# Reclaimed Water Quality – Past and Future

PREPARED FOR: Reclaimed Water Customers

PREPARED AT THE REQUEST OF: TUCSON WATER

PREPARED BY: CH2M HILL

DATE: December 3, 2013

## Background

Tucson Water receives secondary effluent from Pima County, which is then filtered and disinfected to provide Class A reclaimed water to their customers. Pima County is being required by the Arizona Department of Environmental Quality (ADEQ) to upgrade its wastewater treatment facilities. As a result, Pima County is replacing its Roger Road Wastewater Reclamation Facility (WRF), from which Tucson Water Receives 80% of its effluent, with the new Agua Nueva WRF that will nitrify and denitrify the water before delivering effluent to Tucson Water. The Tucson Water reclaimed system will remain a permitted class A water quality system, but the actual reclaimed water deliveries to customers will be approaching a Class A+ water quality with significantly lower total nitrogen and phosphorus concentrations than previously provided. Transition to the new water quality is expected to begin in January 2014, and be completed by May 2014. The intent of this memorandum is to summarize expected water quality changes to the Reclaimed Water System.

## Current Facilities

The Roger Road WRF both discharges effluent to the Santa Cruz River and provides effluent to Tucson Water. Water received by Tucson Water is either pumped to the adjacent recharge basins, for percolation into the ground and future use in the Reclaimed Water System, or pumped to the Reclaimed Water Treatment Plant (RWTP) for filtration and disinfection and immediate delivery to the Reclaimed Water System. A small portion is also delivered directly to the Silverbell Golf Course and the Sweetwater wetlands. After water is recharged to the aquifer through the recharge basins, it is removed by extraction wells, blended with the RWTP finished water, and used in the reclaimed system. Essentially, there are three water sources that provide water directly into the reclaimed distribution system: the RWTP treated effluent blended with extraction well water, extracted water from well EW-007 north of the RWTP, and the Randolph Park WRF effluent. Figure 1 is a schematic of the existing and new facilities.

## Upcoming Changes

Regulatory requirements require that discharge from the county's wastewater facility to the Santa Cruz River be lower in nitrogen. Thus, Pima County is replacing the Roger Road WRF with the newly constructed Agua Nueva WRF.

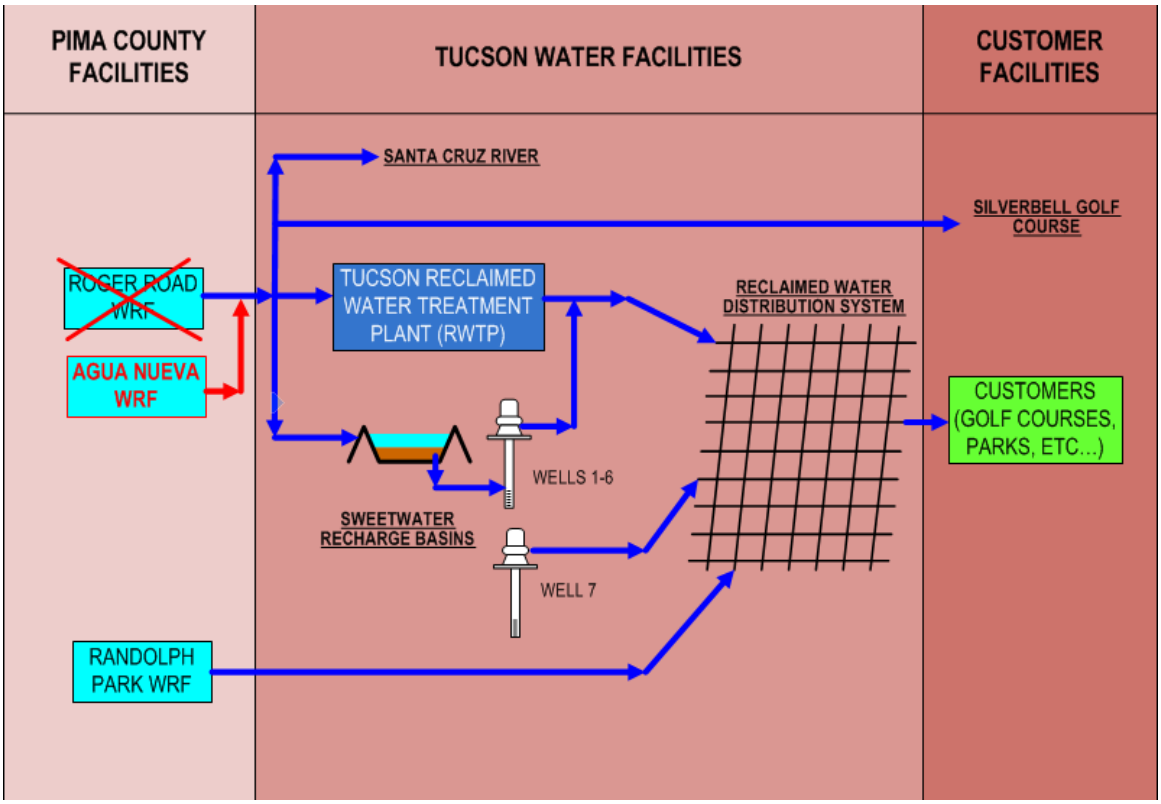



FIGURE 1
Facilities PFD

The new Agua Nueva WRF will reduce the mass of nutrients, both nitrogen and phosphorus, discharged to the Santa Cruz River. The facility is scheduled to come on line in January 2014. This change in effluent source will gradually lower the nutrient concentrations in Tucson Water's reclaimed distribution system.

The concentration of ions that typically impact irrigation practices are not expected to change significantly (e.g. chloride, boron, sodium, calcium, magnesium, total dissolved solids, & SAR). A review of historical and projected water quality is discussed in the following sections.

