5 Historical Changes in Water Quality

5.1 Introduction

A treatment plant has operated at Tucson's Roger Road site since 1951, and in its early operation nearly all of the effluent was sold to area farmers for irrigation. In 1970s Roger Road WRF output exceeded the water demand of the local farmers, particularly during the winter season. At that time, the City of Tucson began discharging effluent into the LSCR. In 1977, the Ina Road WRF came on line and also began discharging effluent to the LSCR. Since that time, water quality of the effluent in the LSCR has been a continual concern. In 1976, the EPA implemented the Clean Water Act and developed water quality criteria intended to protect the most sensitive aquatic species, which applied to discharges such as those from the WRFs.

The WRFs were designed as secondary treatment plants to reduce Biological Oxygen Demand (BOD), suspended solids, fecal coliform, and oil & grease, and the water discharged from the plants was in compliance with permit requirements (Greeley and Hansen, 1984). These original designs did little to achieve tertiary removal of nitrogen or other constituents. However, standards for ammonia were exceeded in most samples of discharge at the outfalls collected prior to 1986 (Harding Lawson Associates; HLA, 1986).

In 1985, the State of Arizona classified the reach of the LSCR from the Roger Rd WRF to Baumgartner Rd in Pinal County as an '*effluent-dominated water' (EDW, which now stands for effluent dependent water)* and asked Pima County to establish a water quality monitoring program for the River. A study was then initiated to assess the physical, chemical and biological characteristics of the effluent-dominated stream in order to attain actual and potential aquatic uses (HLA, 1986). This information was used to develop site-specific water quality sampling for the river, which allowed for water quality sampling to be directed to species that commonly occur at a site (EPA, 1983).

Data on water quality and physical and biological characteristics were collected in 1986 (HLA, 1986), 1997 (HLA, 1997) and 2002 (URS-CDM, 2002). Also, in addition to collecting water quality compliance data from the WRF outfalls, RWRD has collected surface water quality data from select downstream monitoring sites since 2003.

One of the primary concerns has been the nutrients introduced into the LSCR. Nutrients, such as nitrogen and phosphorus, are essential for plants and animals. However, nutrient impacted waters can experience nuisance levels of algae and other aquatic vegetation (macrophytes) growing quickly in response to nutrient availability if other limiting factors such as light, temperature, substrate, etc. are favorable. Algae directly or indirectly causes most problems related to excessive nutrient enrichment. Algae can

bloom as single or multiple species, involving complex relationships of water quality parameters, such as dissolved oxygen (DO).

Abundant biomass of algae and macrophyte vegetation may contribute to severe diurnal swings in DO and pH. Low DO can, in turn, mobilize metals from sediments and increase availability of ammonia and hydrogen sulfide, affecting habitability for aquatic organisms, including fish. Algal growth may cause high turbidity; under turbid conditions, macrophytes may not thrive and algae may be present in dense algal mats. Algae that dies and decays can further reduce the dissolved oxygen level, harming fish and aquatic life. So, a stream's nutrient load impacts its aquatic community composition and species diversity.

Nitrogen, in the forms of nitrate, nitrite, or ammonia, is a nutrient needed for plant growth, while ammonia can be toxic to fish even at low concentrations. Historically nitrogen has been mostly in the ammonia form in the effluent of the LSCR. The total nitrogen concentration in the effluent of the LSCR has typically ranged over 30 mg/l. Arizona EDWs do not have a standard for total nitrogen or nitrate nitrogen, but there is a standard for ammonia. The acute standard varies with the pH of the stream; but, expressed in mg/l, the standard is in the range of 10.1 – 36.1 for pH of 7.0-7.9. The chronic standard varies with both pH and temperature and is in the low single digits (ranging from about 1.5 to 4.7 mg/l). There is no standard for EDWs for phosphorous. The DO standard for EDWs is 3.0 mg/l daytime and 1.0 mg/l nighttime.

The vast majority of water delivered to the WRFs originated as potable water delivered by Tucson Water. Groundwater was the sole source of potable water prior to the 1990s in the Tucson metropolitan area. Water from the central wellfield had a very low Total Dissolved Solids. A recent sample collected by Tucson Water showed that water from the central well field had a TDS of 172 mg/l.

Since 1992 the potable water in the Tucson metropolitan area has been derived from Colorado River water (i.e. Central Arizona Project water; CAP water), which has a higher mineral content. A recent CAP water sample collected in Avra Valley by Tucson Water had a TDS of 569 mg/l. Because the water quality was substantially different than groundwater, CAP water dissolved mineral deposits in water supply piping and resulted in red, discolored water at the tap (Blevens, 2012). There was a public backlash to direct delivery of CAP that resulted in passing proposition 200 in 1995, the Water Consumer Protection act, requiring Tucson Water to cease delivery of CAP until it could be done in a way that did not damage pipes (Song, 2009). By 2001 Tucson Water had built a recharge facility in Avra Valley that recharged CAP and retrieved a blend that would slowly increase in CAP content. This blend is the dominant potable supply delivered to Tucson Water customers, and subsequently discharged to the treatment plants on the LSCR. While early deliveries have been predominantly groundwater, current potable water is a blend of about 50% CAP and 50% Avra Valley groundwater.

According to the CAP website (http://www.cap-az.com/Water/Quality.aspx), the Colorado River water typically has higher total dissolved solids (TDS) levels than some sources of groundwater. TDS are measured by the amounts of calcium (Ca), magnesium (Mg), bicarbonate (HCO_3), sodium (Na) and sulfate (SO_4) in the water. Because CAP water is composed of water from the Colorado and Agua Fria rivers and the system stretches 336 miles, levels of TDS vary throughout the canal. The water quality tests show that the TDS not only vary due to the mixture of the two water sources, but also change by season and other natural conditions, decreasing during floods and increasing during drought periods.

This chapter reviews surface water quality conditions in the LSCR collected by RWRD and Arizona Department of Environmental Quality (ADEQ) and discusses variability over time. The most significant changes evident in the available data are related to nutrient levels and major ion composition of the water. While in recent years, there has been increasing awareness of emerging contaminants in effluent, this chapter does not discuss or present the data on emerging contaminants.

5.2 Selected Water Quality Parameters

Sampling locations of the RWRD and ADEQ data are shown in Map 1. RWRD collected data at all sampling sites from SC-01 to SC-12 in 2004. From 2009 to 2011, samples were collected only at SC-01, SC-03, SC-06 and SC-12. RWRD has continuously collected data for compliance at Roger Rd and Ina Rd WRF outfalls. ADEQ collected data near Cortaro Rd. from late 1980s to early 1990s, and 2010-2011. Both RWRD and ADEQ have been monitoring numerous water quality parameters. In this section, we selected parameters related to salinity and infiltration, in addition to major ions and nutrients that can affect aquatic animals and vegetation. Selected data are summarized in Table 5.1.

Table 5.1 Selected Water Quality Parameters

Parameters	RWRD Data	ADEQ Data
Sodium	x	x
Calcium	x	x
Magnesium	x	x
Bicarbonate	x	x
Chloride	x	x
Sulfate	x	x
Total Dissolved Solids	x	x
Total Kjeldahl Nitrogen	x	x
Ammonia	x	x
Nitrate and Nitrite	x	x
Total Phosphorus		x
Dissolved Oxygen	x	x
Temperature		x
pH		x

5.3 Nutrients

5.3.1 Nitrogen

Nitrogen discharged from the treatment plants takes the form of ammonia, organic nitrogen, nitrate and nitrite. Total Kjeldahl nitrogen or TKN is a common analysit that tests for the sum of organic nitrogen, ammonia (NH_3), and ammonium (NH_4^+) – otherwise known as ionized ammonia. To calculate the total amount of nitrogen (TN) in the effluent, the concentrations of nitrate-N and nitrite-N are determined and added to TKN. The abundance of different species of nitrogen varies depending on the treatment process used, the efficiency of treatment, the time of year, the distance traveled within a stream system, and other factors such as the amount of nitrogen tied up in biomass.

Fig. 5.1.1 shows temporal changes in Nitrogen discharges at the Roger Rd WRF. TKN is higher in the winter when the bacteria digesting the Nitrogen are less active due to lower temperature, and lower in the summer when the bacteria is more active with higher temperature. In addition, the ammonia component of degasses more in the summer when it is warmer. Nitrate and Nitrite are higher in the summer and are a product of the treatment of the TKN. Therefore, Total Nitrogen is dominated by TKN content, but shows less variability than the TKN because of the introduction of higher concentrations of Nitrate and Nitrite in the summer.

Fig. 5.1.2 shows the temporal changes in nitrogen discharge at Ina Rd WRF and how nitrogen concentrations decrease with the implementation of treatment processes to

denitrify the effluent. The graph indicates the point in 2006 when biological nitrogen removal – activated sludge (BNRAS) was introduced for half of the plant's flow – the east train. There is an upturn in nitrogen in the discharge in October 2011 when the east train was removed from service to convert it to the Regional Optimization Master Plan (ROMP) upgraded Bardenpho design (the detail of ROMP will be described in Chapter 7). There is a significant drop in nitrogen in September 2012 when the east train was brought on-line and the west train is taken out of service to convert it to the Bardenpho design. Soon, the entire plant will be discharging low-level nitrogen, and the total nitrogen levels will stabilize at concentrations in the low single digits.

Fig.5.2.1 shows the TKN concentration at the RWRD sampling sites. The TKN concentrations at RWRD sampling sites downstream of Ina Rd. WRF (SC-03-SC-12) in 2004 were higher than the concentrations in 2009, 2010 and 2011. The TKN concentration was relatively high at upstream of Ina Rd. WRF (Roger Rd. and Ina Rd. WRFs and SC-01) in 2011.

