified this process as demineralization, not true softening.

Normal water softening ion exchange resin is called “strong acid”, which means that all the divalent – calcium and magnesium – ions will be removed and replaced with sodium ions. The calcium and magnesium that accumulate on the resin are washed off the resin with an excess of sodium ions in the brine. In this way, all of the calcium and magnesium are washed off as well as the excess sodium and the chloride. All of these salts are in the backwash that goes to sewer. Only a portion of the sodium ions remain on the resin to soften the next volume of hard water.

By contrast, when a "weak acid" ion exchange resin is used, only the hardness associated with alkalinity will be removed. That is the portion that causes scale on heat transfer surfaces. For local supply water, only 125-130 mg/L of alkalinity as calcium carbonate would be removed out of a total hardness of 295-310 mg/L, reducing overall hardness by less than half. If this reduction is sufficient for a given application, then this method may have some merit for commercial accounts or for centralized exchange bottle regeneration. Instead of regenerating the resin with a brine solution, this method uses an acid, such as hydrochloric (muriatic) acid. This means that hydrogen ions are being used to replace the calcium ions.

Weak Acid Cation (WAC) method has had limited use in this country. The following are advantages and disadvantages of WAC method of demineralization compared to true softening.

Advantages include:

1. Smaller more efficient system size. A single, 50-cubic foot resin container can treat approximately 240,000 gallons per regeneration cycle.
2. Smaller waste volume. The above 50 cubic-foot container would generate 1.25 pounds of calcium chloride per 1000 gallons treated.
3. Lower salinity to the sewer. For a normal softener, each mg/L of hardness removed puts 2.20 mg/L TDS in the waste brine to the sewer. For WAC, an actual reduction (>50%) in TDS often is achieved. This is because hydrogen is substituted for the hardness ion.

Disadvantages include:

1. Need to degas or remove the carbon dioxide from the waste brine so that it can be discharged to the sewer at the proper pH.
2. Safety concerns due to handling of acid and a potential need to scrub the air to remove fumes that can occur when hydrochloric acid meets moisture in the air.
3. Cost for regeneration with acid may be higher than for sodium chloride.

Additional investigation needs to be done to determine if this process should be tested as part of an overall salt mitigation strategy.

5.0 RESULTS AND DISCUSSIONS

5.1 Introduction

As the project developed, it was expanded from creating a sampling plan to performing an analysis of the data in an effort to project the impact of increasing salinity on the CCWRP, and its product. The results of that data analysis follow.

5.1.1 Data Sources and Quality

Data from a variety of sources was utilized for this analysis. These include:

- On-line flow and conductivity measurements,
- Data and information provided by other municipalities and the resort selected for this project,
- Analysis performed by the COP's water quality laboratory,
- COP residential water billing data for 2003,
- AWWARF 2274 (DRAFT),
- BOR Water Softener Study (Survey of Water Softener Penetration into the Residential Market in the Phoenix Metropolitan Area, Nov. 2004), and
- The Basis of Design Report for the CCWRP (Final Design Information Memorandum).

No quality control issues were reported for the samples analyzed in the City's water quality laboratory. These data are presented in **Table 5.1**, and are the basis for a significant portion of this analysis.

Table 5.1 SUMMARY TABLE OF WATER COMPONENT DATA for SAMPLING SITES

			Total	Calcium	TOTAL	Cations / Metals						Anions	
Location	description	source of salinity	Hardness	Hardness	Hardness	Calcium	Sodium	Magnesium	Potassium	Molybdenum	Selenium	Chloride	Sulfate
QuartSection / ManHole			mg/L	mg/L	grains/gal	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L
SUPPLY WATER													
CAP	supply water	rocks				70.8	93.45	29.25	4.91	<.010	<4.0	89.5	254.44
Union Hills	supply water	rocks	299		17.49	79	94	27				86	
site supply water	Desert Mariott	rocks + chlorination											
well	Tatum Ranch #l295	rocks + chlorination											
SITE EFFLUENT - to Mayo Interceptor													
42-39 MH 302	Desert Mariott	resort softener	315	165	42.05	66.2	516	36.4	26.2	<.025	<5.0	673	228
41-39 MH 224	Desert Ridge	restaurant softeners	719	407	19.06	163	340	75.7	28.4	<.025	<5.0	464	202
43-39 MH 407	Res. A-Desert Ridge	washing, food, softeners	326	190	19.06	76	261	33.1	28.6	0.006	<2.0	368	192
SITE EFFLUENT - to Cave Creek Interceptor													
56-37 MH 213	Res B -Dove Valley	washing, food, softeners	571	347	33.39	139	445	54.3	54.3	<.020	2.2	737	266
54-37 MH 104	Res C-Tatum	washing, food, softeners	444	265	25.96	106	276	43.5	33	0.014	2	419	269
SITE EFFLUENT -to LS51 diverted to 91st Avenue													
39-40 MH 401	AmExp West	office cafeteria, CT's	626	330	36.61	132	318	71.9	30.3	0.609	<5.0	269	594
39-40 MH 402	AmExp East	office	449	327	26.26	131	216	29.7	25.5	0.024	<4.0	193	280
39-41 MH vault	Mayo Hospital	sofener, CT's, RO	199	117	11.64	46.8	297	20	21.9	0.755	2.6	164	356
39-41 MH 102	East of Mayo	restaurant softeners	454	312	26.55	125	200	34.4	20.7	<.025	<5.0	616	218
CAVE CREEK INFLUENT													
43-33 210	Cave Creek Int. N	supply + sites	387	229	22.63	91.8	277	38.2	36.7	<.010	<5.0	395	233
43-33 206	Mayo Int. E	supply + sites	379	230	22.16	92.3	317	36	36.8	<.010	<5.0	446	260
CAVE CREEK EFFLUENT													
CCWRP	product water	supply + sites + treat	330	192	19.30	76.9	281	33.4	35.2	0.011	<2.0	368	252
Difference UH Supply vs. CCWRP Effluent							**187**					**282**	
% Increase							**236.7%**					**327.9%**	

On-line monitoring at the manholes proved challenging. The primary issue was loss of flow to the conductivity sensors, which resulted in the probes "zeroing out" during low flows at most of the sampling locations. For the purposes of this analysis, conductivities below the potable water background of 1050 µS/cm were excluded from the statistical analysis. There were also issues with flow data from Residential B; however COP has actual flow data for this area based off potable flow readings from each residence. All of the on-line data for each of the sampling locations is included as figures and tables in Appendix A.

Data from the CCWRP Final Design Information Memorandum No. 1 was reviewed as part of this project. Hydraulic design assumed 86 gpcd of wastewater, and 3.2 persons per household. It also assumed a CAP water TDS of 750 mg/l, a residential TDS contribution of 250 mg/L and a commercial TDS contribution of 350 mg/L.

5.2 CCWRP TDS vs. TDS at Other WRPs

TDS changes within the CCWRP were first compared to changes within other sewersheds in the SRV in an effort to better gauge how TDS values observed in this area compared to other communities. The Scottsdale Water Campus and Gilbert WRP were chosen for this comparison. The Scottsdale facility is adjacent to the CCWRP service area, has experienced significant growth over the last decade, and utilizes CAP water exclusively to meet the potable water demands in this area for significant portions of the year. The Gilbert WRF is located in the southeast valley, utilizes a mix of Salt River Project (SRP) water and groundwater, and is beginning its growth phase.

Average potable water TDS for the Gilbert, Scottsdale and Phoenix facilities were 699 mg/L, 624 mg/L and 650 mg/L respectively. **Figure 5.1** shows the increase in TDS between potable supply and reclaimed water for the three facilities. These data indicate that of the three communities examined, the CCWRP experiences the greatest increases in TDS between its potable water and its reclaimed water.

Figure 5.2 shows that a major portion of the increase in TDS at all three facilities is due to the addition of sodium and chloride. Calcium at both the Scottsdale facility and CCWRP remain relatively unchanged, suggesting that concentration technologies (i.e, evaporative cooling and membrane systems) are not significant contributors to the overall rise in TDS in either sewershed. Calcium data from Gilbert was not available.

Figure 5.1 - WRP TDS - Increase over Supply

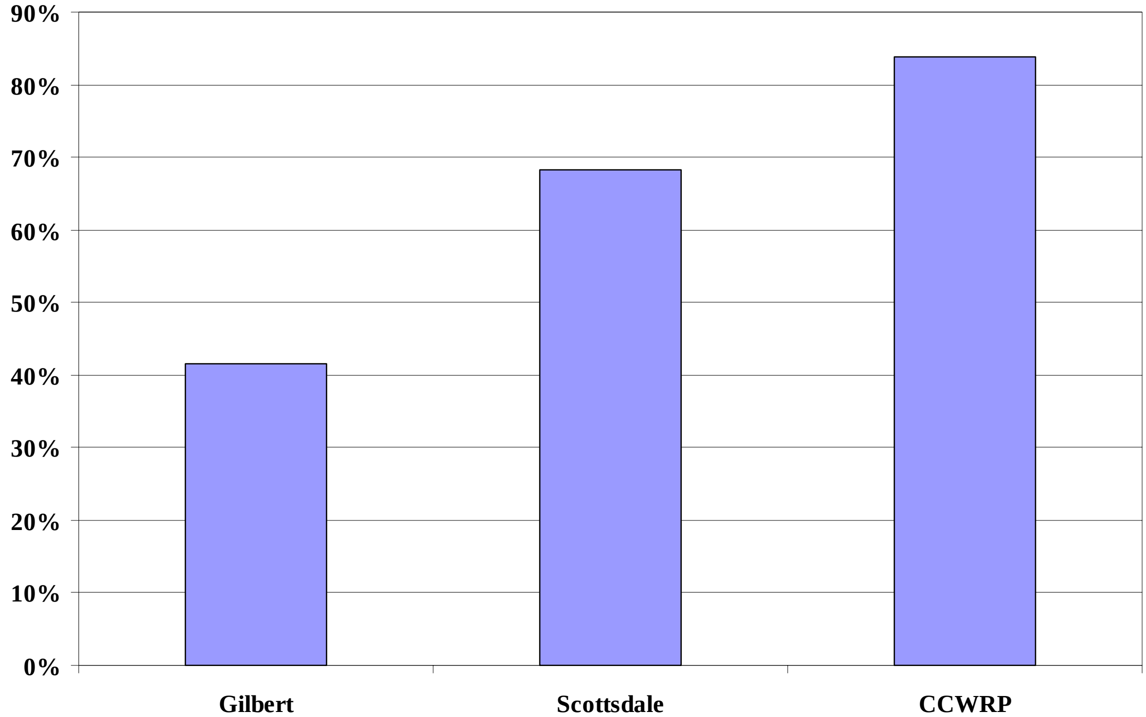
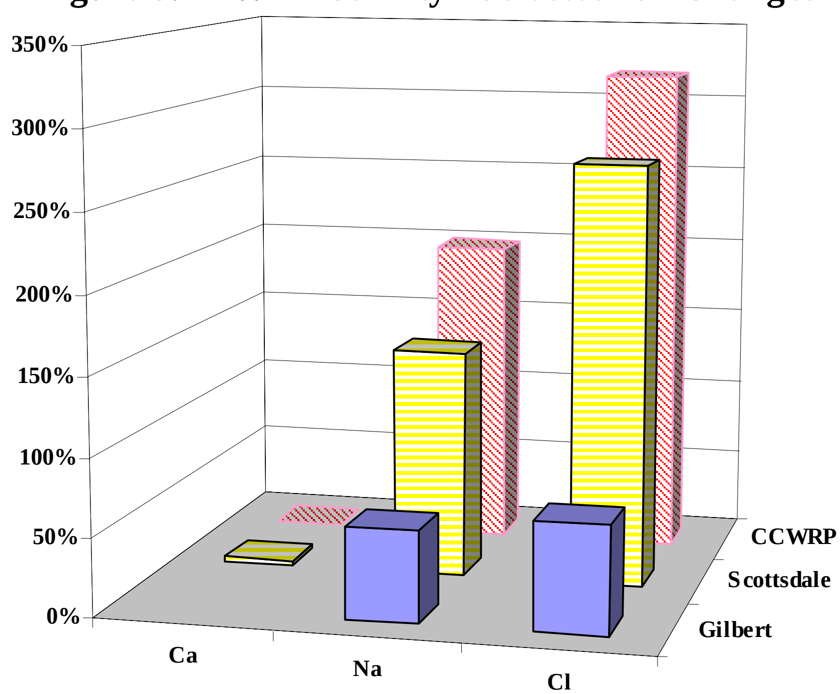