## Reclaimed System Customer Zones

The results of the water quality analysis for the reclaimed distribution system show similar water quality characteristics in the following customer zones:

- **RWTP (522)** - Christopher Columbus Park, Jacobs Park Golf Course, El Rio Golf Course
- **Thornydale** - Dove Mountain Golf Course, Gallery Golf Course, Heritage Highlands Golf Course, Arthur Pack Desert Golf Course, Oro Valley Golf Courses
- **La Paloma** - La Paloma Golf Course, Skyline Country Club Golf Course, Ventana Canyon Golf Course, Arizona National Golf Course
- **Star Pass** - Starr Pass Golf Course, Greasewood Park

- **Mission Manor** - El Pueblo Park, Rudy Garcia Park, Mission Manor Park, Quince Douglas Park
- **Randolph** – Randolph Park
- **Udall** – Udall Park, Dorado Country Club Golf Course, Forty Niner Golf Course
- **Houghton** - Golf Links Sports Complex, Davis Monthan AFB - Blanchard Golf Course, Rolling Hills Golf Course, Abraham Lincoln Park

These zones are shown in Figure 2.

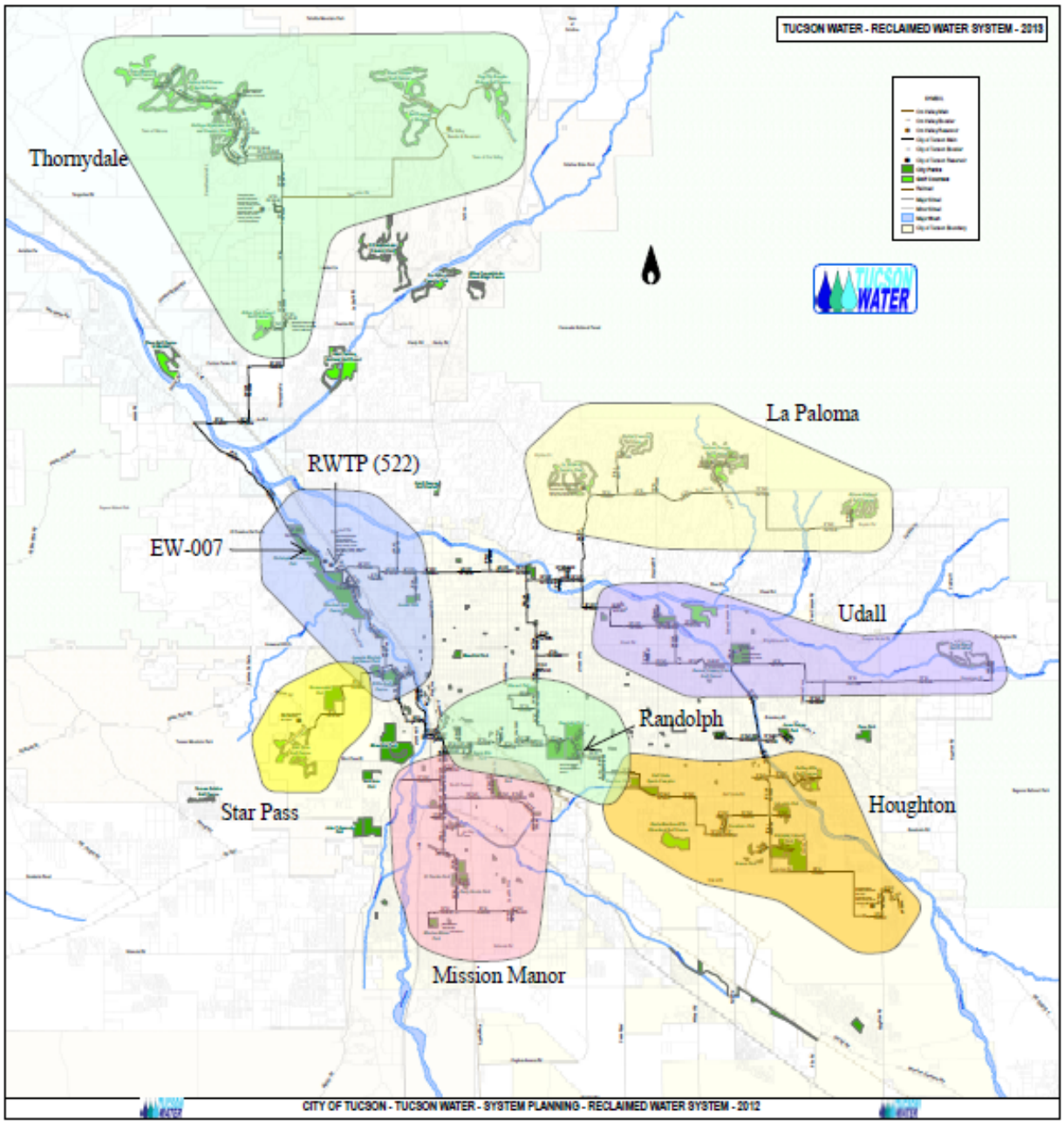



FIGURE 2
Reclaimed System Customer Zones

The customer zones to the north, southwest, and northeast have been primarily fed by the RWTP effluent. This includes the RWTP, Thornydale, La Paloma, Star Pass, and Mission Manor zones. The areas to the east and southeast (Randolph, Udall, and Houghton) are also impacted by the Randolph WRF effluent. Houghton water quality tends to be very similar to water supplied by the Randolph WRF, whereas Udall is influenced by water supplied by both the RWTP and Randolph WRF. Lastly, the Thornydale zone shows significant influence from the contribution of extraction well EW-007 and the RWTP.

Dynamics of the reclaimed water distribution system make predicting future water quality difficult, but changes to the water quality will likely include the following:

- More significant water quality impacts to the distribution zones that have historically been primarily fed by Roger Road WRF (north, southwest, northeast)
- Less significant impact to those areas served by Randolph Park WRF (southeast, east)
- Some adjustment to current fertilization rates may be necessary

In addition, depending on the geographic location in Tucson, the water quality may vary seasonally due to water supply changes in winter and summer. However, it is expected that seasonal variability will decrease from what it has been historically.

## Historical Water Quality

Historical water quality has been analyzed from various locations in the reclaimed system using sampling data starting in 2008 and extending through September 2013. Testing for boron was performed from June 2013 to September 2013 only. System-wide data is provided in Table 1 for chloride, boron, calcium, magnesium, sodium, TDS, conductivity, soil adsorption ratio (SAR), total nitrogen (TN) and total phosphorus (TP). The concentrations represent system-wide statistical concentrations; actual concentrations at specific geographic locations can vary considerably due to spatial variation.