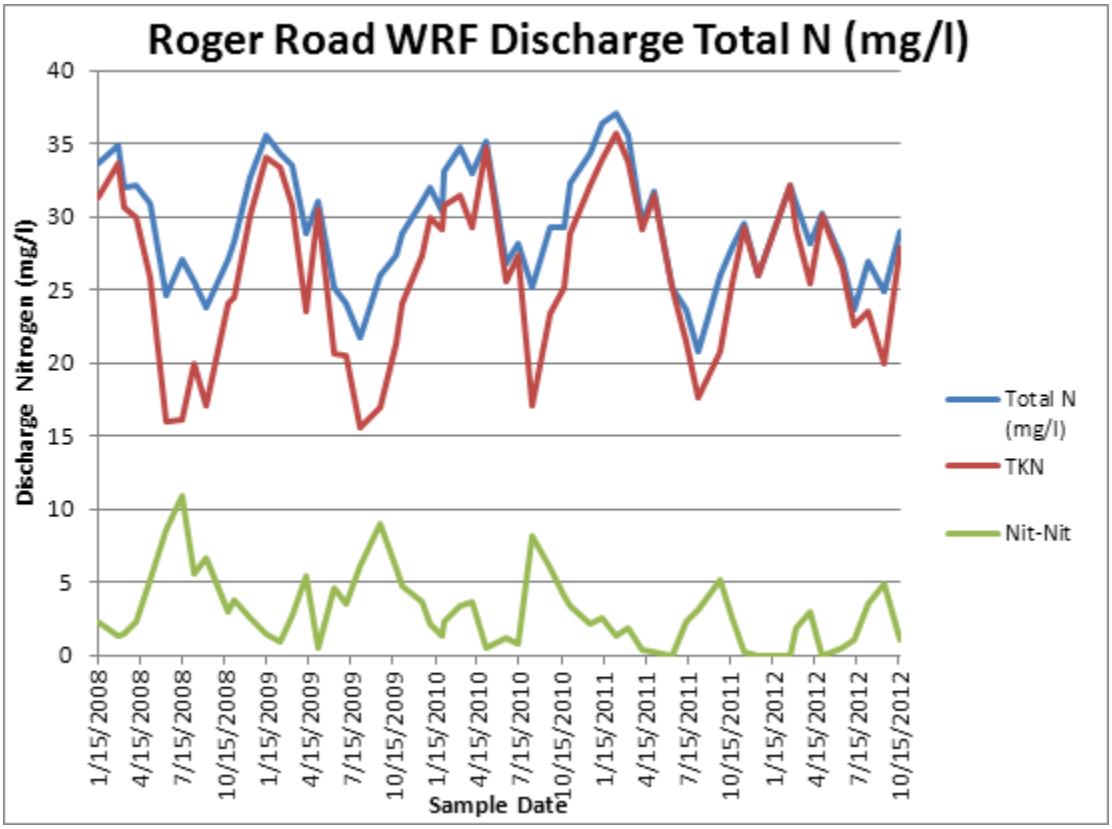

Fig. 5.1.1 Temporal changes in Nitrogen discharge at Roger Rd. WRF

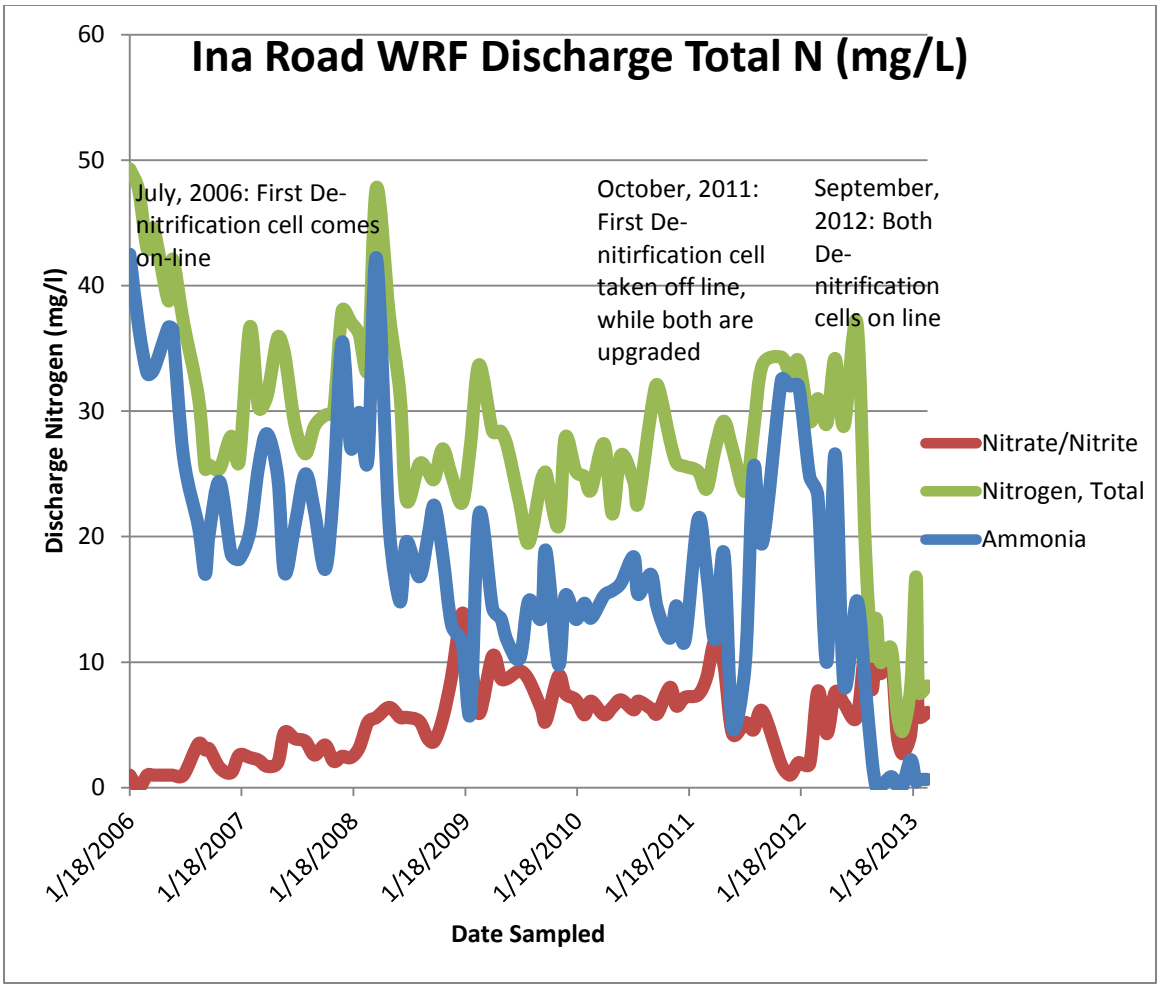

Fig. 5.1.2 Temporal changes in Nitrogen discharge at Ina Rd. WRF (Note: Outliner data was removed)

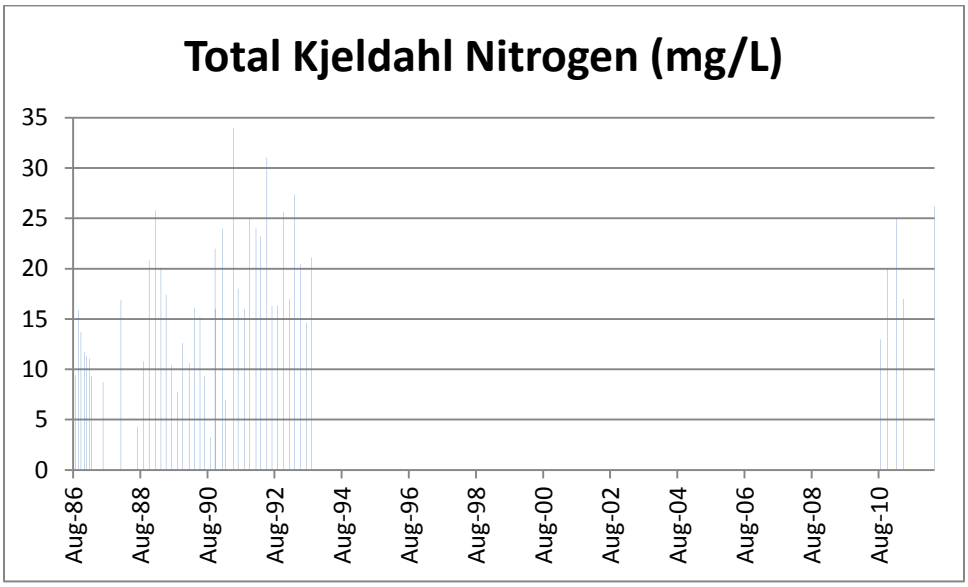

Fig. 5.2.1 Total Kjeldahl Nitrogen concentration near Cortaro Road

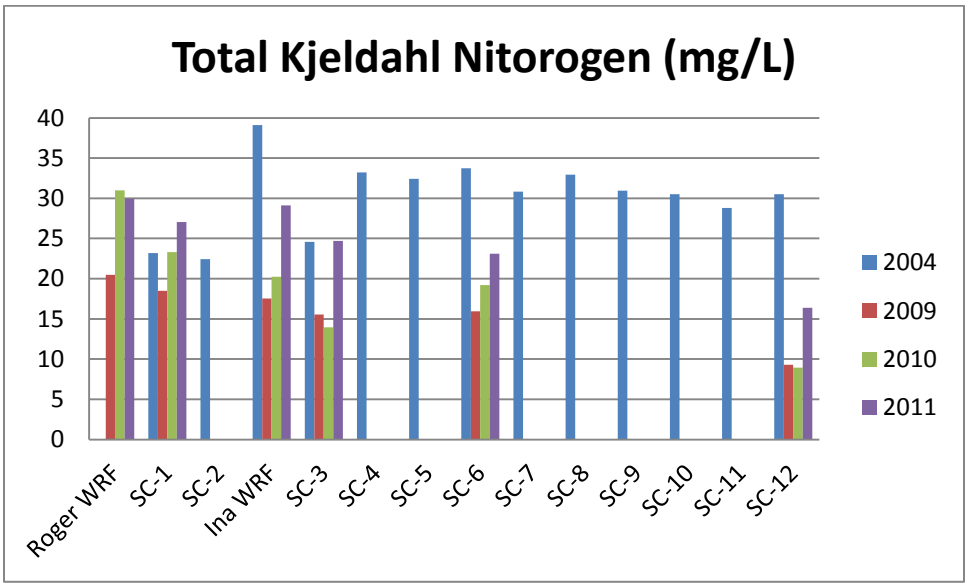

Fig. 5.2.2 Total Kjeldahl Nitrogen concentration at RWRD sampling sites

Fig. 5.3 shows the ammonia concentration near Cortaro Rd with ADEQ standard for effluent-dependent streams. The ADEQ standard of ammonia level varies by temperature and pH (Title 18. Environmental Quality, Arizona Administrative Code). The ammonia concentration near Cortaro Rd. is substantially higher than the ADEQ standard. Walker et al. (2005) reported that the high ammonia concentration in the LSCR may have had negative consequences not only on diversity of aquatic macroinvertebrates, but their ability to survive in the first place. Fig.5.4 shows the ammonia concentration at the RWRD's sampling sites. The ammonia concentration in 2004 tends to be higher at downstream of SC-04 (SC-04-SC-12). The ammonia concentaration was relatively high at the Roger Rd. WRF outfall and SC-01 in 2010 and 2011.