Figure 5.2 - WRP Salinity - Selected Ion Changes

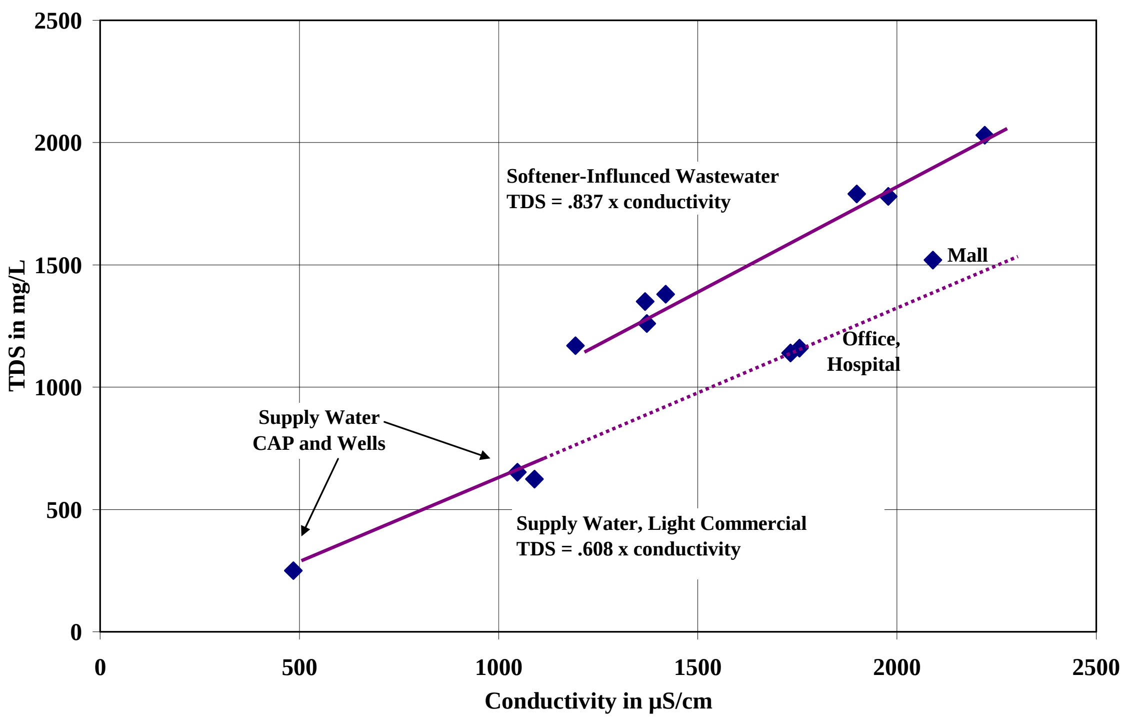


5.3 Conductivity and TDS Results

5.3.1 Conductivity vs. TDS

The relationship between conductivity and TDS is a function of the electrical charge on the ions that make up the TDS. This is especially true in wastewater, where overall TDS can be significantly impacted by organic compounds, which tend to carry a weak electrical charge. Conductivity was used to monitor and record presumed changes in TDS at the WRP and the remote sampling sites selected as part of this project. Conductivity and TDS were determined for each of the samples collected during this study. These data are presented in **Figure 5.3**. Overall, there appears to be a distinct difference in conductivity between waters influenced by softeners and those that are not. Both the mall and the hospital are known large users of softeners, but grab sampling did not catch these events. More work would need to be done in this area before a definitive relationship could be established; however, it should be noted that sodium chloride does have a higher specific conductance (conductivity) than other minerals. Given the significant increase in both sodium and chloride between potable supplies and the wastewater in this area, it is not unreasonable to attribute the differences in these relationships to changes to NaCl concentration.

Figure 5.3 - TDS vs. Conductivity



Unless otherwise indicated, this analysis does not base TDS on conductivity. Conductivity is used as a trending tool to document probable changes in TDS over time at the sampling sites, but is not used to quantify TDS.

-5.3.2 Conductivity Variability at the CCWRP

Conductivity at the CCWRP remained relatively stable during the two week data collection effort (**Figure 5.4**), with three exceptions. Two appear to be "loss of signal" events where readings went to zero. The third (high spike) cannot be explained at this time. A closer inspection of the data (**Figure 5.5**) reveals that conductivity loosely follows a diurnal pattern.

Figure 5.4 - CCWRP Influent Conductivity

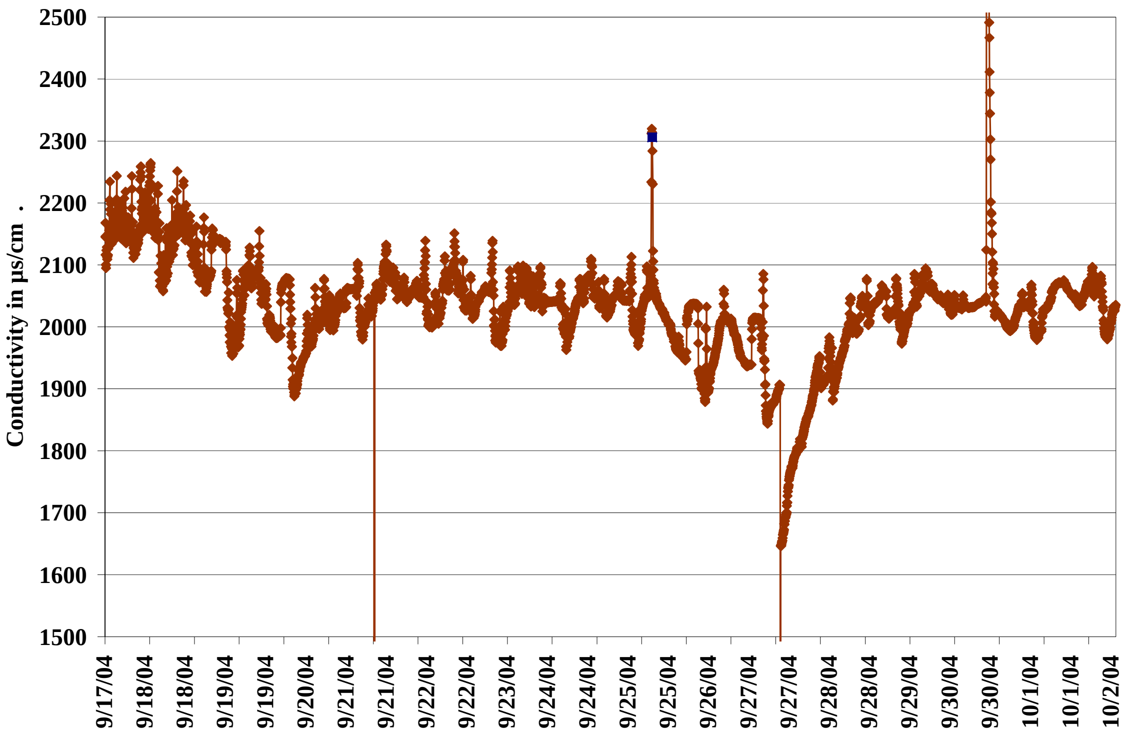
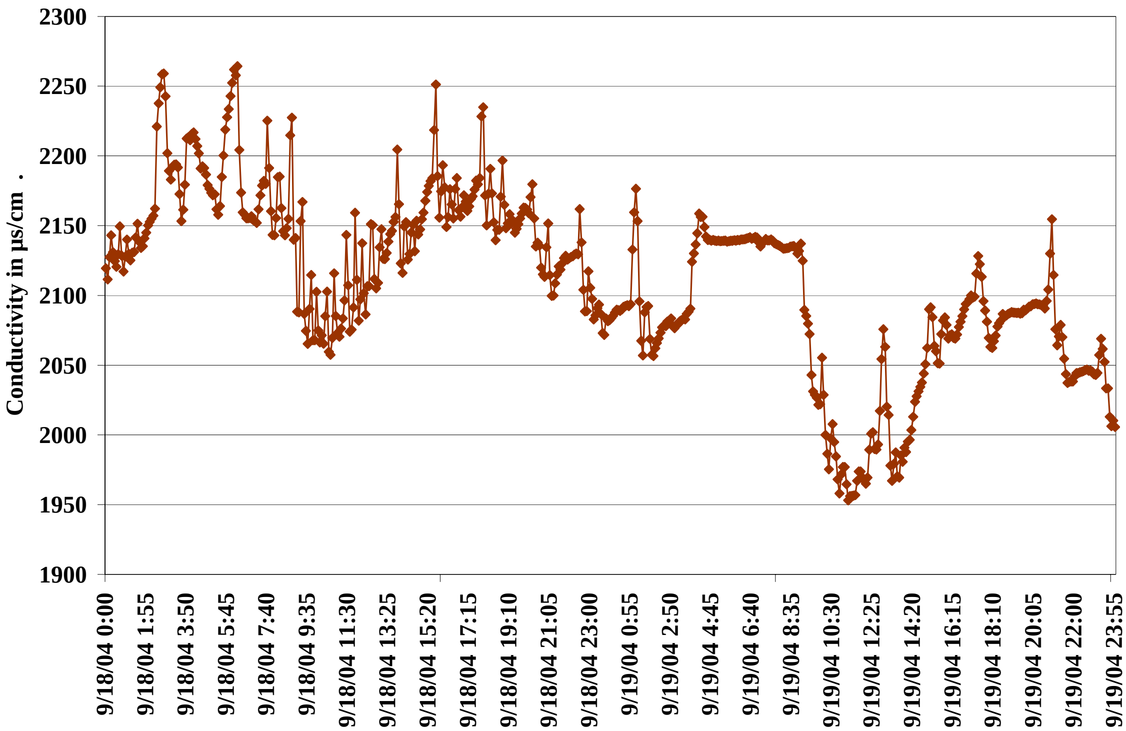