TABLE 1
**System-wide Water Quality**

| Parameter | Number of Samples | Minimum | 1st Percentile | 50th Percentile | 99th Percentile | Maximum |
|---|---|---|---|---|---|---|
| Chloride (mg/L) | 279 | 6.60 | 7.46 | 126.00 | 163.44 | 241.00 |
| Boron (mg/L) | 66 | 0.05 | 0.05 | 0.24 | 0.27 | 0.27 |
| Calcium (mg/L) | 279 | 33.00 | 38.00 | 79.00 | 111.00 | 117.00 |
| Magnesium (mg/L) | 279 | 5.10 | 5.71 | 14.00 | 18.00 | 18.00 |
| Sodium (mg/L) | 279 | 25.00 | 27.56 | 135.00 | 155.22 | 210.00 |

TABLE 1
**System-wide Water Quality**

| Parameter | Number of Samples | Minimum | 1st Percentile | 50th Percentile | 99th Percentile | Maximum |
|---|---|---|---|---|---|---|
| TDS (mg/L) | 213 | 209.00 | 218.72 | 711.00 | 825.40 | 845.00 |
| Conductivity (µS/cm) | 279 | 329.00 | 352.00 | 1160.00 | 1312.44 | 1354.00 |
| SAR | 279 | 1.01 | 1.10 | 3.54 | 4.18 | 6.48 |
| Total Nitrogen (mg/L as N) | 279 | 1.70 | 1.89 | 10.35 | 24.09 | 26.30 |
| Total Phosphate (mg/Las P) | 279 | 0.01 | 0.05 | 1.90 | 4.17 | 4.90 |

[a] Table Notes

Graphs have also been prepared for each customer zone (Attachment A) to present the historical water quality for the following groups of parameters:

- Boron and Chloride
- Calcium, Sodium, and Magnesium
- Soil Adsorption Ration (SAR), Electrical Conductivity (EC), and Total Dissolved Solids (TDS)
- Total Nitrogen (TN) and Total Phosphorus (TP)

The intent of these graphs is to provide information that is relevant to the reclaimed customers. With the exception of total nitrogen and total phosphorus, the concentration of the other water quality parameters listed above is not expected to change significantly with the change in water from Roger Road WRF to Agua Nueva WRF.

## Boron and Chloride

The reclaimed system historical chloride levels have ranged from 100 to 160 mg/L for the zones mostly impacted by the RWTP and 80 to 140 mg/L for Randolph and Houghton. Boron results show a range in concentration of 0.2 to 0.3 mg/L for all areas, although this is based on a limited amount of data collected from June 2013 through September 2013.

## Calcium, Sodium, and Magnesium

Calcium in the reclaimed system ranges from about 75 to 100 mg/L in areas impacted by RWTP and from 40 to 85 mg/L at Randolph and Houghton. Udall is impacted by both sources with a range of 60 mg/L to 85 mg/L.

Sodium ranges from 100 to 150 mg/L in most areas impacted by the RWTP and 80 to 125 mg/l at Randolph and Houghton.

Magnesium ranges from 12 to 16 mg/L in most areas impacted by the RWTP and 5 to 12 mg/l at Randolph and Houghton.

The lower values for these ions near Randolph are likely a result of the water supply for the southeast area of town having a lower percentage of Central Arizona Project (CAP) water and higher percentage of well water.

## SAR, EC and TDS

SAR is used to assess the relative concentrations of sodium, calcium, and magnesium and act as a useful indicator for potential effects on soil structure and permeability. The 50th percentile SAR for the distribution system is 3.5.

Electrical Conductivity (EC) is a measure of the degree in which water conducts electricity and is used to estimate the concentration of TDS in water. The 50th percentile EC for the distribution system is 1.15 dS/M.

SAR and EC are often used in combination to evaluate potential impacts to the soil infiltration rate. The combination of the 50% SAR of 3.5 and the 50% EC of 1.15 dS/M, puts the reclaimed water into a low risk for soil infiltration hazard (see Figure 3).