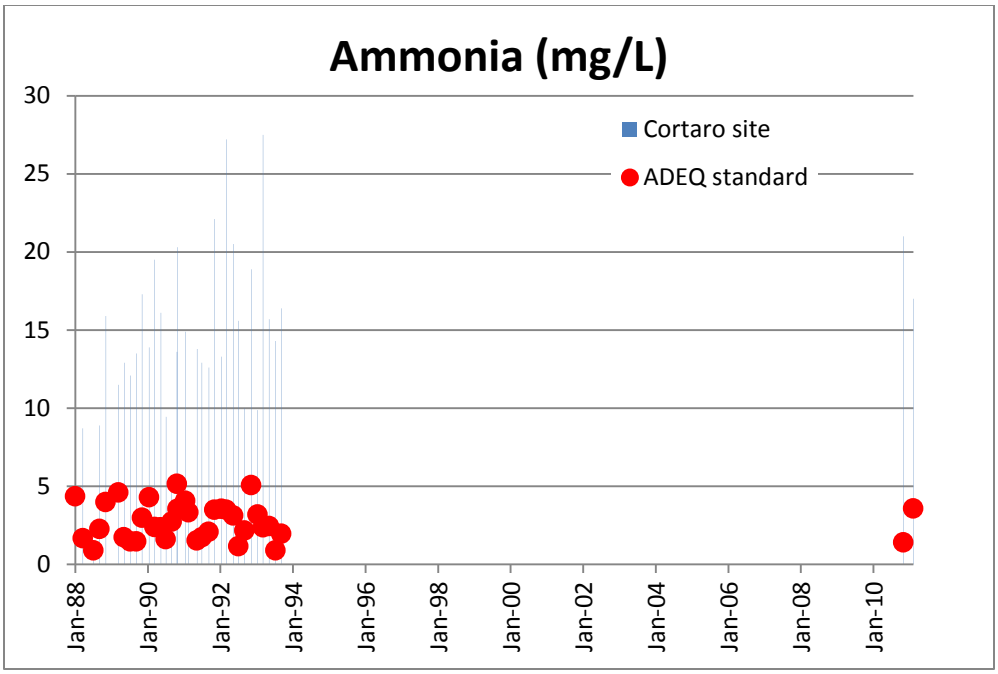

Fig. 5.3 Ammonia concentration near Cortaro Road

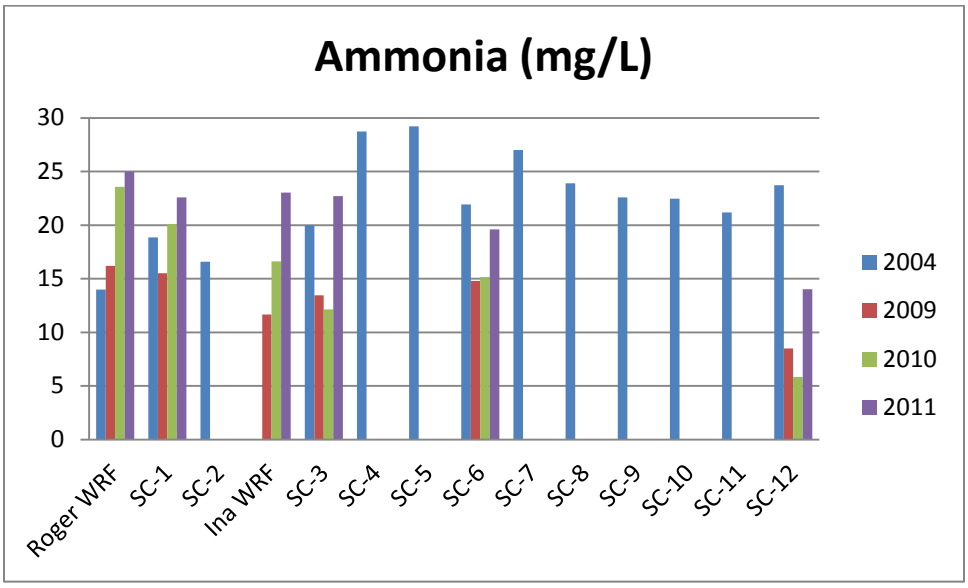

Fig. 5.4 Ammonia concentration at RWRD sampling sites

Fig. 5.5 shows the nitrate and nitrite concentration near Cortaro Rd. Fig.5.6 shows the the nitrate and nitrite concentration at the RWRD's sampling sites. The nitrate and nitrite concentration near Cortaro Rd. and the RWRD sampling sites tends to be higher during the period of 2009- 2011 (Figs. 5.5 and 5.6).

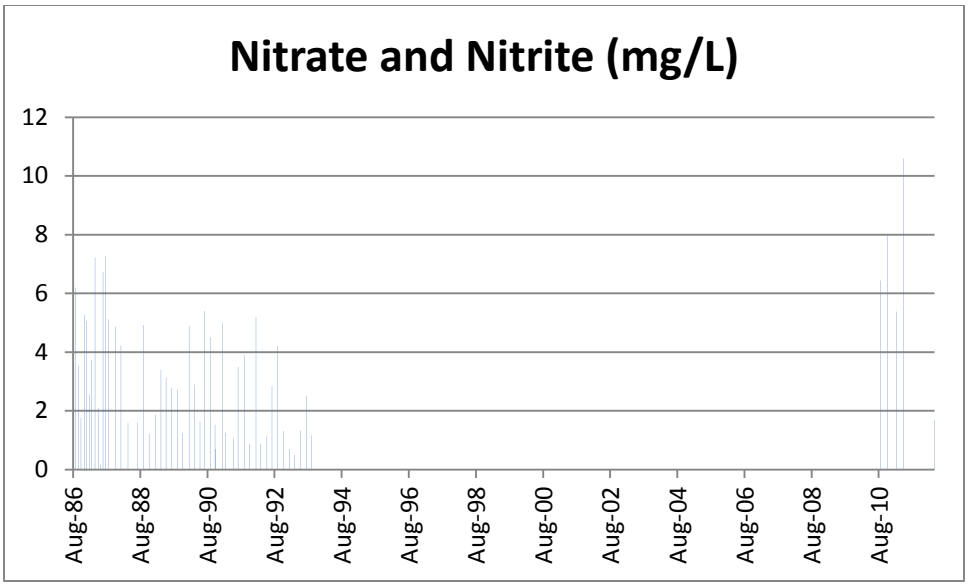

Fig. 5.5 Nitrate and Nitrite concentration near Cortaro Road

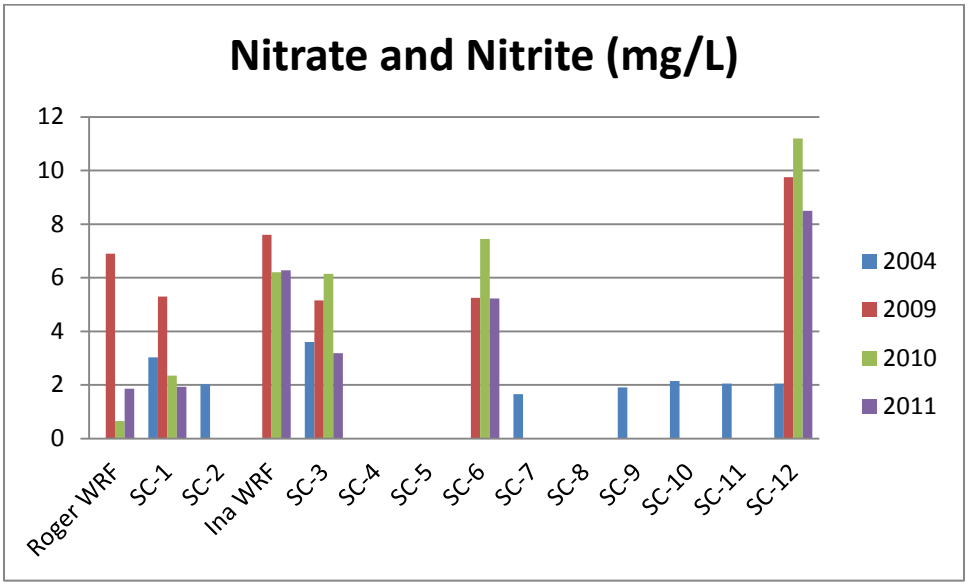

Fig. 5.6 Nitrate and Nitrite concentration at RWRD sampling sites

During the period of 2009-2011, the nitrate and nitrite concentration was relatively high at SC-12, compared to the other RWRD sites (Fig. 5.6). As described above, Nitrate and Nitrate are products of the biological processing of TKN (especially the ammonia component of TKN). Therefore, the higher concentrations of Nitrate and Nitrite at SC-12 are likely the product of increased biological conversion of TKN as the flow moves downstream.

ADEQ's Santa Cruz Watershed Assessment issued as the 305b Report for 2010 identified both the Roger Rd and Ina Rd downstream reaches as "Not Attaining" for ammonia (Appendix D). With respect to the Ina Rd WRF, most of the data points used in

the assessment preceded the change to BNRAS treatment for the east half of the plant, which occurred in July, 2006. ADEQ's report recognizes that both Roger and Ina WRFs are under compliance schedules that require ROMP upgrades directed at remedying the problem. The 305b assessment also identifies certain metals (copper, lead, zinc) that are elevated when stormwater flow is present in the channel.

5.3.2 Phosphorous

Fig. 5.7 shows phosphorus concentration near Cortaro Rd. The phosphorus concentration apprears lower in 2010-2011, compared to the period from late 1980s to early 1990s. This may be the effect of the denitrification in the east train, which can also break down some of the phosphorus.

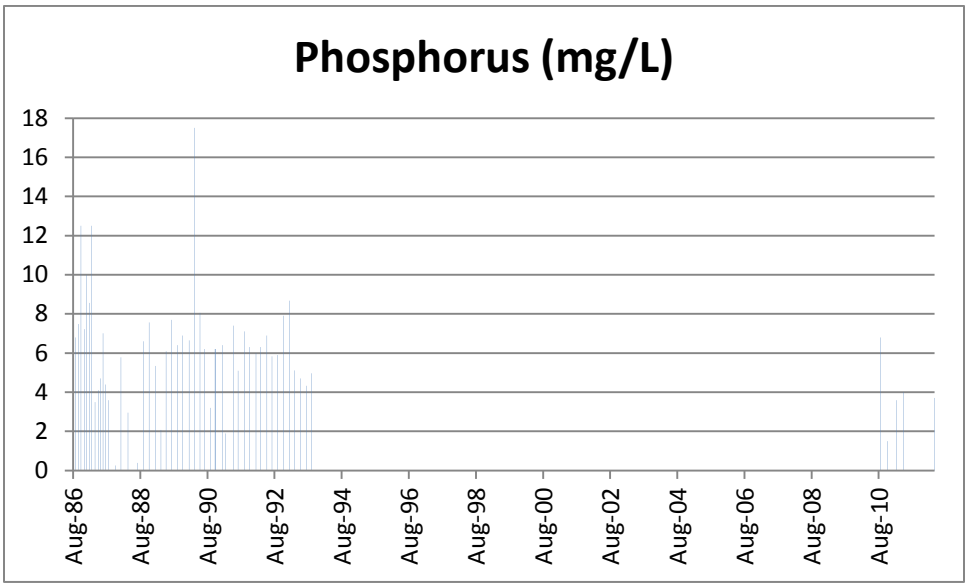

Fig. 5.7 Phosphorus concentration near Cortaro Road

5.4 Dissolved Oxygen

In winter 2003 and summer 2004, Walker et al. (2005) measured linear profile and diurnal pattern (24 hour period, every 30 min) of the DO levels near the outfall of the Roger WRF and at a point north of the Canada del Oro Wash confluence upstream of Ina WRF. They reported that DO levels were relatively low (approximately ranging from 4.0 to 6.0 mg/l) along the entire channel length and DO levels are extremely low (1 to 2 mg/l) for a substantial period of time (nighttime) over a 24-hour period upstream of the Ina WRF, especially in summer. They pointed out that temperature obviously had an effect on dissolved oxygen levels, with summertime temperatures increasing loss of DO from the water. The sampling results suggested that the DO levels were not adequate to support aquatic life for long periods of time.