Figure 5.5 - CCWRP Influent Conductivity (Detail)



5.3.3 Conductivity and TDS within the Sewershed

Conductivity within the sewershed was highly variable (**Table 5.2**), due primarily to the influence of water softeners. This variability is particularly evident in the data colleted from the J.W. Marriott Resort, but can also be seen in the Residential A data. Residential B showed the most stability; however, there were multiple sampling difficulties at this site, and the overall amount of electronic data is limited.

Table 5.2 - Summary of Conductivity Data

	Average	Median of all peaks	Peak
Residential C	1716	3765	5870
Residential A	2054	5564	10317
Residential B	1495	1593	6555
Marriott Resort	4091	45627	119386
Desert Ridge	1770	4033	5172
Mayo Interceptor	2420	6814	10250
CC Interceptor	1738	2030	7683
CCWRP	2031	2217	2791

In general, conductivity stabilized as wastewater moved from the point of discharge through the system. Conductivity swings were wider in the interceptor serving the commercial area than they were in the interceptor serving the residential area.

Overall, conductivity had stabilized by the time wastewater entered the WRP. This would suggest that diverting flows to the 91st Ave. WRP during high conductivity events may not be effective. However, diverting flows from large point-source contributors could be practical under the right conditions. Further, if a large salt discharger were to locate near the CCWRP, its impact could be significant, and diversion strategies may be practical.

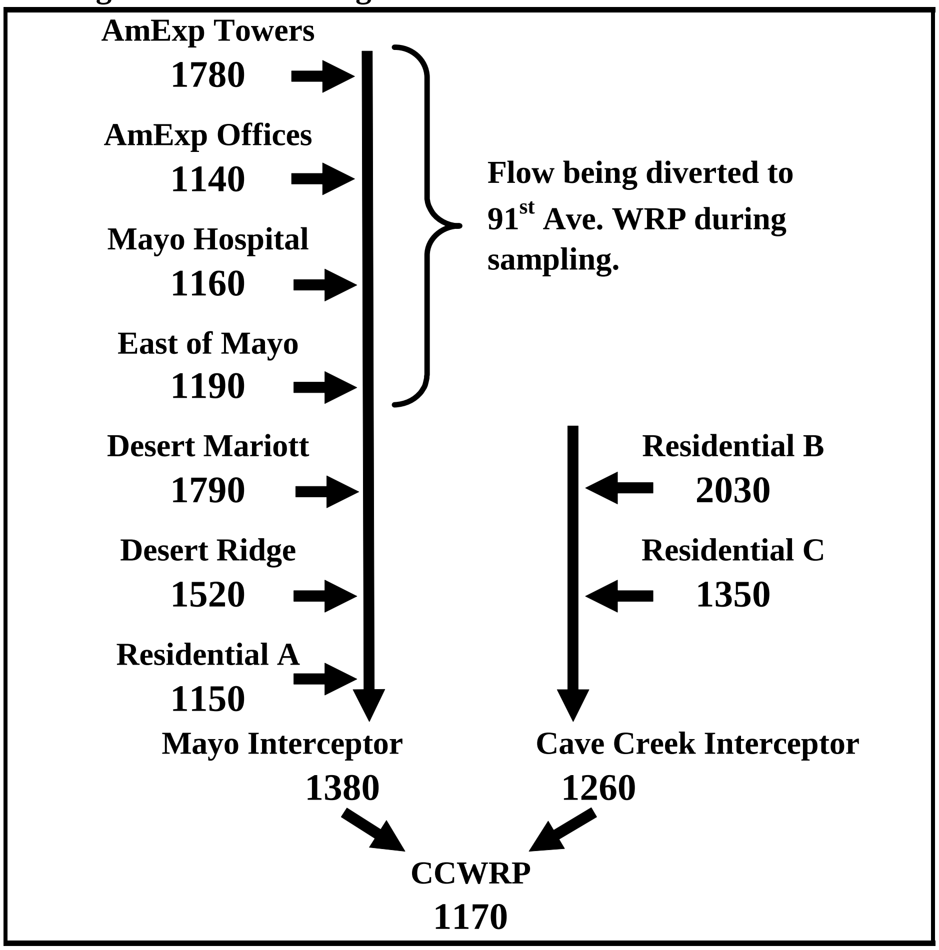
TDS analyses were performed on composite samples collected from each of the sampling sites, and are presented in **Table 5.3**. **Figure 5.6** provides a flow diagram of TDS throughout the sewershed during the sampling event.

Table 5.3 - Sewershed TDS

Location	description	TDS	Change
Union Hills WTP	supply water	653	
42-39 MH 302	Desert Mariott	1790	274%
41-39 MH 224	Desert Ridge	1520	233%
43-39 MH 407	residential A	1150	176%
56-37 MH 213	residential B	2030	311%
54-37 MH 104	residential C	1350	207%
39-40 MH 401	AmExp Offices	1140	175%
39-40 MH 402	AmExp Towers	1780	273%
39-41 MH vault	Mayo Hospital	1160	178%
39-41 MH 102	East of Mayo	1190	182%
43-33 210	Cave Creek Interceptor	1260	193%
43-33 206	Mayo Interceptor	1380	211%
CCWRP	product water	1170	179%

Residential B had the highest TDS (2030 mg/L) during this sampling event, with the second highest TDS at the J.W. Marriott Resort. All TDS values were significantly higher than the background value of 650 mg/L and sixty percent were more than twice the background level. This contrasts with the anticipated increase of 250 mg/L and 350 mg/L, for residential and commercial dischargers respectively, forecast in the Design Information Memorandum.

Figure 5.6 - Flow Diagram of Sewershed TDS Contributors



TDS as mg/L

5.4 TDS Contributions from Residential Developments

Subdivisions utilized for this study are generally described in **Table 5.4**, and reflect the transition in construction practices that have occurred over the approximately 16 years they represent.

Table 5.4 - Residential Sampling Locations

ID	Name	Accounts	Age	Manhole
Residential A	Desert Ridge	503	1988 - 1994	43-39 MH 407
Residential B	Dove Valley	1015	1998 - 2004	56-37 MH 213
Residential C	Tatum Ranch	865	1993 -1998	54-37 MH 104

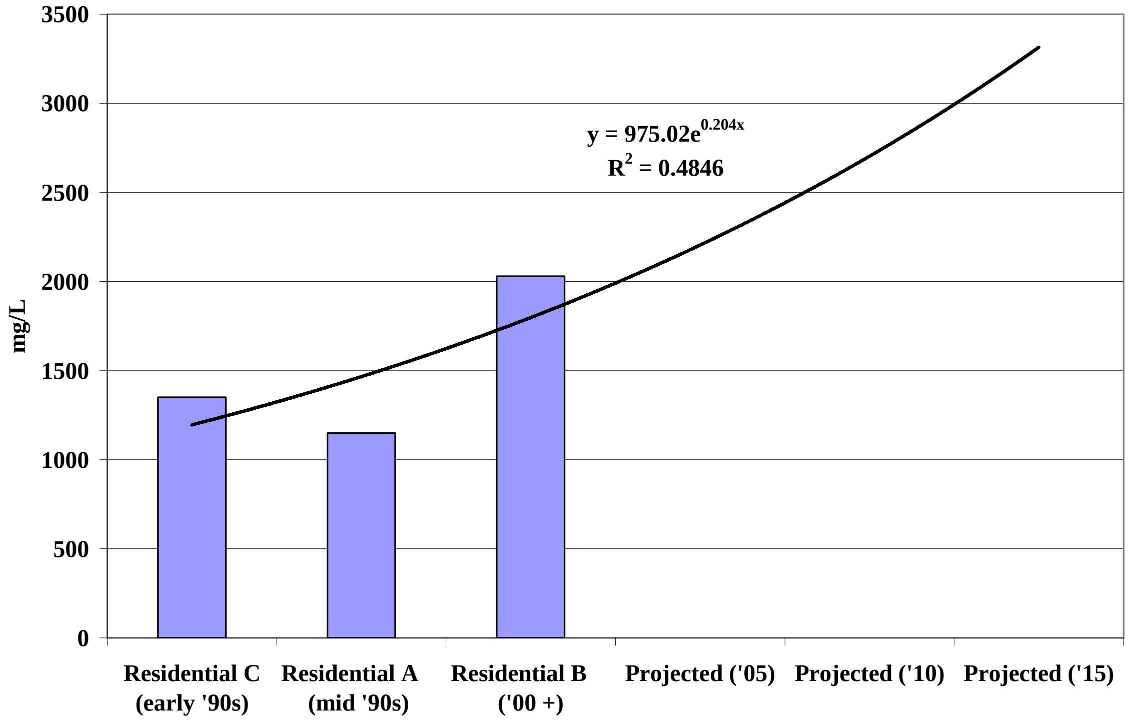
These changes in construction practices include:

- A shift away from evaporative coolers because of low electrical costs, improved insulation techniques, and higher air conditioner efficiencies,

- More frequent inclusion of water softeners as part of a new home package, and
- More water efficient plumbing.