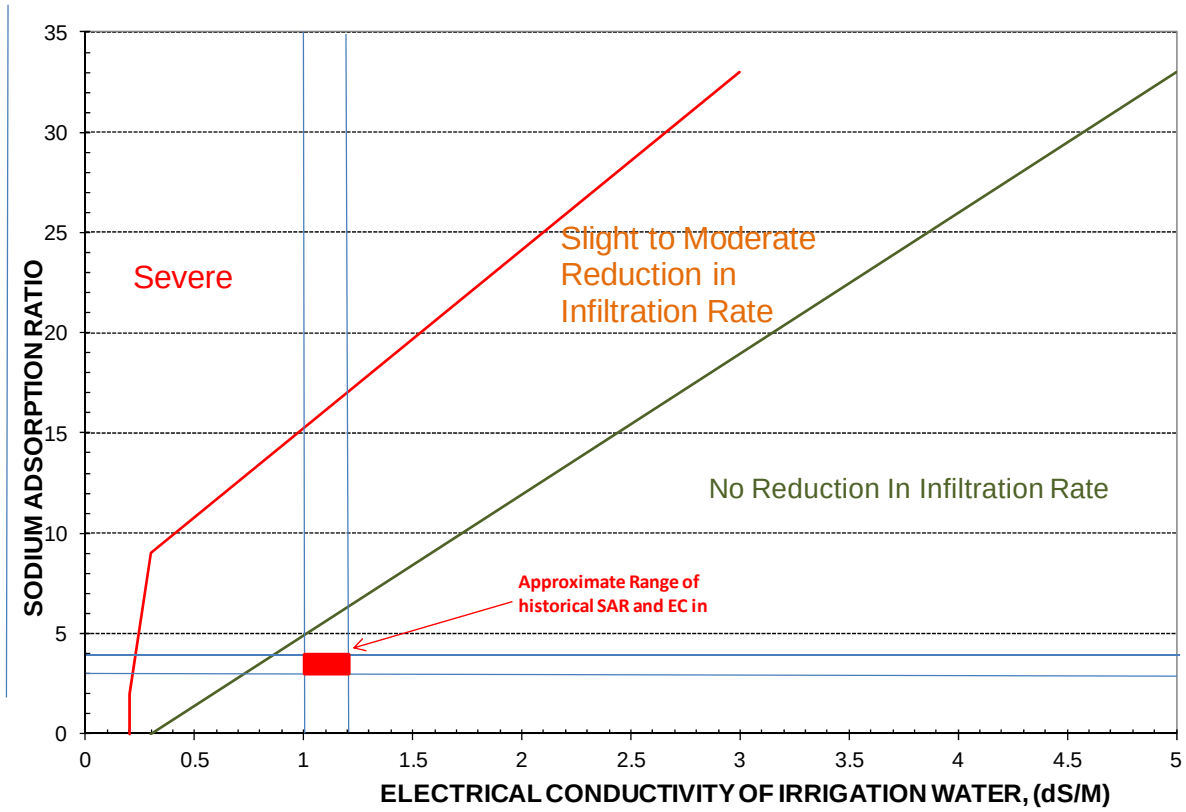



FIGURE 3
SAR vs. EC

## Total Nitrogen and Total Phosphorus (TN and TP)

The nutrient loading of the reclaimed water impacts how much additional nitrogen and phosphorus the customer may need to apply through fertilizer. Historically, the 50th percentile TN for the system has been 10.4 mg/L with 95% of the water samples being less than 20 mg/L. For areas that are mostly fed by RWTP effluent, TN ranges from about 7 to 20

mg/L. TN at the RPWRF and Houghton ranges from about 5 to 12 mg/L. TN in the effluent from the new Agua Nueva WRF is expected to be less than 10 mg/L and therefore more similar to the RPWRF and Houghton areas.

TP has been less than 4 mg/L for the majority of the historical samples (98%). There is no clear variation in phosphorus concentration between locations. TP in the effluent from the new Agua Nueva WRF is expected to be less than 1 mg/L.

Current and future nitrogen and phosphorus loadings are shown in Table 2. These nutrient loadings are estimates based on historical and projected water quality. Actual loadings will vary based on many factors, such as treatment plant performance, contribution amounts from each water source, and water blending.

Table 2 shows an estimated current average nitrogen loading of 3.4 lb N/acre per inch of irrigation water for the RWTP, Star Pass, Thornydale, and La Paloma locations, which are the areas that are most impacted by water quality changes at the RWTP. In the future, this is expected to decrease to about a third of the current amount as a result of the low nitrogen in the effluent at the Agua Nueva WRF. In addition, the average phosphorus at those locations is estimated to decrease by about half from 0.4 to 0.2 lb P/acre per inch of irrigation water.

Nitrogen and phosphorus loadings at Randolph and Houghton are expected to stay about the same since water quality from the Randolph WRF effluent will not change. Udall will likely experience a decrease in these loadings but to a lesser degree than the other areas, as it is fed reclaimed water from both locations (RWTP and Randolph WRF).

TABLE 2
**Current and Future Nitrogen and Phosphorus Loading**

| Location | Average Nitrogen Loading per Inch of Irrigation Water (lb N/acre per inch) | | Average Phosphorus Loading per Inch of Irrigation Water (lb P/acre per inch) | |
|---|---|---|---|---|
| | **Current** | **Future** | **Current** | **Future** |
| RWTP, Star Pass, Thornydale, La Paloma | 3.4 | 1.1 | 0.4 | 0.2 |
| Randolph, Houghton | 1.6 | 1.6 | 0.5 | 0.5 |
| Udall | 2.3 | 1.6 | 0.4 | 0.3 |

[a] Table Notes: For an annual irrigation application of 60 inches, nitrogen loading would be 204 lb N/ac/yr for current and 68 lb N/ac/yr for future conditions (a 136 lb N/ac/yr reduction) on average within the Starr Pass, Thornydale, La Paloma service areas.

## Conclusions

Water quality changes in the reclaimed water will begin to occur gradually from January to April 2014. The new Agua Nueva WRF will produce effluent with lower nitrogen and phosphorus concentrations than what was previously supplied to the RWTP by the Roger Road WRF. Therefore, nutrient loading in the reclaimed system is expected to decrease. Lower nitrogen and phosphorus concentrations may require a change to fertilization rates for users.

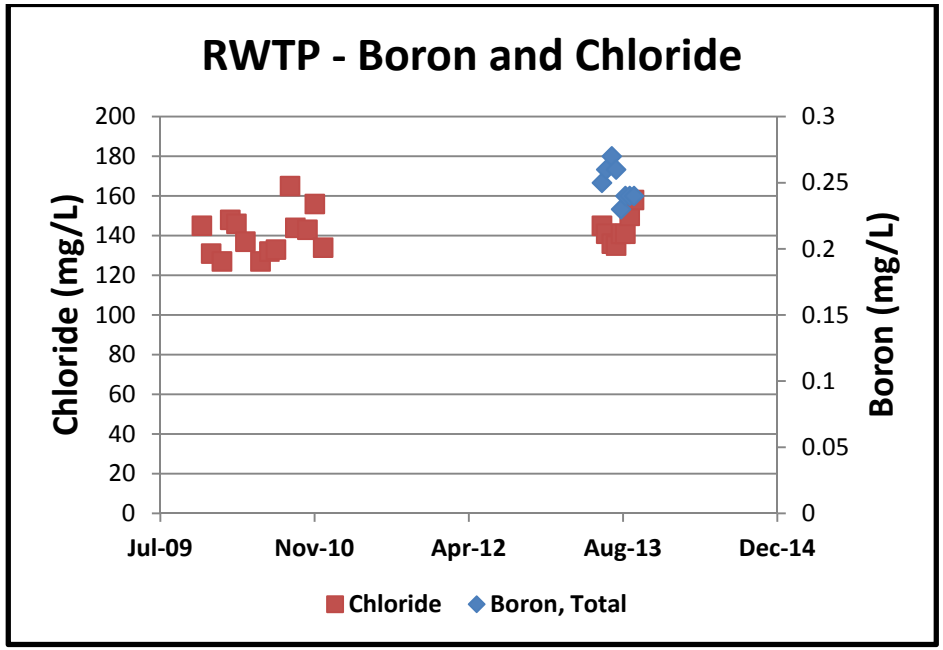
These water quality changes will likely have more of an impact on the distribution zones that have historically been primarily fed by Roger Road WRF (north, southwest, northeast) and less of an impact to those areas served by Randolph Park WRF (southeast, east).