Fig. 5.8 shows dissolved oxygen (DO) near Cortaro Rd. while Fig. 5.17 shows DO at the RWRD sampling sites. The DO level near Cortaro varies from 2 mg/L to over 9 mg/L (Fig. 5.16). The DO levels at the RWRD sampling sites ranged from 3.5 mg/L to over 7 mg/L (Fig. 5.9).

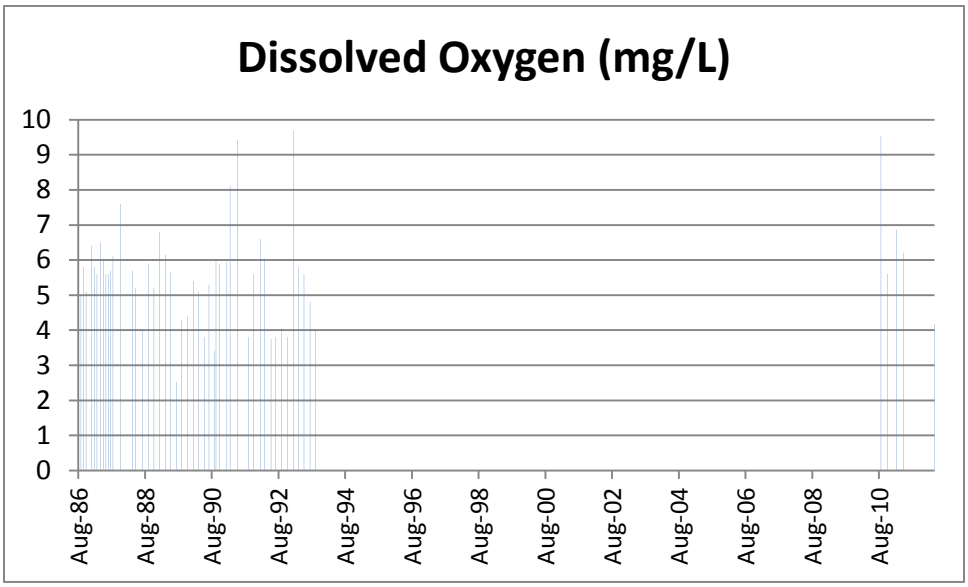

Fig. 5.8 Dissolved oxygen concentration near Cortaro Road

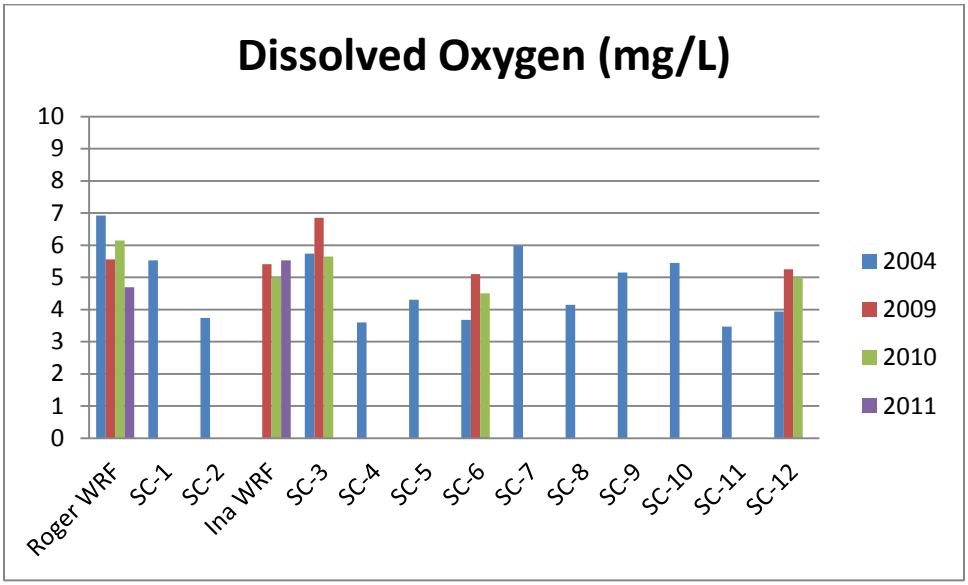

Fig. 5.9 Dissolved oxygen concentration at RWRD sampling sites

5.5 Total Dissolved Solids and Major Ions

5.5.1 Total Dissolved Solids

A shift in major ion composition of water in the Tucson metropolitan area is underway, and it is affecting surface water quality. One indicator of this change is seen in the Total Dissolved Solids (TDS) data. As mentioned previously, CAP water typically has higher TDS levels than Tucson's groundwater supply with CAP having about triple the TDS than in central well field water. CAP was originally introduced to central Tucson residents with direct delivery in 1992. However, direct delivery of CAP temporally ceased after the disastrous introduction of direct delivery. Since 2001 the water delivered to Tucson Water customers has been a blend of groundwater and CAP water. Water quality in the influent water to the WRFs and their effluent is, by necessity, impacted by the potable water that has been discharged to the sewer system. The water delivered to the WRFs contains increasing amounts of CAP water because of the recharge and recovery process.

Fig. 5.10 shows the TDS levels measured by ADEQ in the Santa Cruz River near Cortaro Rd. from late 1980s to early 1990s, and 2010-2012. TDS was lower (around 500 mg/l) prior to the direct introduction of CAP water in 1992, at which point TDS levels increased. The TDS level of the CAP water was 662.7 mg/l in 2009, while it was 623.3 mg/l in 2011. ADEQ data are not available between 1993 and 2010, but that was a period of change. Between 1994 and 2001, CAP was not used, and since 2001, increasing proportions of CAP have been delivered. One of the RWRD monitoring sites (SC-04) is located approximately 3000 feet downstream of the ADEQ's sampling site near Cortaro Rd. Average TDS level at SC-04 is 532.5 mg/L in 2004.

Fig. 5.11 shows the TDS level measured at RWRD's sampling sites. The TDS level measured in 2004 varied from approximately 500 (similar to the pre-CAP TDS) to 700 mg/L, but was generally lower than TDS levels measured more recently from 2009 to 2011. The TDS levels at Roger Rd. WRF outfall and SC-01 have been relatively high (above 700 mg/l) from 2009 to 2011.

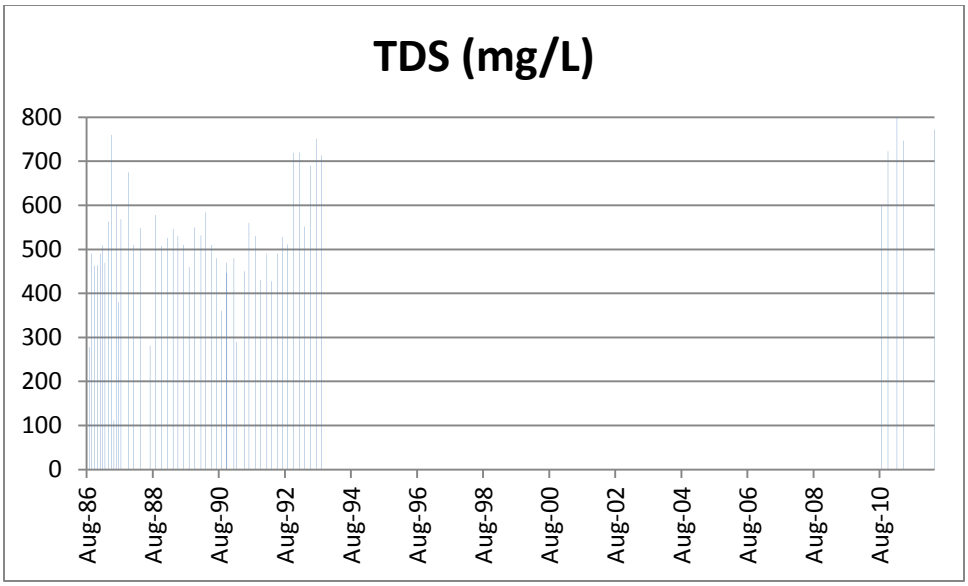

Fig. 5.10 Total Dissolved Solid (TDS) near Cortaro Rd.

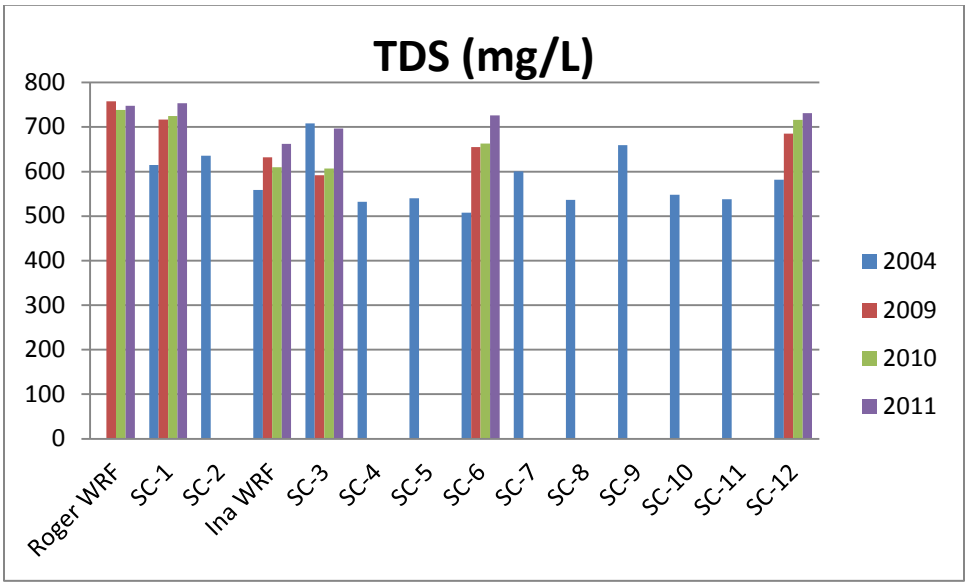

Fig. 5.11 Total Dissolved Solid (TDS) at RWRD sampling sites

5.5.2 Major Ions

One way to understand the distribution of major cations and anions is to represent water quality as a Stiff Diagram, a polygon with six ordinates defined by the three major anions (Cl, HCO_3 and SO_4) and three major cations (Na, Ca and Mg) (H.A. Stiff, 1951). Stiff Diagrams are useful in making a rapid visual comparison between water from different sources. Sometimes, Potassium concentrations are added to the Sodium and CO_3 added to HCO3, but these two ions tend to occur in relatively small concentrations, and are not usually important for assessing major trends. Ionic compositions are plotted as milliequivalents per liter, which is a measurement of the molar concentration of the ion,

normalized by the ionic charge of the ion. Cations are plotted on the left side of the zero axis, one to each horizontal axis, and anions are plotted on the right side.

i) ***Temporal Changes in Major Ions:*** The ADEQ data collected at Cortaro has the longest period of record, so it is most useful for examining temporal change. Because data collection was not consistent, all major cations and anions are not available for all events, so average concentration for each ion was calculated for each year. Potassium and CO_3 were used in this calculation, however they occur in low concentrations and are relatively unimportant.