The last two shifts in building practices have the most significant impact on salinity within the Phoenix Metropolitan Area because; taken together, they simultaneously add salt and reduce dilution volume. **Figure 5.7** shows the residential TDS within the CCWRP watershed as a function of development age, and suggests that there is a significant increase in TDS concentration coming from newer homes.

Figure 5.7 - Average Wastewater TDS by Residential Development Age



5.4.1 Water Conservation and TDS

Water conservation increases TDS concentrations in effluent from homes. The impact is even greater from those homes with water softeners, primarily due to the time-based operation of most water softeners on the market today. Under these conditions, the quantity of TDS remains constant, while water use, and therefore dilution, decreases over time.

Table 5.5 is derived from actual billing data for homes that discharged into the CCWRP sewershed in 2003, grouped by the year they were first occupied (from 1990 through 2002). Flows from all houses for January through March were averaged to determine the flow on which sewer billing is based. These data show that from 1990 through 1999 sewer flows were somewhat lower (~20%) than the planning estimate of 86 gpcd, and began to drop further in 2000. It is believed that this decreased flow is due to the installation of more efficient plumbing during the construction of these newer homes.

Table 5.5 - 2003 Household Impact of Conservation on TDS by Year Occupied

Year Occupied	JAN Flow	FEB Flow	MAR Flow	Average Potable Flow	Sewer Flow (75%)	GPCD Sewer Flows	Softener Based TDS Increase
1990	9055	8577	8155	8595	6447	67	744
1991	8631	8286	7545	8154	6115	64	784
1992	9281	8703	8618	8867	6651	69	721
1993	9053	8624	8769	8815	6611	69	725
1994	8371	8274	7891	8179	6134	64	782
1995	8817	8376	7699	8297	6223	65	771
1996	9108	8425	8001	8512	6384	66	751
1997	9267	8453	8005	8575	6431	67	746
1998	8772	7896	7684	8117	6088	63	788
1999	9008	8119	7699	8275	6207	65	773
2000	8340	7487	7055	7627	5720	60	838
2001	7305	6898	6445	6883	5162	54	929
2002	6907	6779	6849	6845	5134	53	934
	2003 AVERAGE			**8134**	**6101**	**64**	**786**

All Flows are average gallons per month per residence derived from COP billing data
Sewer flow is assumed to be 75% of billing flows
TDS assumes one 40 lb. bag of salt per month added to sewer flow

The last column of data show the TDS impact of an average 2003 household with a softener based upon when it was initially occupied. For example, if a house was occupied in 2002, it contributes approximately 150 mg/L more TDS than one initially occupied in the 1990s. Based on these data, it is safe to assume that average gpcd sewer flows will continue to drop as newer homes begin to dominate the area.

5.4.2 Residential Water Softeners and TDS

The major ions contributed by water softeners are potassium, sodium, and chloride. The concentrations for each of these ions, related to residential activity from sampling sites, are summarized in **Table 5.7**. While all show significant increases over background, there were questions regarding some of these data; namely, the data from the early 1990's homes (Residential C) were higher than the mid-1990's homes (Residential A).

A review of the calcium (Ca) and magnesium (Mg) data showed similar patterns, and it was hypothesized that some degree of concentration was occurring. To test this, Ca and

Mg results from the residential sample sites were compared to their concentration in source water, and a concentration factor (CF) was calculated based on the change (**Table 5.6**). The resulting CFs were consistent for each analyte. This calculated CF suggests concentration effects in the data, since there are no known technologies or residential activities that add significant quantities of "new" Ca or Mg to the system. Softening could contribute to this in that Ca and Mg are retained on the resin and eventually flushed to the sewer, while Na continues through the system and may be "lost" outside of the homes plumbing.

Table 5.6 - Concentration Factor Calculations (Residential)

	Ca	$CF_{(Ca)}$	Mg	$CF_{(Mg)}$	$CF_{(A)}$
Union Hills (Source)	71	-	29	-	-
Residential C (early '90s)	106	1.49	44	1.50	1.50
Residential A (mid '90s)	76	1.07	33	1.14	1.10
Residential B ('00 +)	139	1.96	54	1.86	1.91
Cave Creek Interceptor	92	1.30	38	1.31	1.30
CCWRP	77	1.08	33	1.14	1.11

CF= Concentration Factor, and equals $Analyte_{(Sample)}$ / $Analyte_{(Source)}$.
$CF_{(A)}$ = Average Concentration Factor
All data (except CF) as mg/L

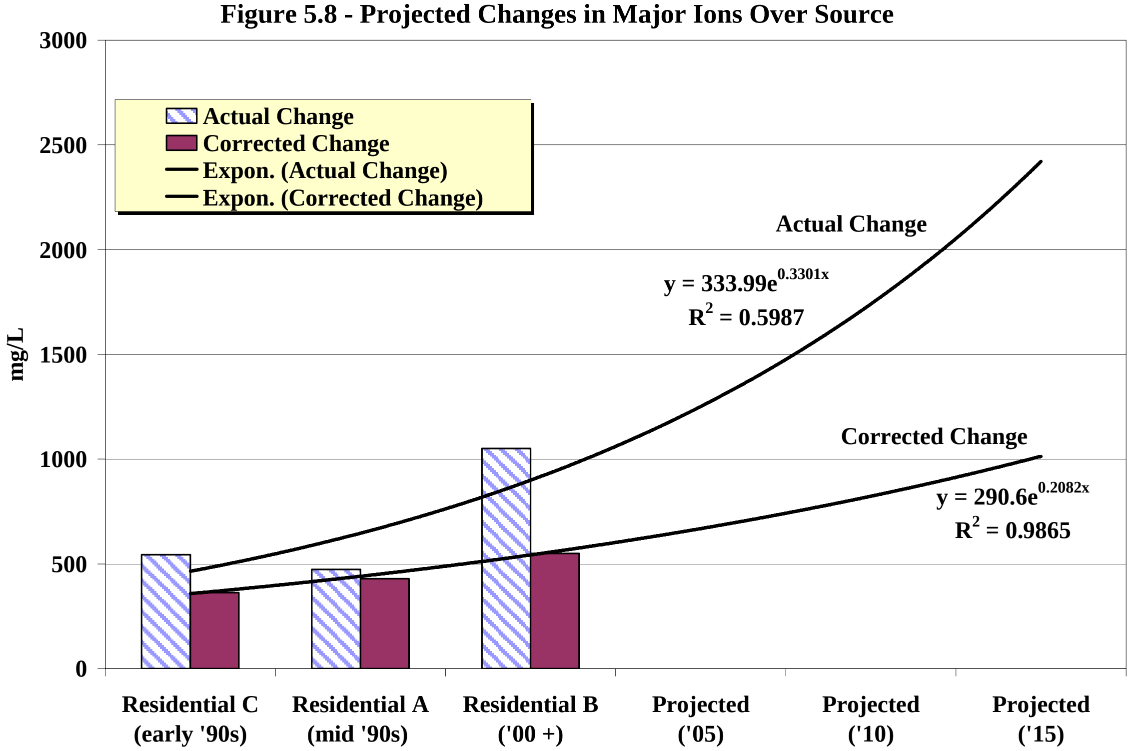
The resulting CF was then applied to each of the sample results (**Table 5.7**). **Figure 5.8** plots the measured change and corrected change for the three residential sampling sites, and shows that when corrected for concentration, a stable and predictable rise in softener-related ion concentration is observed. The high R^2 value for the corrected plot shows a high reliability for this curve, which may indicate that it is a useful predictive tool. However, it is important to remember that the CCWRP must deal with the actual TDS entering the facility.

Table 5.7 - Major Constituents (Residential Change Over Source)

	K	Na	Cl	Total	Actual Change	$CF_{(A)}$	Corrected Change
Union Hills (Source)	5	94	86	185	-	-	-
Residential C (early '90s)	33	276	419	728	543	1.50	363
Residential A (mid '90s)	29	261	368	658	473	1.10	428
Residential B ('00 +)	54	445	737	1236	1051	1.91	550
Cave Creek Interceptor	37	277	395	709	524	1.30	402
CCWRP	35	281	368	684	499	1.11	449

All data (except CF) as mg/L

Figure 5.8 - Projected Changes in Major Ions Over Source



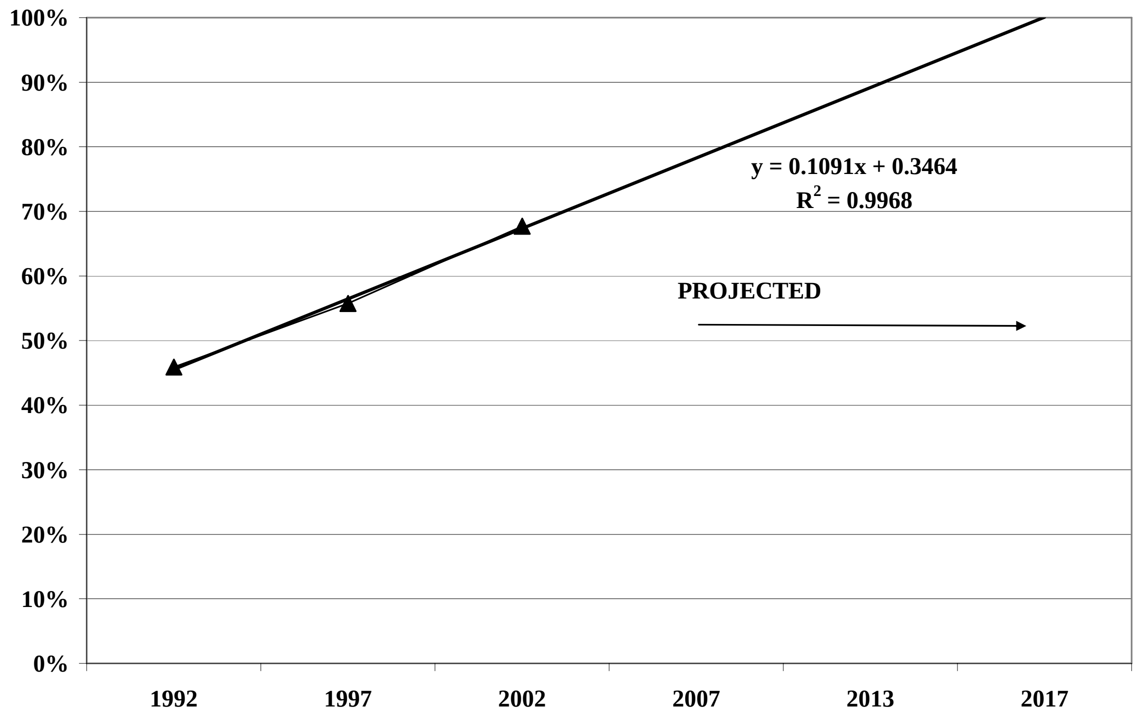
5.4.2.1 Updated Residential Water Softener Market Penetration Results

The BOR Water Softener Survey indicated that 47% of the homes built in the 1990's, and 51% of the homes built after 2000, were equipped with water softeners. Data from **Table 5.7**, and the average TDS of 786 mg/L generated in **Table 5.5**, were combined to back calculate water softener use based on the water quality data generated during this study. The results are presented in **Table 5.8**, and shown graphically in **Figure 5.9**.