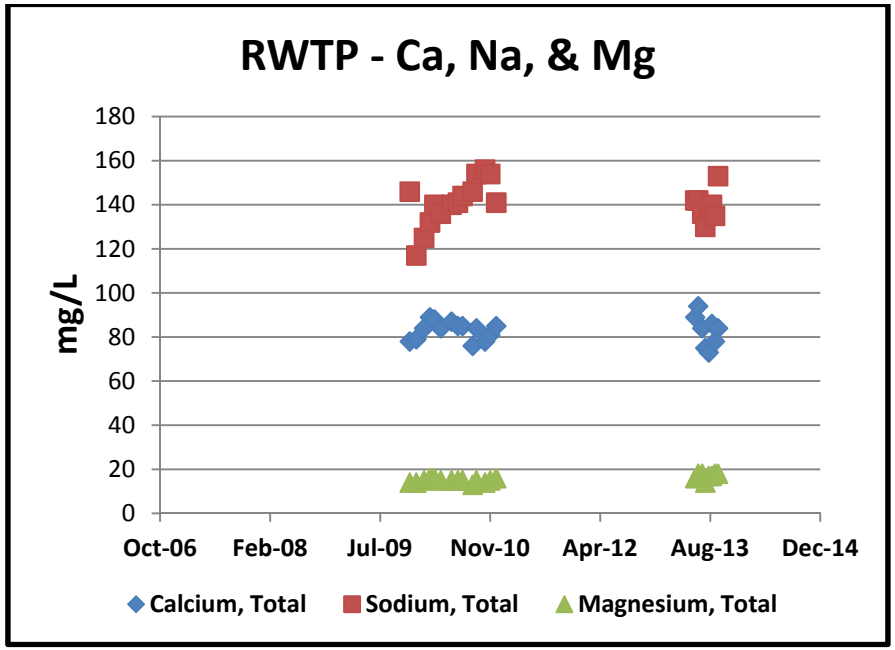
The concentration of ions that typically impact irrigation practices is not expected to change significantly (e.g., chloride, boron, sodium, calcium, magnesium, total dissolved solids, SAR). There are historical differences for these ions when comparing the southeast portion of the reclaimed distribution system (Randolph and Houghton) and the other areas. This most likely is a result of the difference in the water supply for the southeast (less CAP water & more well water).

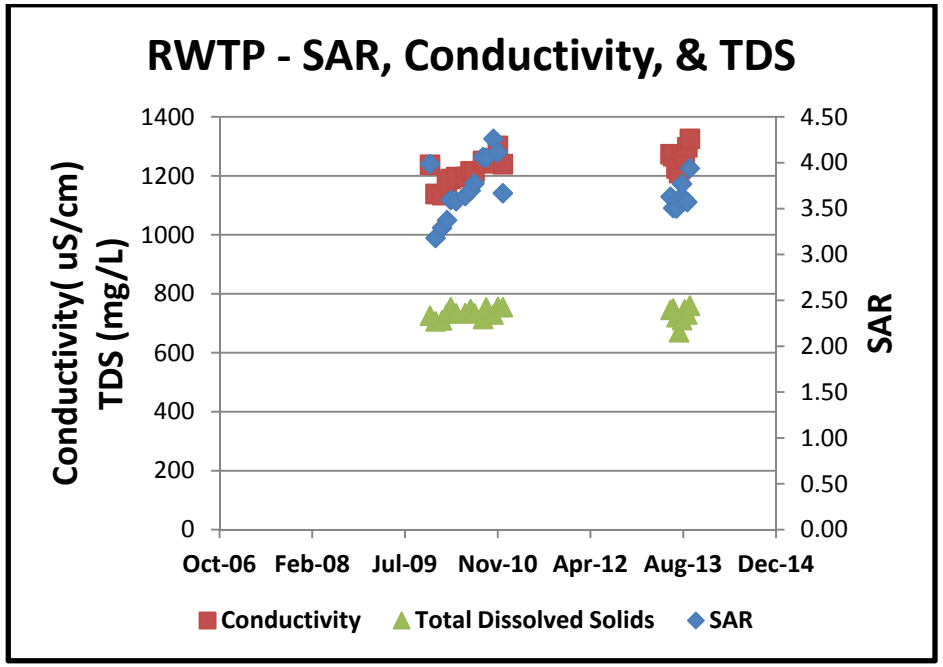
Water in the reclaimed system has historically experienced seasonal variability. This should decrease to some extent in the future resulting in more consistent water quality.

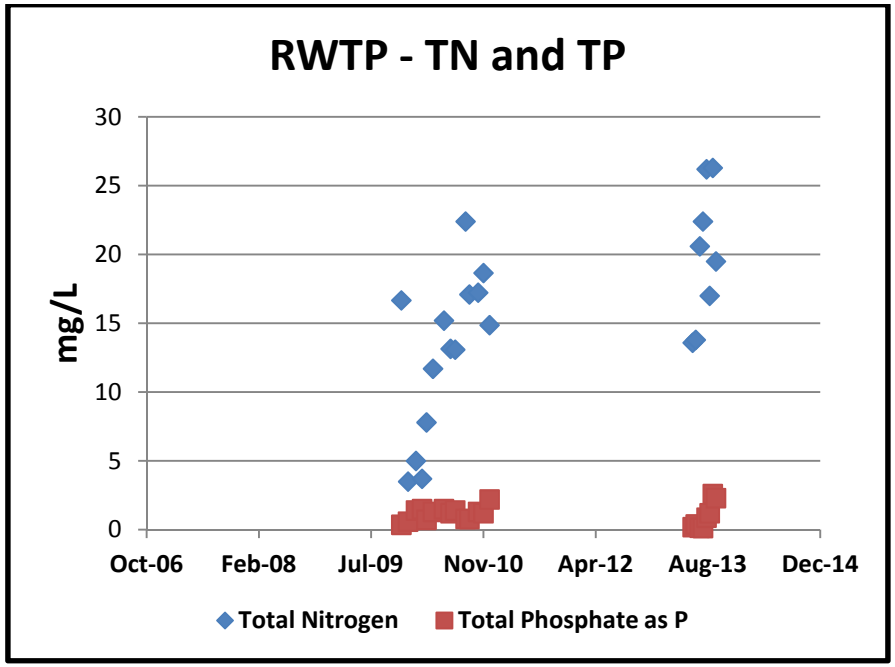
Water quality sampling will continue through July 2014 to assess water quality changes after the new Agua Nueva WRF plant comes on-line. There will be a second meeting with reclaimed users in late summer 2014 to discuss the new water quality data.