The temporal changes in water quality are illustrated in Fig. 5.12. The primary temporal changes occurred in the anions and in Sodium concentration. As the figure shows, from 1986 to 1991 water quality is fairly uniform with the cations dominated by Na at about 4 meq/l, Ca at about half that, and a small contribution from Magnesium. Anions were dominated by Bicarbonate at about 4 meq/l and Chloride at about 2 meq/l and Sulfate at slightly less. This would be described as a sodium bicarbonate-chloride type of water.

In 1993, the Stiff Diagrams seem to show the effect of the failed attempt to introduce CAP water directly into Tucson Water's delivery system. Chloride, Sodium and Sulfate are all markedly higher. However, because much of the Tucson Water delivery area was still on groundwater, the full effects of CAP water were not manifest in the Stiff Diagram. This would be described as a mixed water because none of the anions is dominant. The two waters are very different as shown by Stiff diagrams of well water and CAP water as shown in Fig 5.13. The well water and CAP water data was collected in February 2013.

The data from 2010 to 2012 shows a clear change from prior water quality. Chloride increased from about 3 meq/l to 5 meq/l over this period and Sulfate increased from about 2 meq/l to 4 meq/l. In addition, Sodium shows an increase from about 4 meq/l in the 1990s to nearly 6 meq/l in 2012. This would be described as a sodium chloride-bicarbonate water. While there are several possible reasons for this increase in Sodium, Sulfate and Chloride, the most likely is increased use of CAP water in the CAP/groundwater blend being delivered by Tucson Water. Other possible contributing factors to this water quality shift may be use of sodium bisulfite as a chemical additive to dechlorinate the effluent, increasing use of water softeners, and changes in detergents.

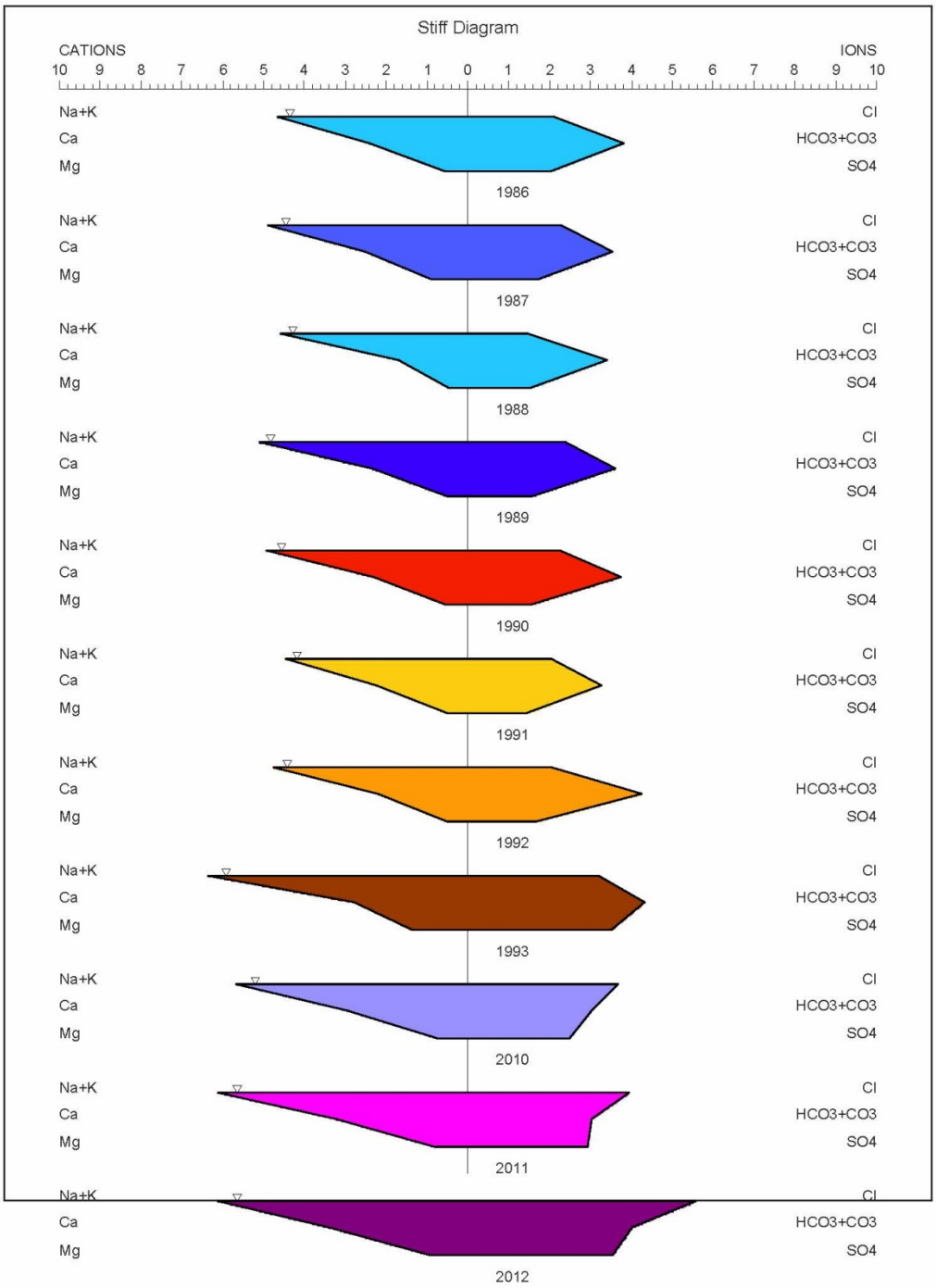

Fig. 5.12 Temporal Changes in Major Ions (meq/l) near Cortaro Road

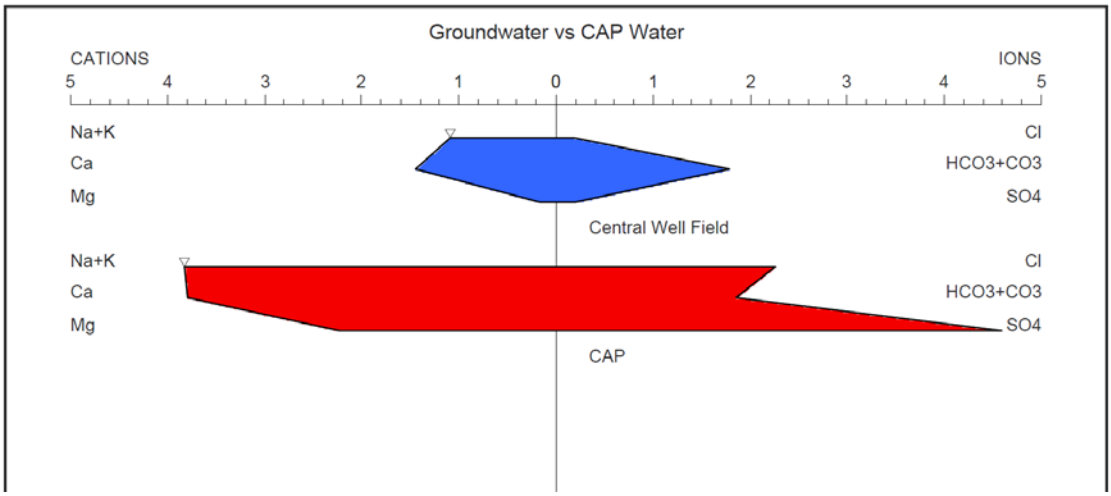

Fig. 5.13 Major Ions of Central Well Field and CAP Water

ii) ***Major Ions at Treatment Plant Outfalls:*** Adequate data sets for plotting Stiff Diagrams are only available since 2009. Fig. 5.14 shows the water quality for the two outfalls The water quality at the outfalls is similar, but shows some subtle distinction. Discharge from Roger Rd WRF tends to have more Sodium, Chloride and Sulfate than Ina Rd. This effect may reflect a higher proportion of the CAP blend being distributed by Tucson Water in the part of its service area that contributes to the Roger Rd WRF. The trends mimic the trends seen in the temporal data from the River Samples with increasing Sodium and Chloride over time – especially at Roger Rd.