Table 5.8 - Softener Use Based on Water Quality Data

	Estimated Year	Corrected Change (Tbl 5.7)	Estimated Softener Use
Residential C (early '90s)	1992	364	46%
Residential A (mid '90s)	1997	442	56%
Residential B ('00 +)	2002	537	68%

Figure 5.9 - Estimated Residential Softener Use Based on Water Quality Data



These data suggest a higher use of water softeners in the CCWRP sewershed than was predicted in the Greater Phoenix area BOR survey, as well as a steady increase of approximately 2% per year in utilization as development continues.

5.4.3 Projected Residential TDS Increases as a Function of Softener Use and Conservation

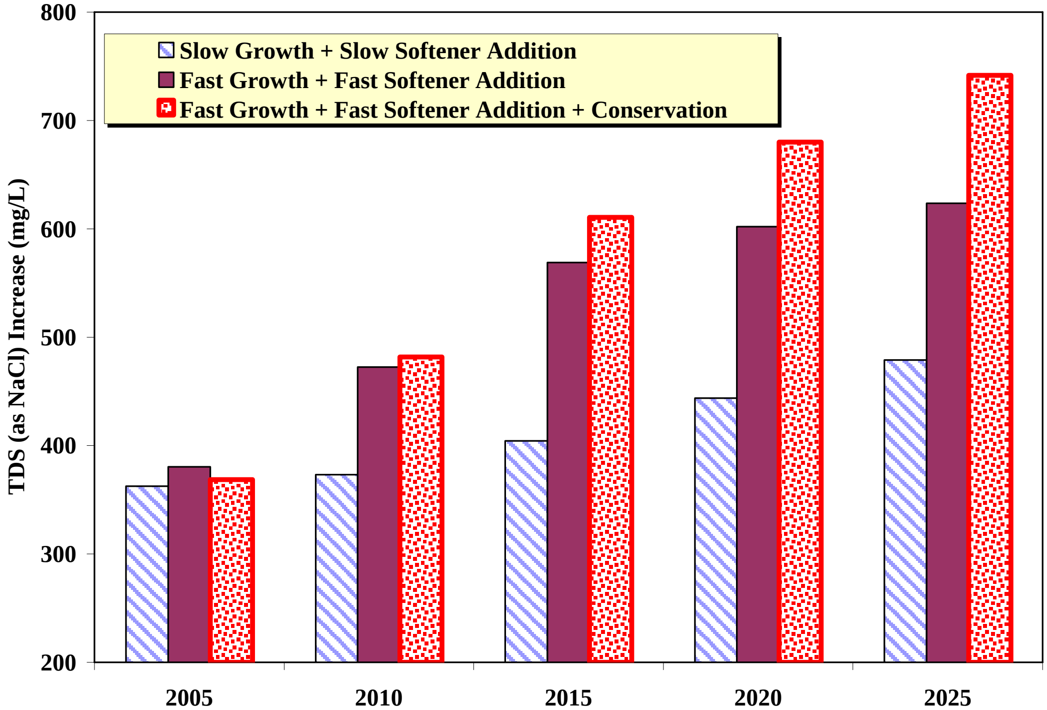
TDS increases were projected for a 20 year period as a function of growth rate, updated water softener market penetration, and water conservation. Assumptions used in this analysis were that softener use would slow down beginning around 90% market saturation, and conservation would reduce water use by 1% per year.

These projections are summarized in Table 5.9, and shown graphically in Figure 5.10. Taken together, they indicate a significant increase in TDS will result as water softener use increases and conservation efforts reduce water use.

Table 5.9 - Projected TDS Increases as a Function of Softener Use and Conservation

A. Slow Growth / Slower Softener Market Penetration / No Additional Conservation										
Year	CCWR Pop	GPCPD	Total Effluent 64 gcpd	Existing Houses	Houses w/softener (47%)	New Houses - population/3.2	% of New Houses With Softeners	**New Houses w/softener**	Total LBS salt/day	Increase in TDS at WWTP (mg/L)
2005	31,001	64	1,984,064	9,270	4,357	418	**52**	217	5,999	**363**
2010	35,341	64	2,261,833	9,270	4,357	1,774	**57**	1,011	7,040	**373**
2015	47,711	64	3,053,474	9,270	4,357	5,640	**62**	3,497	10,300	**404**
2020	64,409	64	4,122,191	9,270	4,357	10,858	**67**	7,275	15,255	**444**
2025	86,952	64	5,564,957	9,270	4,357	17,485	**72**	12,589	22,224	**479**
B. Rapid Growth / Faster Softener Market Penetration / No Additional Conservation										
Year	CCWR Pop	GPCPD	Total Effluent 64 gcpd	Existing Houses	Houses w/softener (47%)	New Houses - population/3.2	% of New Houses With Softeners	**New Houses w/softener**	Total LBS salt/day	Increase in TDS at WWTP (mg/L)
2005	31,001	64	1,922,062	9,270	4,357	418	**70**	292	6,098	**380**
2010	48,000	64	2,976,000	9,270	4,357	5,730	**80**	4,584	11,726	**472**
2015	70,000	64	4,340,000	9,270	4,357	12,605	**90**	11,345	20,592	**569**
2020	80,000	64	4,960,000	9,270	4,357	15,730	**93**	14,629	24,899	**602**
2025	95,000	64	5,890,000	9,270	4,357	20,000	**95**	19,000	30,632	**624**
C. Rapid Growth / Faster Market Penetration / Conservation = 1% Reduction per Year										
Year	CCWR Pop	GPCPD 1% Reduction/yr	Total Effluent	Existing Houses	Houses w/softener (47%)	New Houses - population/3.2	% of New Houses With Softeners	**New Houses w/softener**	Total LBS salt/day	Increase in TDS at WWTP (mg/L)
2005	31,001	**64**	1,984,064	9,270	4,357	418	**70**	292	6,098	**368**
2010	48,000	**61**	2,918,400	9,270	4,357	5,730	**80**	4,584	11,726	**482**
2015	70,000	**58**	4,043,200	9,270	4,357	12,605	**90**	11,345	20,592	**611**
2020	80,000	**55**	4,389,760	9,270	4,357	15,730	**93**	14,629	24,899	**680**
2025	95,000	**52**	4,952,198	9,270	4,357	20,000	**95**	19,000	30,632	**742**

Figure 5.10 - Projected Residential TDS Impacts from Growth, Softener Use, and Conservation



It should be noted that there are water softeners that operate based on flow and/or conductivity; however, these tend to be more expensive and are not prevalent at this time; therefore this analysis assumes no additional efficiency improvements in residential water softener technology.

5.4.4 Pools and TDS

5.4.4.1 General Impact of Pools on TDS

Pools concentrate salts through evaporation, and in Arizona, evaporation rates are approximately 7 feet per year. In a pool that is 5 feet deep, this significantly increase the concentration of naturally occurring salts. Had a pool in Residential A been dumping high TDS water during the sampling event, it may explain the high Ca levels; however, it would not explain the high sodium and chloride levels.

5.4.4.2 Salt Pools

A relatively new contributor to salt loads on a sewershed is the salt pool. The technology is intended to replace more traditional disinfection technologies such as chlorination, and works by electrically generating Cl^- from NaCl. To work, the salt concentration in the pool must be at least 3,000 mg/L with a range of up to 7,000 mg/L. If the pool is backwashed, the salt is sent to the sewershed (or local groundwater if the home is on a septic system), and is replenished when TDS in the pool drops below the desired salt concentration as measured by conductivity.

Literature indicates that some systems can operate up to ocean salinity levels (~35,000 mg/L) and beyond. There are also suggestions that a softening effect takes place when Ca and Mg precipitate on the electrode. It is not clear where these compounds go, but if they go to the sewer, they could contribute to the higher Ca and Mg levels seen in the Residential B sample.

The industry reports that in recent years, market penetration has exceeded 25%.

5.5 TDS Contributions from Commercial Development

TDS contributions from commercial developments were examined as part of this study. Commercial development was broken down into subcategories covering resort, office, medical, school and retail operations.

Concentration factors were not applied to commercial development. It was felt that unlike residential development, the range of technologies (softeners, cooling towers, reverse osmosis) that may concentrate salts was too complex to assess based on a 24 hour composite.

5.5.1 TDS Contributions from Resorts

The J.W. Marriott Resort served as a test site for this study. In reviewing information from this facility, it was felt that the site could best be characterized as “intense residential.”