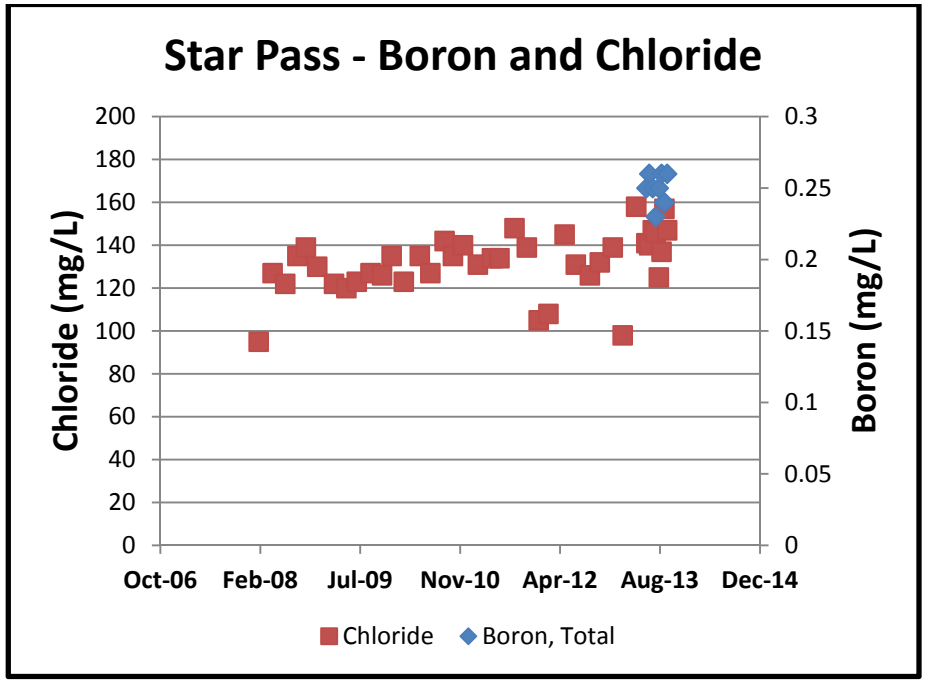
# Attachment A

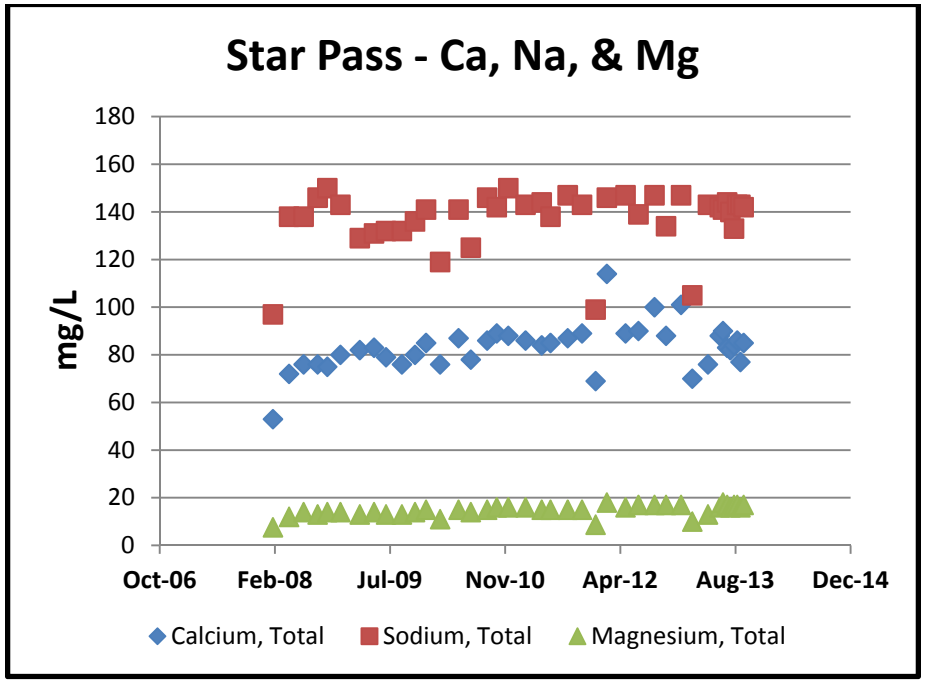

RWTP - Boron and Chloride
Chloride (mg/L)
Boron (mg/L)
200
180
160
140
120
100
80
60
40
20
0
0.3
0.25
0.2
0.15
0.1
0.05
0
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Chloride
Boron, Total