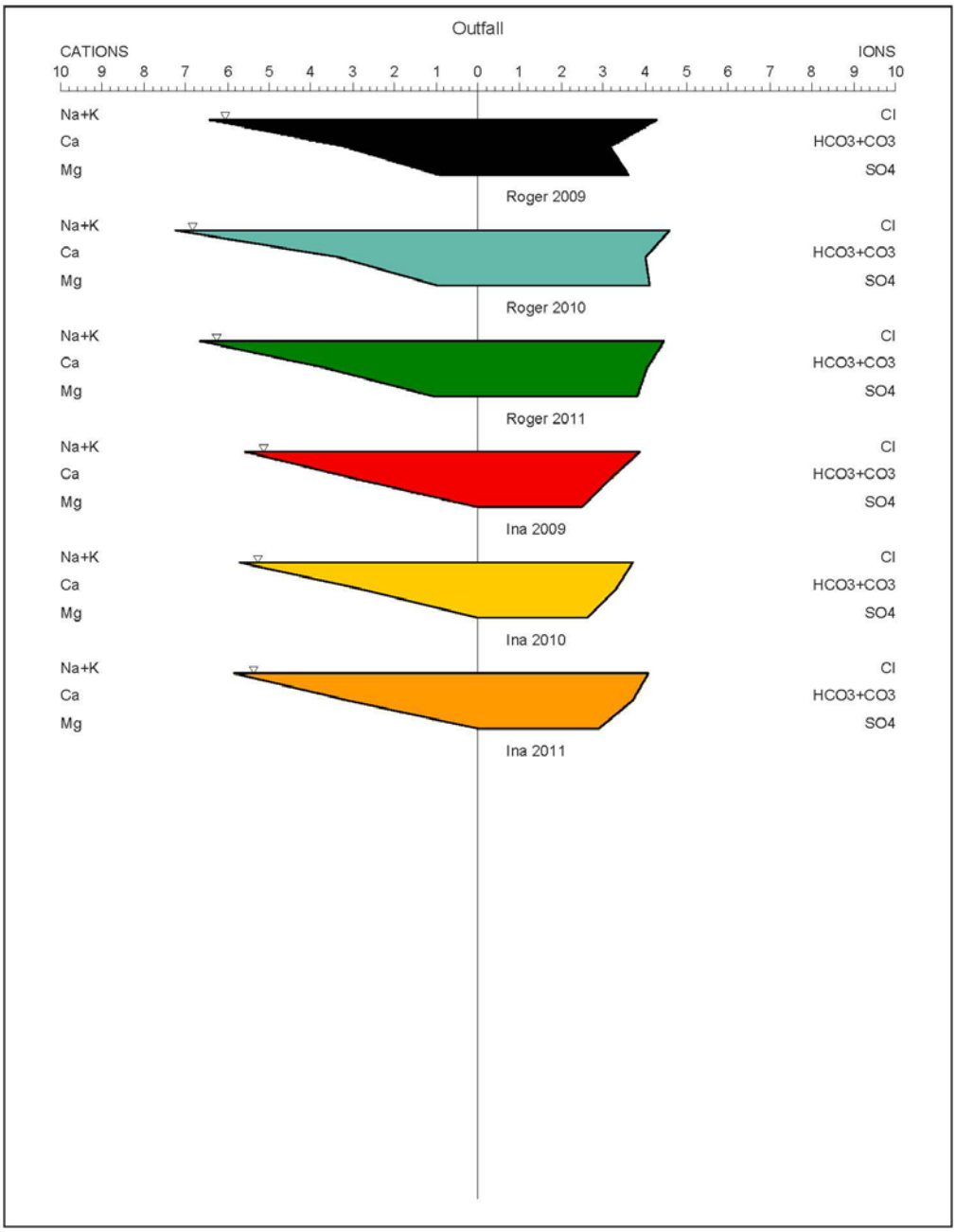

Fig. 5.14 Major Ion Concentrations at Outfalls (meq/l)

iii) ***Spatial Changes in Major Ions:*** The spatial changes are best illustrated by examining the data from RWRD for sampling locations SC-03 (Fig. 5.15.1), SC-06 (Fig. 5.15.2) and SC-12 (Fig. 5.15.3). These sampling locations are shown on Map 2.

Fig.5.15.1-3 show the same temporal trends noted in the ADEQ data set. The water from 2004 resembles the quality of the deliveries from 1986 to 1992. However, by 2009, increases in Sodium, Chloride and Sulfate are notable, and these tend to increase between 2009 and 2011. As noted above, the likely reason for this change is the increasing use of CAP in the blend being delivered to Tucson Water customers.

A spatial decrease in Bicarbonate can also be seen in the water quality samples from 2009 to 2011. At SC-03 Bicarbonate concentrations are higher than Sulfate. Bicarbonate shows a notable decrease downstream at SC-06 and a further decrease at SC-12, while Sulfate and the other cations and anions show little change downstream. This bicarbonate loss is due to an as yet unidentified in-stream process affecting the hydrochemistry.