Each of the facilities 950 rooms utilizes softened water, so the equivalent water softener market penetration is expected to be 100%. Additionally, laundry, dishwashing, and other household activities occur more intensely than within a residential household. To verify this, salt use was obtained from resort staff for a one year period. They indicate that a total of 518,500 pounds of salt was purchased for their softeners between September 2003 and September 2004. This translates into 43,208 pounds of salt per month, and when compared to residential salt use (one 40-pound bag of salt per month per softener), is the equivalent of 1080 residential softeners. Resort staff indicates that occupancy rates were 90% throughout the year. The occupancy rate was not used to adjust the room count for actual use since it was felt that water would still be used by cleaning staff even though the room was empty. Therefore, water softener market penetration equals:

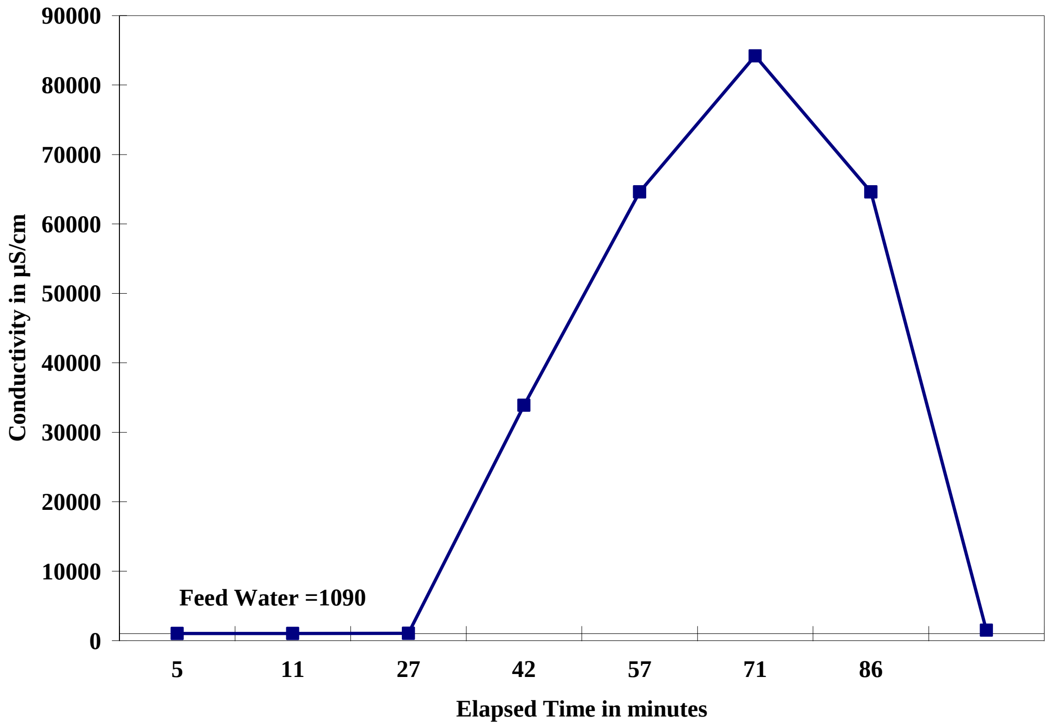
1080 equivalent softeners / 950 rooms, or 114%.

This is a reasonable estimate for a facility of this type.

All water that enters the resort is softened and then blended back to 4 grain hardness. The resort operates three softeners based on flow, regenerating every 45,000 gallons. Typically, two of the units are online, while the third is either being regenerated or is in standby mode. **Figure 5.11** provides on-line conductivity as a function of time during a regeneration cycle.

Fortunately, the effluent from this facility is well buffered. Were the peak NaCl discharges from a facility of this type discharged unbuffered (closer) to the WRP, the impact could be far more immediate.

Figure 5.11 - Commercial Softener Regeneration Cycle Conductivity vs. Elapsed Time



5.5.2 TDS Contributions from Non-Resort Commercial Operations

TDS contributions from non-resort commercial operations were, in general, lower than the contributions seen in new residential and resort-type development. The exception to this was the American Express East building.

The data from the development east of Mayo Hospital were not used for this analysis. The sum of reported ions exceeded TDS for this sample.

5.5.2.1 TDS Contributions from Mayo Hospital

TDS coming from Mayo Hospital was 1160 mg/L. This is similar to CCWRP product, residential A, and office/light commercial sites such as American Express West. There were some concerns about the low calcium and magnesium concentrations found in this sample, which were both lower than that of the source water. Engineering and maintenance staff indicated that the softeners regenerated two to three times per week (every 200,000 gallons), so the facility's softeners may not have regenerated during the sampling event. Therefore, the lower calcium and magnesium numbers observed may have been the result of the ion exchange process. Each regeneration uses approximately 1400 pounds of salt, which calculates to 182,000 pounds of salt per year.

5.5.2.2 TDS Contributions from American Express

TDS for American Express West and American Express East were 1780 mg/L and 1140 mg/L respectively (**Table 5.1**). American Express West houses a data center for their credit card processing operations as well as a cafeteria that services both buildings. Data centers require larger cooling systems than commercial buildings of similar size. This extra cooling requirement is due to the presence of multiple large data servers, which generate a significant amount of heat. The cafeteria kitchen has a small commercial water softener. American Express East consists of offices only, and did not show the TDS increase seen in the West building.

5.5.2.3 TDS Contributions from Desert Ridge

TDS from Desert Ridge was 1520 mg/L (**Table 5.1**). Desert Ridge houses 31 restaurants and bars of various size, most of which use water softeners. A survey of restaurant managers revealed softener salt use ranges between 500 and 15,000 pounds per year. The total annual softener salt used by 14 of the 31 establishments is 61,583 pounds. Aerial photograph of the Marketplace show packaged air conditioning units on all the retail spaces. A large grocery store on this site, Albertson's, usually has cooling towers (250-300 tons total) and softeners for the coffee shop and food preparation areas.

5.5.2.4 TDS Contributions from Pinnacle High School

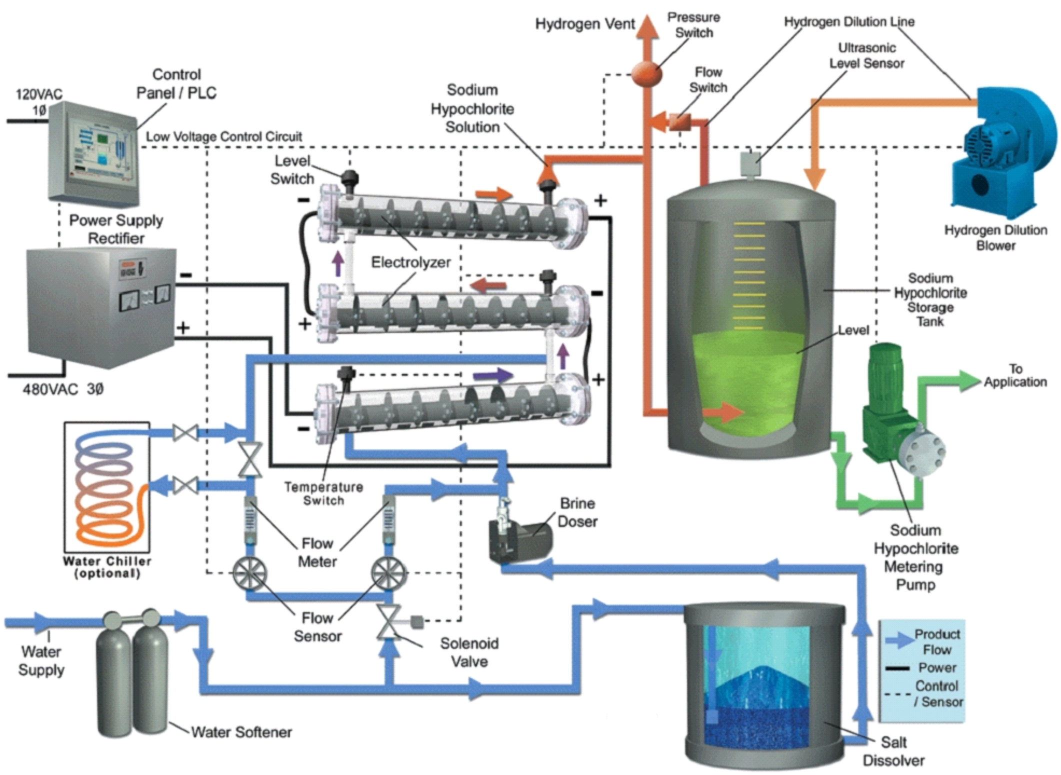
No sampling data were collected from Pinnacle High School. Maintenance staff indicates that no softener was installed in the cafeteria. Four cooling towers (typically 1000 – 1500 tons total) service the entire campus for 1900 students. The school had requested reclaimed water for its fields, but at that time, the request had not been finalized and approved.

5.6 Disinfection and TDS

5.6.1 Salt Use for Disinfection

On-site chlorination technology is used for disinfection of the water supply at wells, elevated storage sites and booster stations. **Figure 5.12** shows a schematic flow drawing of an on-site chlorine generator. This equipment uses a sodium chloride salt brine which is then electrolyzed to create sodium hypochlorite. The lower left shows a softener on the supply water used to dilute the saturated (30%) brine in the brine tank. The brine concentration sent to the electrolyzer is reduced to 3%. It takes 3 pounds of salt to generate one pound of chlorine.

Figure 5.12 On-Site Chlorine Generator Schematic



5.6.2 Impact of Disinfection on TDS

It is assumed that all of the salt added into the disinfection points will wind up on the wastewater flow to the CCWRP. **Table 5.10** contains the data provided by City of Phoenix identifying the on-site chlorine generation locations and type of disinfection salt (sodium chloride or calcium hypochlorite) used. The monthly amounts were projected over one year. The concentration added into the supply water was calculated from the pounds per day of salt added (947 pounds) divided by the winter average sewer discharge for all 9,270 accounts in the Cave Creek Sewershed. This activity adds 44.6 mg/l TDS to the water delivered to both residential and commercial customers in the CCWRP sewershed. The TDS is made up of either calcium or sodium hypochlorite.

Table 5.10 Salt and Hypochlorite Use for Disinfection Within the CCWRP Sewershed

Site	Description	Type	Type of Salt Used	Pounds of Salt./Tablets per Month	Pounds per Year	Tons per year
6A-B2	Booster-Mayo Int.	On-Site	Salt - Sodium Chloride	6000	72000	36
6A-ES1	Elev.Stor.-Mayo Int.	On-Site	Salt - Sodium Chloride	5250	63000	31.5
6A-W292	well-Mayo Int.	Tablet	Calcium Hypochlorite	900	10800	5.4
6A-W293	well-Mayo Int.	On-Site	Salt - Sodium Chloride	1500	18000	9
6A-W295	well-Mayo Int.	On-Site	Salt - Sodium Chloride	1500	18000	9
7A-B1	Booster-CC Int.	Tablet	Calcium Hypochlorite	2250	27000	13.5
7A-W291	well-CC Int.	Tablet	Calcium Hypochlorite	out of service		0
8A-B1	Booster-CC Int.	Tablet	Calcium Hypochlorite	600	7200	3.6
8A-W287	well-CC Int.	Tablet	Calcium Hypochlorite	out of service		0
8A-W288	well-CC Int.	On-Site	Salt - Sodium Chloride	1500	18000	9
8A-W289	well-CC Int.	Tablet	Calcium Hypochlorite	1500	18000	9
9A-W280	Arsenic Treat well	On-Site	Salt - Sodium Chloride	7500	90000	45
9A-W281	well - CC Int.	Tablet	Calcium Hypochlorite	300	3600	1.8
			Total	**28800**	**345600**	**172.8**

5.7 Impacts of TDS

5.7.1 Impacts of TDS on Turf Irrigation

The most significant negative impact of TDS on turf irrigation comes from sodium, which impedes root development, and breaks down the clay in the soil, thereby reducing permeability. **Figure 5.12** shows the increase in soil sodium content as a function of sodium in irrigation water for the Wildfire Country Club Golf Course. This course is part of the Desert Marriott Resort (the resort in this study), and because of the high sodium levels in CCWRP's effluent, additional water is utilized simply to flush sodium away from the root zone.