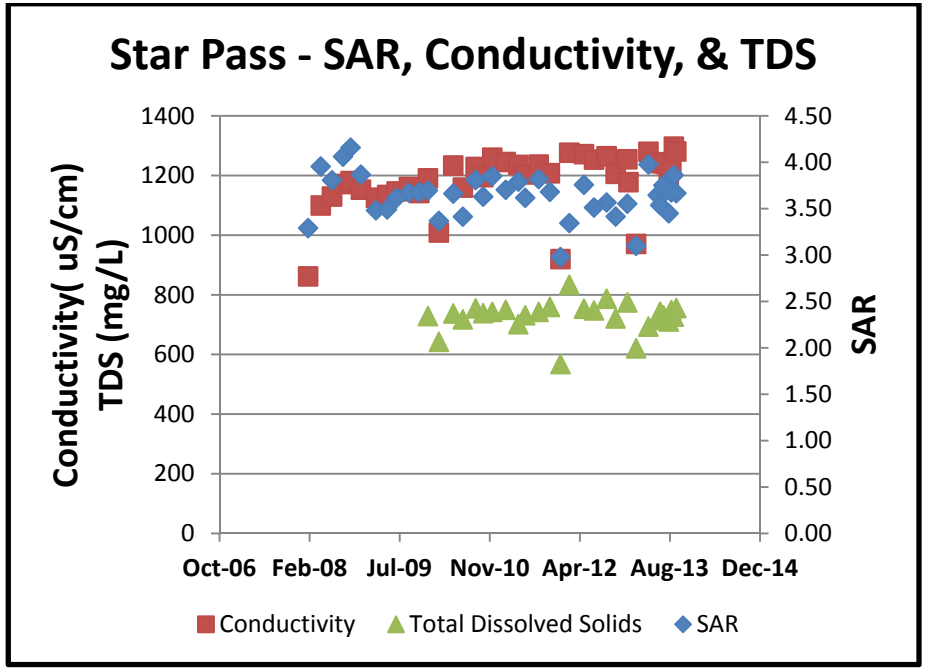

RWTP - Ca, Na, & Mg
mg/L
180
160
140
120
100
80
60
40
20
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Calcium, Total
Sodium, Total
Magnesium, Total

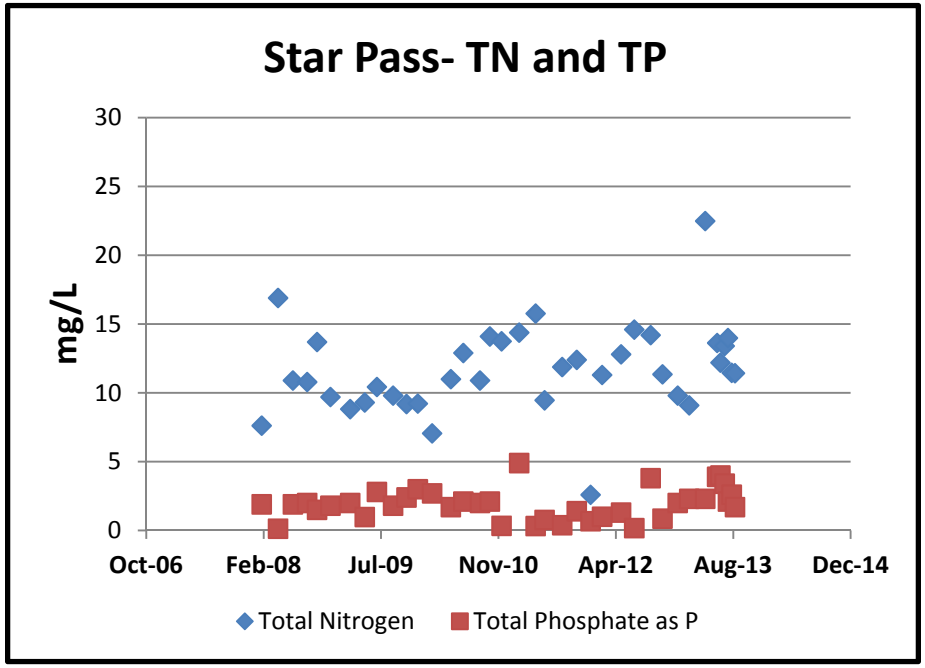

RWTP - SAR, Conductivity, & TDS
Conductivity( uS/cm)
TDS (mg/L)
SAR
1400
1200
1000
800
600
400
200
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Conductivity
Total Dissolved Solids
SAR

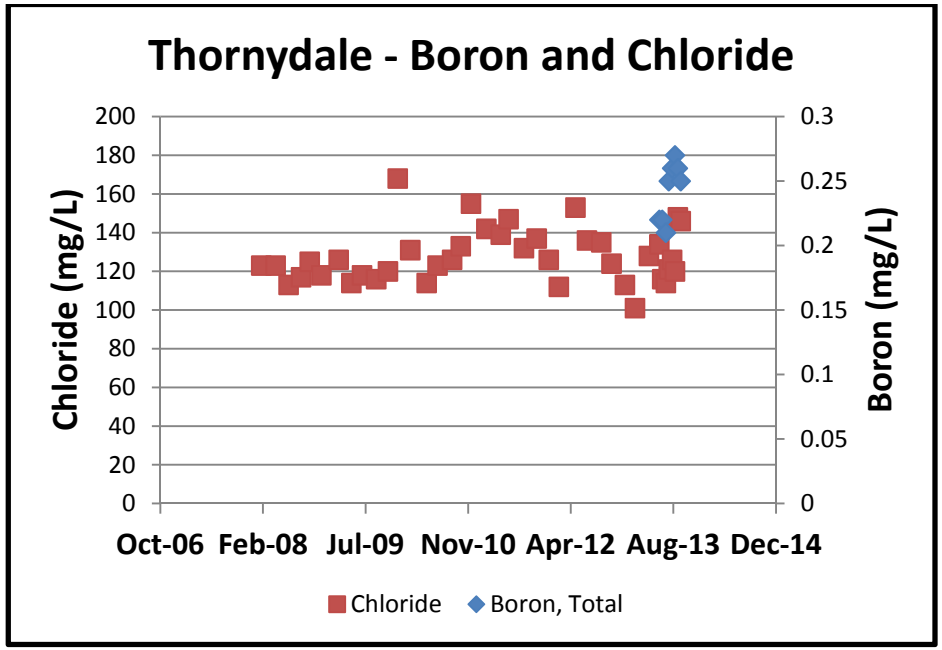

RWTP - TN and TP
mg/L
30
25
20
15
10
5
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Total Nitrogen
Total Phosphate as P