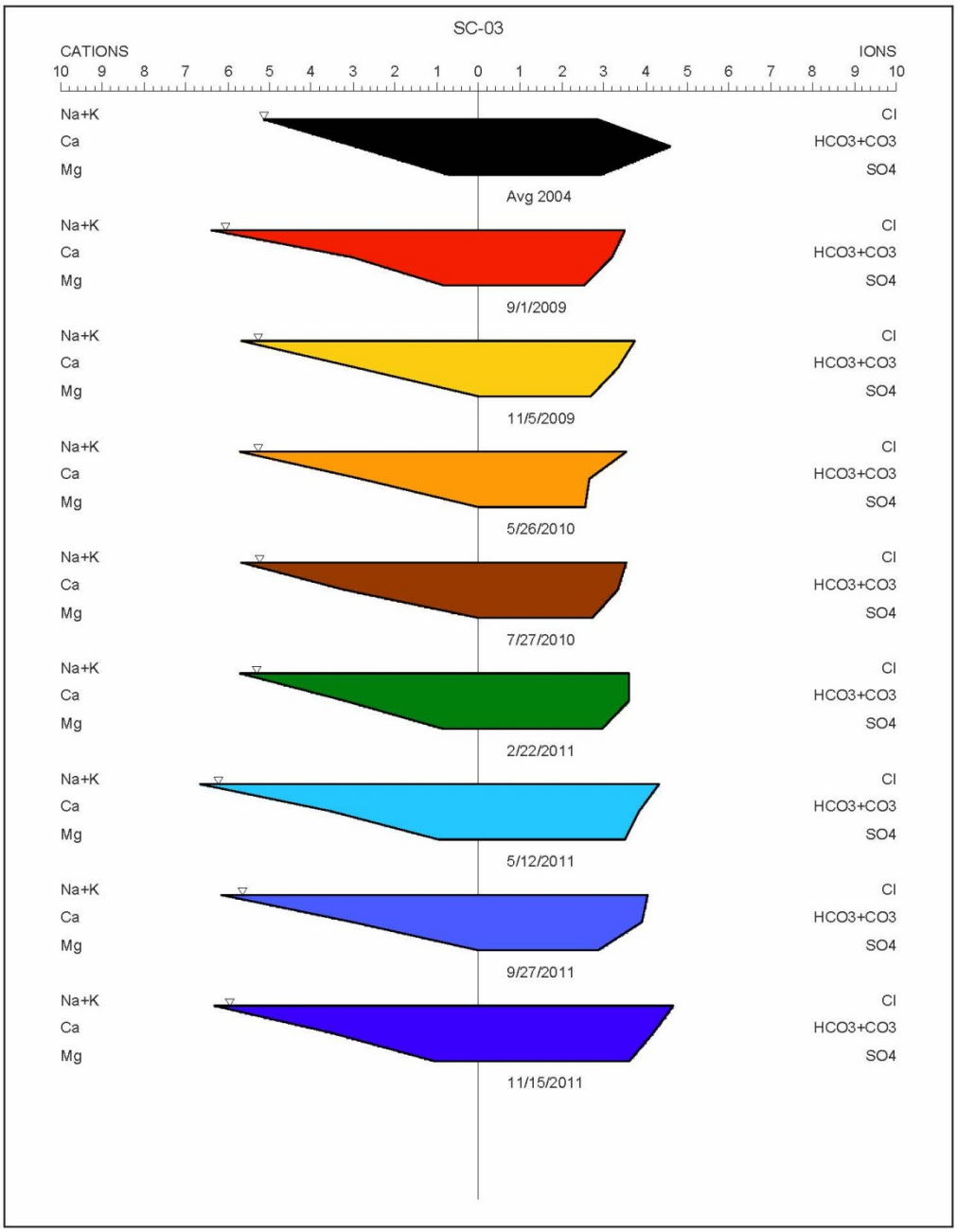

Fig. 5.15.1 Major Ion Concentrations (meq/l) at SC-03

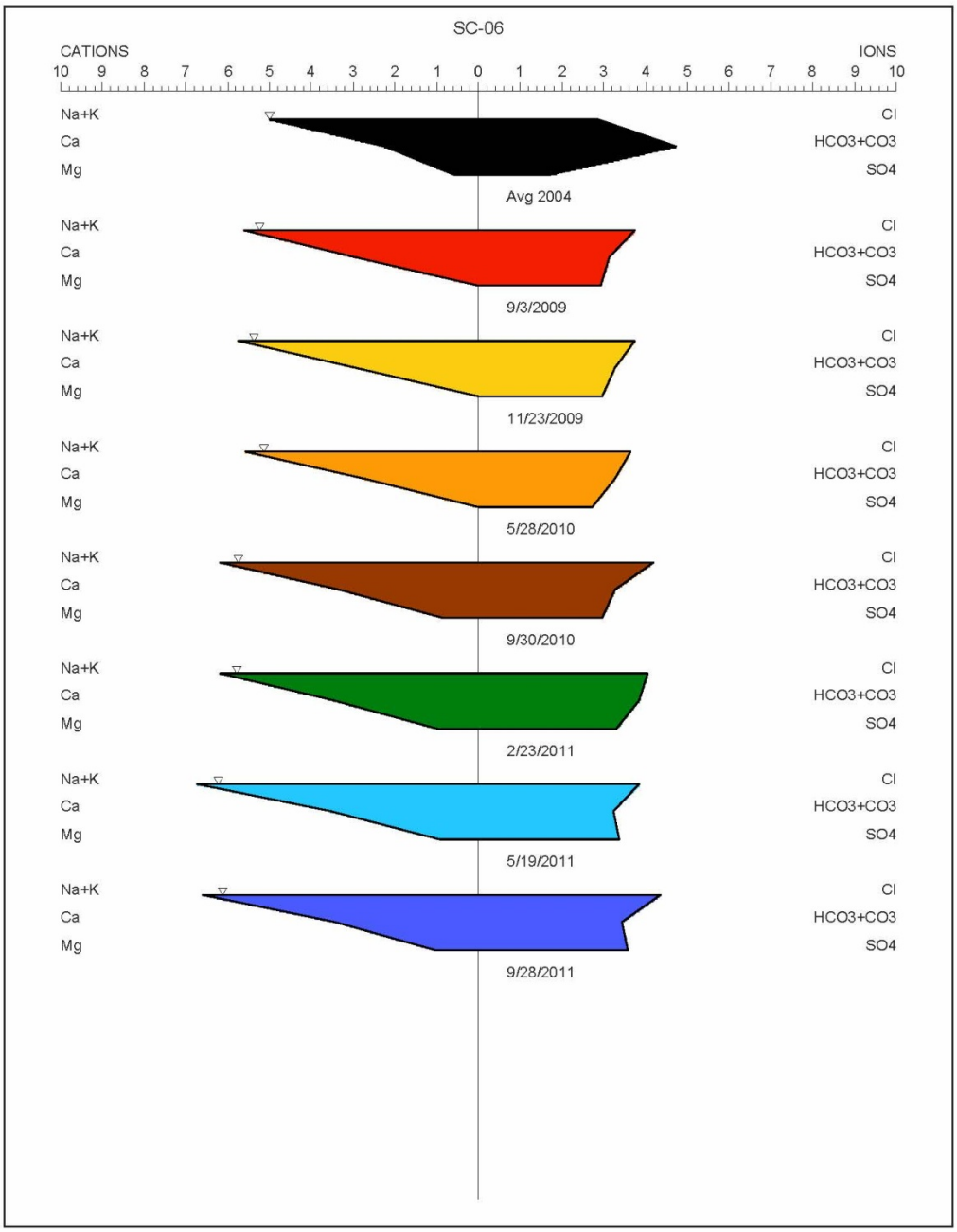

Fig. 5.15.2 Major Ion Concentrations (meq/l) at SC-06

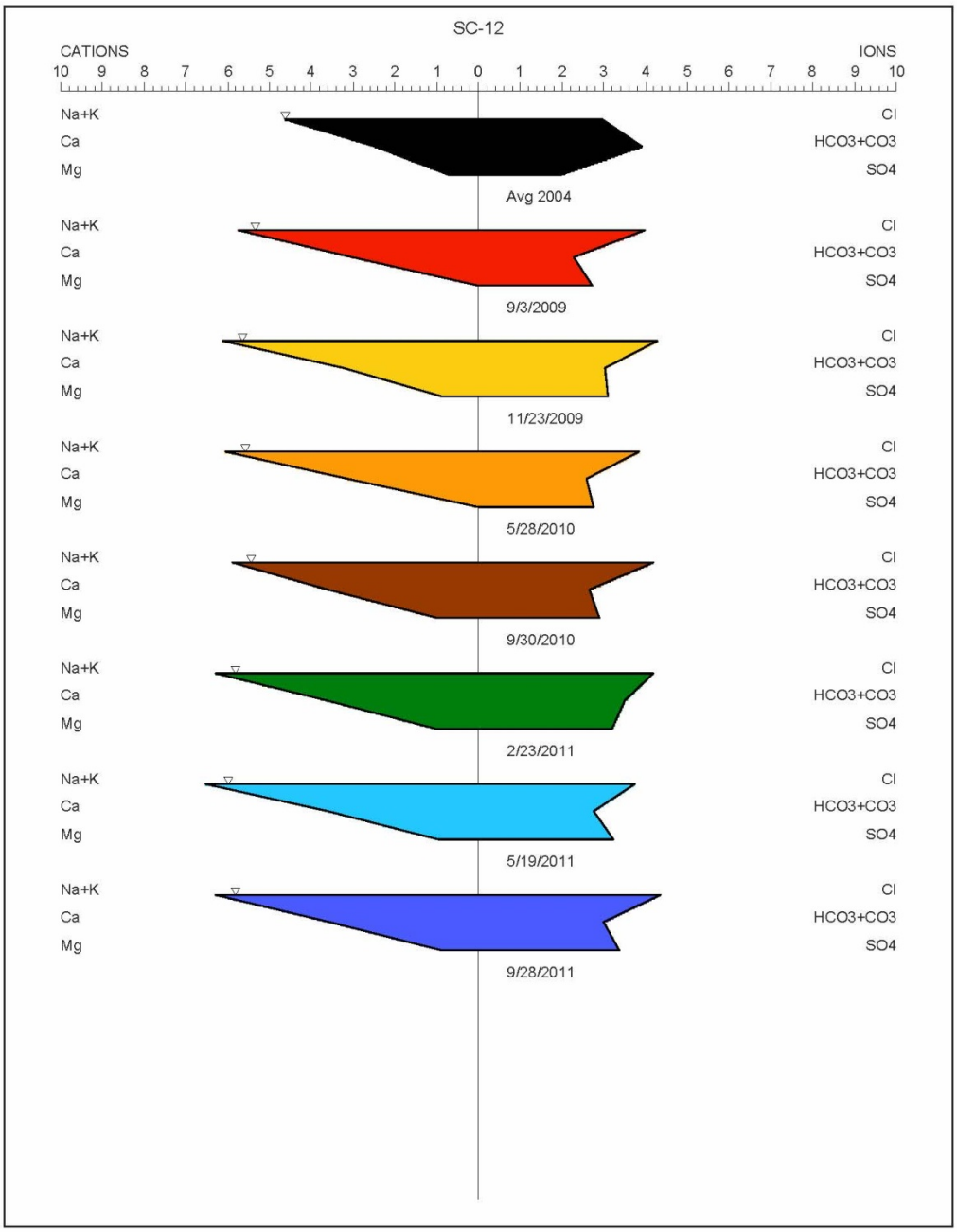

Fig. 5.15.3 Major Ion Concentrations (meq/l) at SC-12

5.5.3 Sodium Adsorption Ratio (SAR)

Studies of irrigation water have determined that water with higher sodium and potassium can disperse clays and reduce infiltration rates. Two most common water quality factors controlling infiltration rate are the salinity of water (total quantity of salts in the water) and its sodium content relative to the calcium and magnesium content. A high salinity water tends to increase infiltration, while infiltration rate decreases when sodium content in water is relatively high compared to the calcium and magnesium contents. It is possible that the CAP water and effluent derived from CAP water would have water quality that is less conducive to infiltration.

The most common measure to assess infiltration rate related to a sodium imbalance is described as the Sodium Adsorption Ratio (SAR). The SAR is the proportion of sodium (Na) ions compared to the concentration of calcium (Ca) plus magnesium (Mg).

$$SAR = \frac{[Na+]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}}$$

Where concentrations are in meq/L

Average annual SARs near Cortaro Rd (ADEQ sampling site) are shown in Fig. 5.16. Fig. 5.17 shows average SARs near Cortaro Rd. for the period before CAP became primary portable water source (1986-1991), immediately after that (1992-1993), and the past two years (2010-2011). Average annual SARs at the RWRD sampling sites are shown in Fig. 5.18.

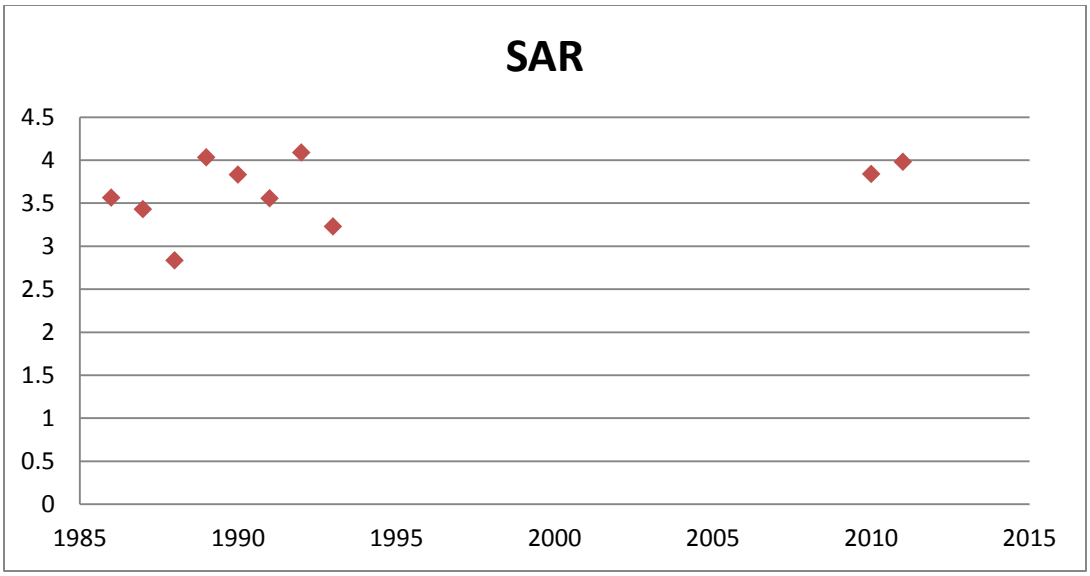

Fig. 5.16 Sodium Adsorption Ratio (SAR) near Cortaro Road. SAR at SC-04 (located approximately 3000 feet downstream of the ADEQ's sampling site) is 3.84 in 2004 (Fig. 5.17).