Sodium Adsorption Ratio (SAR) is used to determine the impact that sodium will have on a particular soil. It is calculated as follows:

$$\mathbf{SAR} = \frac{Na}{\sqrt{(Ca + Mg)/2}}$$

Figure 5.13 shows the SAR for key waters in this study, and indicates that the highest SAR can be found in the resort's effluent. SAR is not significantly affected by the technologies used at the CCWRP.

Figure 5.13 - Irrigation Water Sodium and Soil Sodium

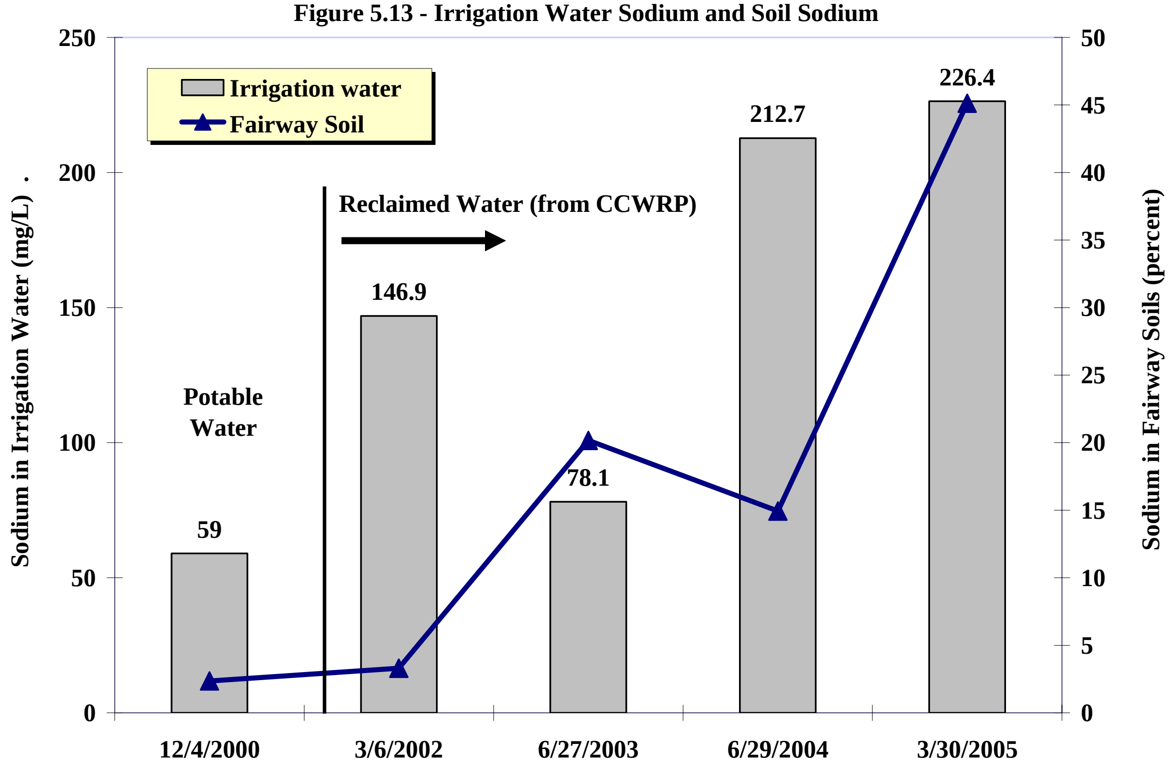
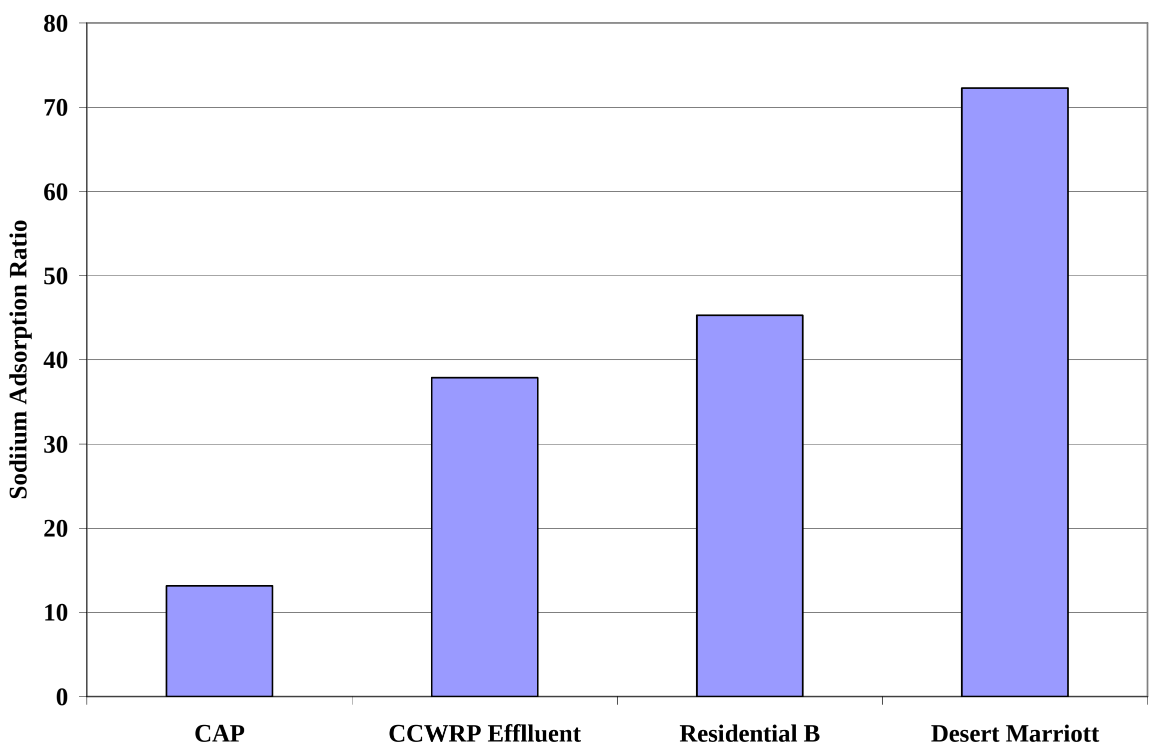


Figure 5.14 - Sodium Adsorption Ratio



5.7.2 Impacts of TDS on Recharge and Recovery

The CCWRP service area is located over a high quality aquifer. The area has not been influenced by irrigated agriculture, and groundwater TDS is generally less than 500 mg/L. As recharge occurs in this area, the local groundwater will be impacted by the quality of the recharge water. Given the high TDS found in CCWRP product, it is anticipated that the TDS of local groundwater will increase. As COP begins utilizing this water, it may find that wellhead treatment is required before these waters can be incorporated into the potable supply.

5.7.3 Impact of TDS on Compliance Requirements

CCWRP has reported sublethal toxicity in approximately 1/3 of its Whole Effluent Toxicity (WET) tests using Ceriodaphnia dubia as the test organism, and has initiated a study to determine the cause of this toxicity. Several studies, including AWWARF 290 (Major Ion Toxicity in Membrane Plant Concentrate), suggest that chloride may contribute to WET test failures. Another study (TOXICITY REDUCTION EVALUATIONS AT TEXTILE MILLS, *Burke, North Carolina Division of Pollution Prevention and Environmental Assistance,*) reports that chloride above 450 mg/L and sodium above approximately 300 mg/L can be a source of chronic toxicity to Ceriodaphnia dubia. During this sampling event, both chloride and sodium levels in the CCWRP product were near these levels, and samples from several of the contributors to this sewershed exceeded them.

Undefined during this study is the impact of chloride, particularly chloride concentration swings, on the treatment process as a whole. If chloride is impacting bioassay results used to monitor the WRP product, it is not illogical to deduce that it may impact biological processes utilized within a WRP. These impacts may manifest themselves as turbidity increases, nitrification, or denitrification inhibitions; however, there is little industry data addressing this issue one way or the other. The argument here is not that chloride kills the bacteria necessary for these processes; rather it is a suggestion that chloride, and particularly chloride swings, may stress organisms utilized in the treatment process. A brief internet search revealed several discussions regarding the impact of water softeners on septic tanks. Among the reports are a loss of solids, loss of clarity, and poor settling and grease isolation. Were a large resort to begin discharging close to the WRP, wide chloride swings could negatively impact the performance of the facility.

5.7.4 Impacts of TDS on Reclamation Costs

The cost of TDS reduction is well described in the CASS Phase I and II documents, and will not be included here. Generally, monovalent salts, such as sodium and potassium chloride, are the most expensive to remove from water. Precipitation technologies commonly used to remove calcium and magnesium are ineffective at removing chlorides, so some form of advanced treatment, such as nanofiltration or reverse osmosis, are required. Significant pre-treatment is necessary to prevent membrane fouling, and the resulting brine must be disposed of. Overall, the cost is significant.

5.7.5 Summary of the Impacts of TDS on Water Supply

Probably the most important issue facing water managers is that increasing TDS concentrations have the potential to make water unfit for use. This is particularly important in desert areas, where water supplies are limited, and drought is a routine occurrence. In this study area for example, we see one water source that is negatively impacting turf irrigation practices, groundwater quality, and regulatory compliance goals. If TDS is allowed to increase unaddressed, the issues it presents will only increase in magnitude.

6.0 Conclusions

The trends noted in this study are applicable to all new-growth wastewater contributors within the Phoenix Metropolitan Area.

6.1 Water Softeners and Conservation

This study determined from residential TDS data that the percent of homes with softeners exceeds what was predicted by the BOR Softener Survey. Water conservation had not been previously considered as part of a salinity study, but it is obvious from the water meter reading data that gpcd declined significantly in homes built after 1999. The combination of water conservation and water softening are having a more significant impact on the CCWRP than originally anticipated. These impacts may be inhibiting the COP's desire to meet compliance requirements, is negatively impacting its reuse customers, and will probably impact groundwater quality in the area.

6.2 Actual TDS vs. Predicted

Overall TDS entering the CCWRP exceeds what was predicted in the Basis of Design Report. The impact of water softening and conservation could not be anticipated at that time of its development.

The Basis of Design Report for this sewershed indicates that CAP water TDS would be 750 mg/L, and that overall wastewater TDS would be around 1000 mg/L for the life of the project. TDS at the CCWRP was approximately 1150 mg/L during this sampling event. This is an increase of 500 mg/L over the CAP water source (650 mg/L). Further, the Cave Creek interceptor contained 1260 mg/L TDS, and the Mayo interceptor was 1380 mg/L, suggesting an overall TDS of at least 1200 mg/L. Finally, the design report predicted a wastewater flow of 86 gpcd. Actual wastewater flow was approximately 64 gpcd during the planning, design, and commissioning phase of the CCWRP project, and has decreased significantly since then in new housing developments as a result of water conservation efforts.

Overall, planning estimates do not reflect current conditions within the CCWRP sewershed.

6.3 The Impact of TDS

Effluent from the CCWRP provides a product that is negatively impacting a customer, is showing sub-lethal toxicity during its bioassay testing, and will negatively impact the quality of groundwater within its recharge zone. As TDS increases, as it is expected to do, these impacts will increase.

The J.W. Marriott Resort is one of the largest point source contributors of salinity and sodium in the sewershed and its Wildfire golf course experiences the downside impact of salinity on its fairways and greens. Discussions with resort personnel indicate they are interested in being a part of the solution to the salinity problem. Other turf irrigation customers, however, do not bear the same kind of responsibility and have less opportunity to mitigate the impacts (such as underdrains, overwatering, chemical additions).

6.4 Prioritized TDS Contributors

This work has prioritized salt contributors to the sewershed in **Table 6.1**.

Table 6.1 Prioritized TDS Discharges

PRIORITY	Description	Justification
1	**New residential**	This area can produce a TDS greater than 2000 mg/L, is showing 60% water softener utilization,and represents an increasing percentage of the sewershed.
2	**Resort/Large Hotels**	These facilities can deliver a TDS greater than 1700 mg/L, and represents 100% water softener utilization.
3	**Intense commercial, (restaurants, bars, data centers)**	These facilities can produce a TDS greater than 1500 mg/L, and represent significant softener use
4	**Hospitals**	TDS greater than 1100 mg/L, existing SIU
5	**Pre-2000 residential**	TDS greater than 1100 mg/L, may change with time
6	**Light retail, office, schools**	TDS greater than 1100 mg/L, expected to remain consistent

6.5 Impact of Growth

Cave Creek offers an up-scale lifestyle, high quality homes and amenities. Because of this, growth in the area will continue at a fast rate. It is reasonable to assume that at least another 15,000 homes will be built in this area. At present, most of the homes in this area were built before 2000. The percent of these homes with softeners is higher than predicted in the BOR study, and the percentage of new homes with water softeners is even higher. Additionally, new homes will have the latest water conservation technologies. As this process continues, the discharges from these newer homes will dominate residential contributions to the sewershed.

To support this population increase, small and large retail will likely double. Commercial areas at major intersections along the Cave Creek Interceptor will add small contributions of salinity while large retail, such as the development expected to be larger than Desert Ridge Marketplace, will add significantly more TDS to the Mayo Interceptor. More people means additional schools will be built and hospital expansion that is already underway will continue to grow to meet an aging population demand.

Amenities of an upscale lifestyle include golf courses, recreation areas and green belts. The largest users of reclaimed water for turf irrigation are golf courses, but other large users include schools, hospitals, parks, industries, and green belts. Use of reclaimed water has resulted in a build-up of salts in soils, required selection of salt tolerant turf, and requires application of up to 25% more water than is needed for agronomic purposes, simply to leach the salts through the soil column and into the groundwater. Turf irrigation in well-designed golf courses, with sophisticated underdrain systems will delay the need to address salinity in reclaimed water, although it is wasteful. However, continued turf irrigation in other areas such as public parks, may be threatened more quickly.

6.6 Future Trends

Based on this analysis, the following are expected to occur:

- Water softeners will be more commonplace in new residential development than originally believed.
- Conservation will reduce the dilution volume carrying TDS (as NaCl) from water softeners.
- Together, conservation and softening will continue to increase TDS concentrations within the sewershed.
- Reuse, recharge and recovered water quality will deteriorate.
- Reclaimed water will incur additional costs for improving reclaimed water quality.
- Salinity increases will exacerbate WRP compliance.
- Small WRPs will feel the effects of increased salinity sooner than large plants and serve as a bell-weather for such impacts.

7.0 Recommendations

Based on this study, the following recommendations are made:

- Determine actual gpcd flows for this sewershed from residential developments since 2002. Additional analysis of the water meter readings since 2002 will confirm the gpcd trend. This will not only allow COP to refine the relationship between water softeners and conservation, it will also allow the City to verify planning assumptions for future WRP expansions.

- Determine actual flows from commercial developments and compile them with softener use. This will verify the contribution of commercial development to overall salinity in the wastewater flowing to each of the interceptors.

- Verify the level of sodium and chloride that are toxic to Ceriodaphnia dubia through the on-going Toxicity Identification Evaluation.

- Continue diurnal study of conductivity spikes and the short-term impacts on CCWRP activated sludge process.

- Begin tracking groundwater quality in the vicinity of the CCWRP if this is not already being done.

- Compare and contrast salinity impacts at CCWRP to other high growth areas in Central Arizona such as Goodyear and Gilbert. Scottsdale, which is built-out, offers a similar developments and TDS issues.

- Develop an understanding of salt pool technology, to determine its potential for future salinity discharges to the sewershed.

- Confirm impact of LS51 flows when they return to CCWRP after repairs are completed.

- Consider speeding up the development of an overall salinity management strategy for this sewershed. Elements within such a strategy may include:

    - Consider installing dedicated sewer lines to send softener waste from large commercial developments to the 91st Ave. WRP. In the case of the J.W. Marriott resort, this would remove over 500,000 pounds of salt from the sewer shed.

    - Continuing the dialog begun with J.W. Marriott engineering and golf course management personnel to engage them in determing best technology and methods to reduce salt discharges that are negatively impacting turf irrigation.

    - Determine the impact to residents and commercial establishments of improving water softener efficiency or encouraging the use of exchange bottles that are regenerated at central locations.

- Confirm sodium and chloride levels in discharges and project regulatory impacts that will require mitigation steps.

APPENDIX A – STATEMENT OF WORK

TASK ONE: Kick off Meeting

TASK TWO: Review Existing Data

Review "sewershed" maps, AWWARF Draft Report and existing water data from the CCWRP. This effort focuses on confirmation of the sampling points identified in the meeting of 7/9/04 based upon the conclusions of the AWWARF study. Review data formats and useful information that can link to this project, enhancing the value of the AWWARF study to the specific needs of the CCWRP.
DELIVERABLE: Email summary points from the review.

TASK THREE: Data Collection / Sampling Plan

Verify sampling plan locations, frequency and grab-sample water chemical component analysis. Visit the eight sampling locations to confirm the sewershed map details and determine if any other point source salinity contributors should be characterized, such as the hospital site - Mayo. The sites are: Desert Ridge Mall, Marriott Resort, Pinnacle High School, residential districts in the Desert Ridge or Tatum Ranch areas, Mayo Clinic, American Express, and the commercial district east of Mayo Clinic. City personnel will take conductivity and flow measurements using Sonde equipment. In addition to conductivity, the same probe collects pH and Temperature data. Conductivity is an easy-to-determine, continuous measurement for any given location, while TDS is a lab-based batch test. Therefore, it was important to determine the correlation of TDS to conductivity is based upon the chemical composition of the water. A series of tests points are used to develop a TDS vs. conductivity calibration curve for the sampling points. Identify other data and sampling points that can be valuable to this effort during the early course of this project so that the time and effort for sampling would yield as much useful information for current as well as future needs.

DELIVERABLES: Summary of site visits and confirmation of sampling plan. Calibration curve test method.

REVIEW MEETING: Meet with Peggy and other lab personnel as needed to confirm calibration curve test method and chemical analysis for grab samples.

Expanded Scope TASK THREE: Review raw data from the Sonde units and create Excel graphs which allow comparison of time-of-day events between flow and conductivity measurements.

TASK FOUR: Softener Salt Use

Conduct a system-wide evaluation of softener salt sales, by visiting sites to determine the types of salt sale outlets – grocery, hardware, warehouse, chemical companies – and to determine the amount of sales and especially the ratio of potassium vs. sodium salt sales. Meet with the representatives of softener equipment vendors to determine the market penetration, attitude towards the alternative potassium salt and other issues of note in the marketplace. Quantify the economics and penetration of potassium vs. sodium in the local market and Phoenix metro area. Compare the higher cost of the potassium to the benefits – to the user as well as to the CCWRP. Define the technical set up of commercial vs. residential softeners based upon the type of equipment, timing for regeneration and the types of regeneration methods. Interview off-site regeneration firms, such as Culligan, and Rayne, to determine this portion of the market and the locations, since they are large point-source salinity contributors. From the information and the technical basis for ion exchange, calculate the actual need for softening and the efficiency of use of salt in regeneration – both on-site and off-site.

Changed Scope TASK FOUR: Interview industry representatives f softener equipment and exchange bottle industry in greater Phoenix to obtain basic sales information. Interview Mayo Hospital, American Express, Pinnacle High School, Marriott Resort and Golf Course, various restaurants in Desert Ridge Mall, and various hotels, apartments and restaurants in Triange Bell, Scotsdale/101 retail developments. From these interviews determine annual salt consumption, which is directly discharged into the sewers to CCWRP.

Expanded Scope TASK FOUR:
Use data from interviews of salt users was to show relative contribution by types of salt users. Include the salt contribution from water disinfection. Review and analyzedzoning maps, CCWRP Design information, development permits and population projections to develop projections of the salt load to CCWRP for 2010, 2015, and 2020. Document all assumptions.

TASK FIVE: Write draft report. *DELIVERABLE:* Draft Report

TASK SIX: Complete Final Report, prepare and present summary of Final Report to City of Phoenix and CASS. *DELIVERABLE:* Final Report and one presentation

Expanded Scope TASK SIX:

Co-author and co-present a technical paper to the AWPCA Conference in May 2005 and the WateReuse Conference in September, 2005

APPENDIX B - REFERENCES

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