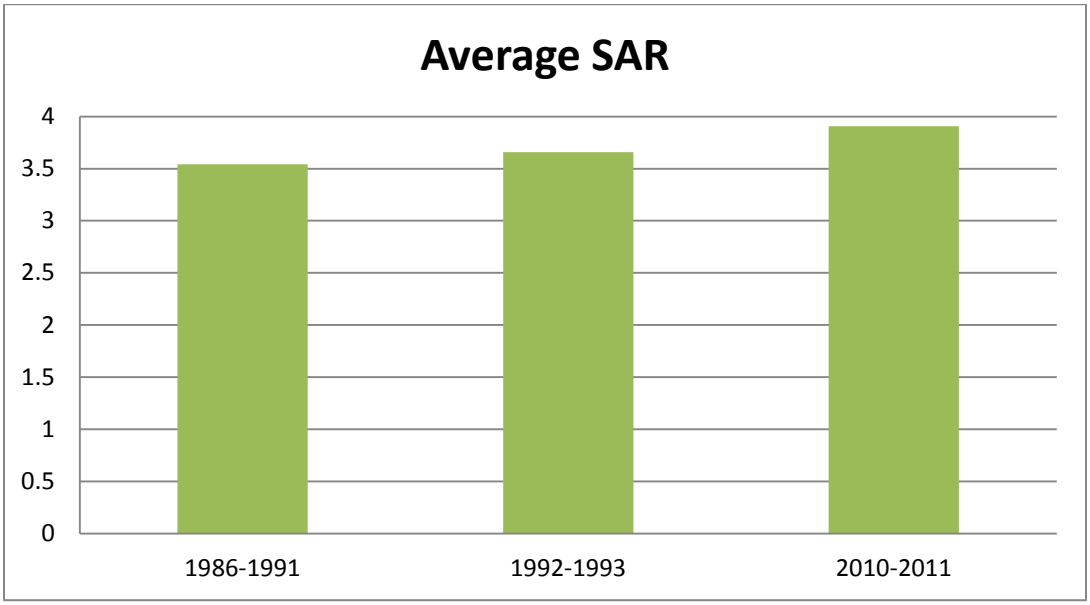

Fig. 5.17 Average Sodium Adsorption Ratio near Cortaro Road

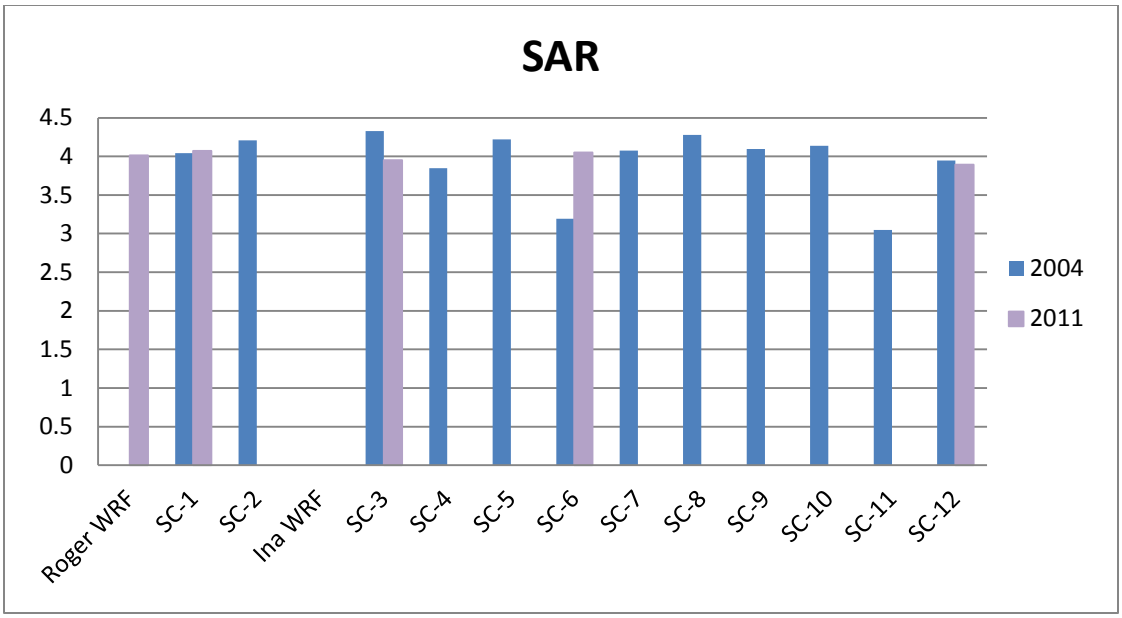

Fig. 5.18 Sodium Adsorption Ratio (SAR) at RWRD sampling sites

SAR and adjusted SAR were calculated based on river samples collected from two different stream segments in 1990-1992 (Esposito, 1993) and samples collected in 2004 by RWRD. Cortaro segment data includes sampling sites SC-03 through SC-06, while Marana segment data includes sampling sites SC-08 through SC-12. Calculating an adjusted SAR accounts for the fact that $CaCO_3$ can precipitate out if Calcium and Bicarbonate (HCO_3) are high. The SAR and Adjusted SAR are lower in the downstream Marana segment than in the Cortaro segment. However, SAR and Adjusted SAR are higher in the samples collected in 2004 than the values for 1990-92. The extent of reduced infiltration effects caused by increased SAR depends on soil conditions. Without measuring the Electrical Conductivity (EC) of the soil, it is impossible to know whether the soils will have diminished infiltration rates with the slight increase in SAR observed in the data.

Table 5.2 Water Quality Data

	Esposito (1990-1992)		RWRD (2004)	
	Cortaro mg/l	Marana mg/l	Cortaro mg/l	Marana mg/l
Ca	48	55	50	51
Mg	7	10	7	9
Na	103	108	118	115
K	12	13	16	20
HCO_3	231	234	232	223
Cl	76	83	100	108
SO_4	84	86	120	87
NO_3	4	5		
NH_3			25	23
SAR	***3.68***	***3.52***	***4.14***	***3.90***
Adj SAR	***4.54***	***4.36***	***5.15***	***4.76***
TDS	**565**	**594**	**643**	**613**

Note: Cortaro data includes RWRD's sampling sites SC-03 through SC-06, while Marana data includes SC-08 through SC-12.

5.6 Other Constituents

5.6.1 E Coli

Escherichia Coli (*E. Coli*) is fecal indicator bacteria. As an Effluent Dependent Water, the Lower Santa Cruz River is expected to meet standards for Partial Body Contact designated use. The ADEQ standard for a single-sample maximum for partial body contact is 575 MPN/100 mL. E.Coli was measured at SC-03 and SC-11 in August, 2004. The measured value is 727 MPN/100 mL at SC-03 and over 2419 MPN/100 mL at SC-11. The sampling results showed that *E. Coli* levels in the stream exceeded the ADEQ standard in 2004.

E. Coli was also measured at the Roger Rd. WRF and Ina Rd. WRF from 2009 to 2011. The *E. Coli* level at the Roger Rd. WRF outfall ranged from less than 1.0 to over 107.6 MPN/100 mL in 2009, from less than 2.0 to 93.4 MPN/100 mL in 2010, and from less than 1.0 to 150.0 MPN/100 mL in 2011. The *E. Coli* level at the Ina Rd. WRF outfall ranged from less than 1.0 to over 2419.6 MPN/100 mL in 2009, from less than 1.0 to 156.5 MPN/100 mL in 2010, and from less than 1.0 to 85.7 MPN/100 mL in 2011. These results suggest that the *E. Coli* level at the two treatment plants generally tends to be lower than the single-sample maximum ADEQ standard. Not enough data were evaluated to determine whether the few higher E Coli Levels constitute an exceedance because the standard is given as a geometric mean when multiple samples are available. However, ADEQ has not identified these stream segments as "Not Attaining" for *E. Coli* in the state's most recent (2010) 303d list analysis.

Higher *E. Coli* levels measured at SC-03 and SC-11 in 2004 could be explained by either of two possible mechanisms. After dechlorination and discharge at the outfall, regrowth of bacteria is likely to occur within the stream. Also, it is likely that bacteria are contributed to the river by wildlife sources within the downstream wetland environment.

5.6.2 pH

Fig. 5.19 shows pH measured near Cortaro Rd. Fig. 5.19 shows temperature measured near Cortaro Rd. This data show temperatures range frequently above 80ºF. Temperature measured at SC-04 by RWRD (located approximately 3000 feet downstream of the ADEQ's sampling site shown in Fig. 5.20) in 2004 was 82.2 F in April, 91.6 F in July, and 89.8 F in August. Walker and others (2005) noted the elevated temperatures in this stream segment are often above 91ºF and that the high temperatures contribute to the effect of low DO. Both pH and temperature affect the ADEQ standard for ammonia – lower temperatures and higher pH result in more restrictive standard levels.

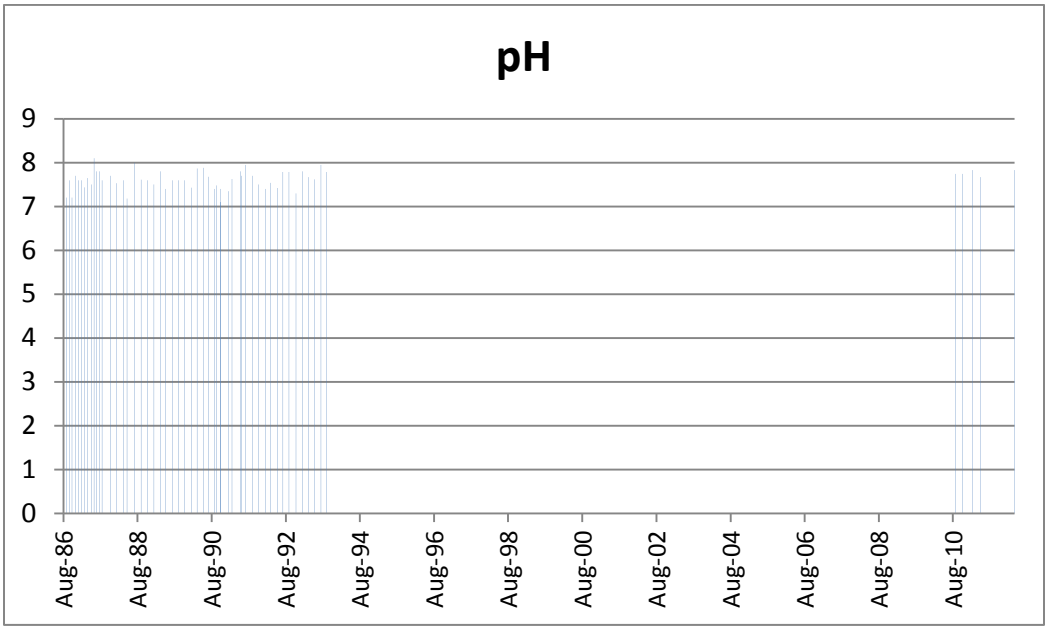

Fig. 5.19 pH measured near Cortaro Road. Average pH at SC-04 (located approximately 3000 feet downstream of the ADEQ's sampling site) in 2004 was 7.6.

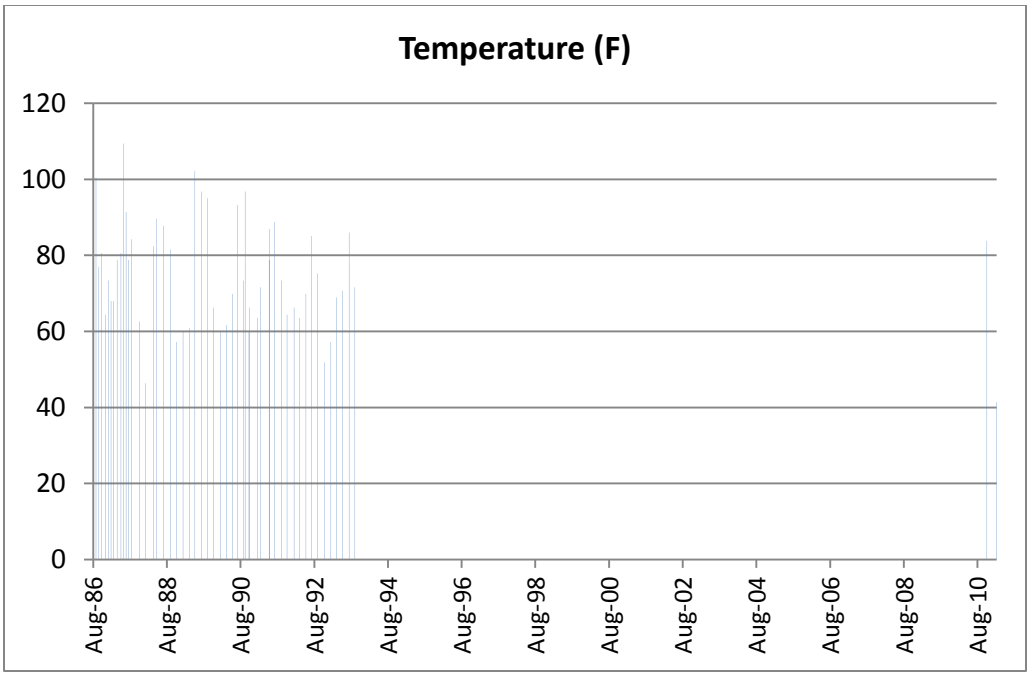

Fig. 5.20 Temperature measured near Cortaro Road

5.7 References

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