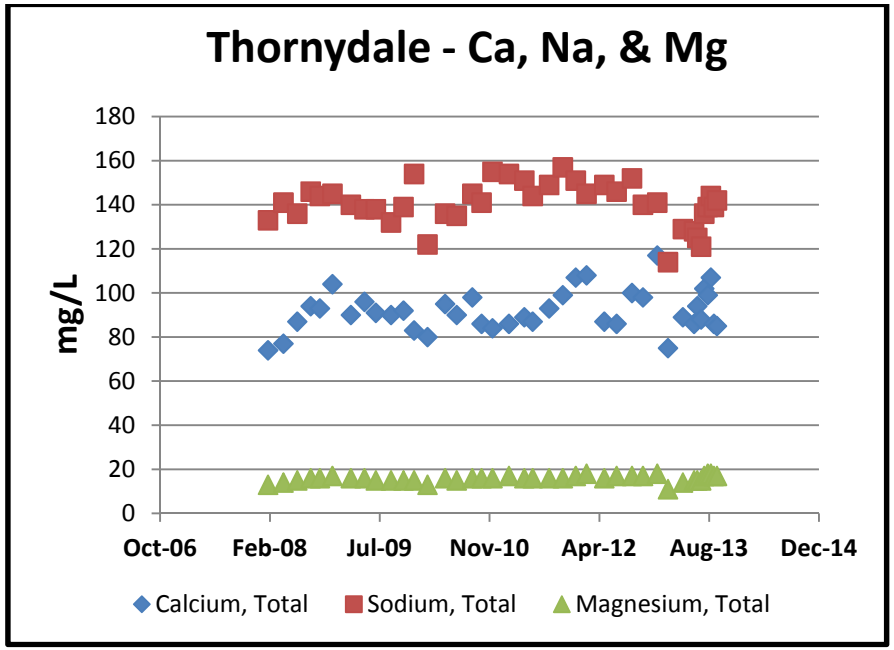

Star Pass - Boron and Chloride
Chloride (mg/L)
Boron (mg/L)
200
180
160
140
120
100
80
60
40
20
0
0.3
0.25
0.2
0.15
0.1
0.05
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Chloride
Boron, Total

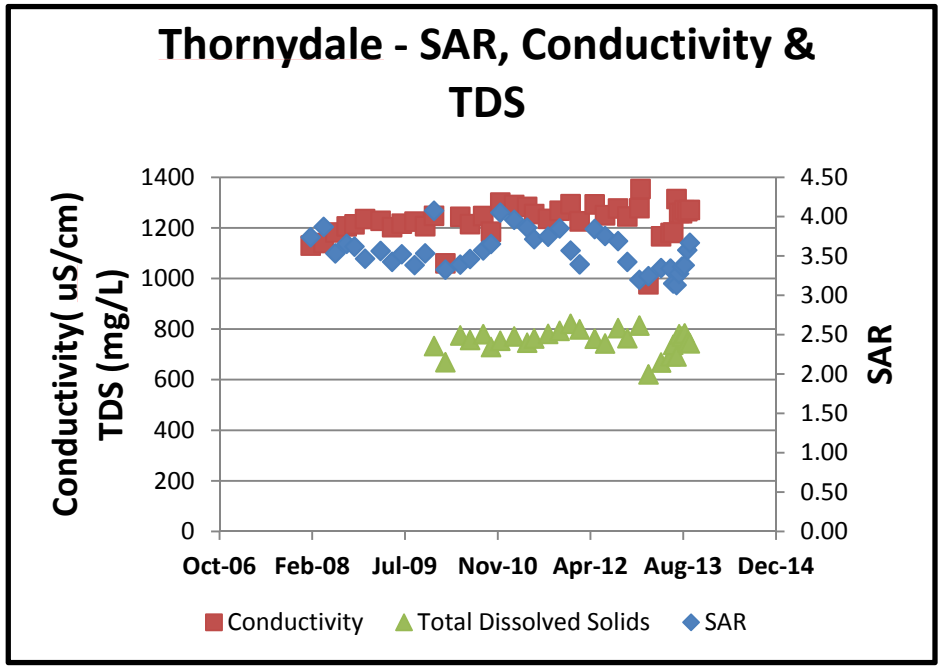

Star Pass - Ca, Na, & Mg
mg/L
180
160
140
120
100
80
60
40
20
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Calcium, Total
Sodium, Total
Magnesium, Total

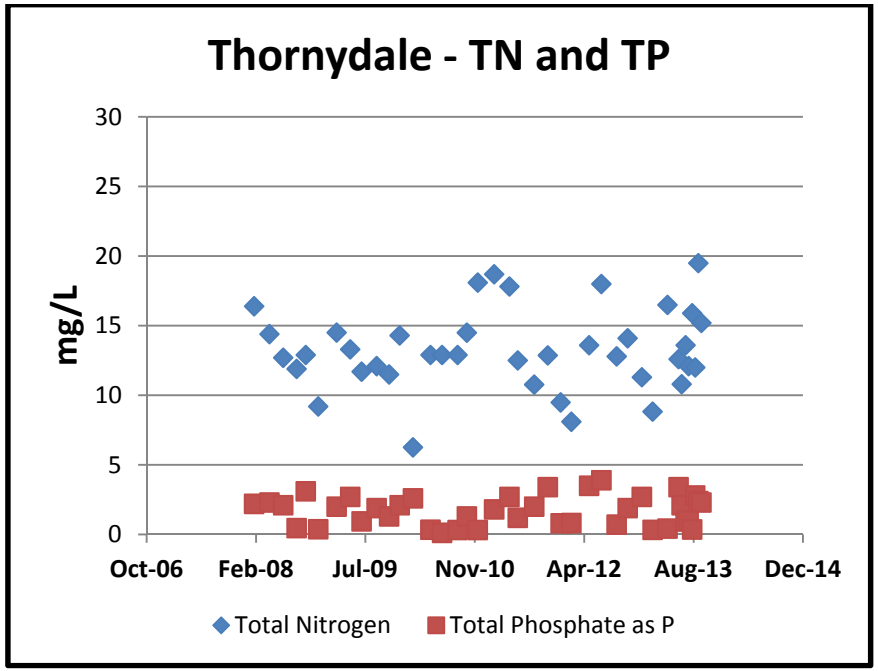

Star Pass - SAR, Conductivity, & TDS
Conductivity( uS/cm)
TDS (mg/L)
SAR
1400
1200
1000
800
600
400
200
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Conductivity
Total Dissolved Solids
SAR

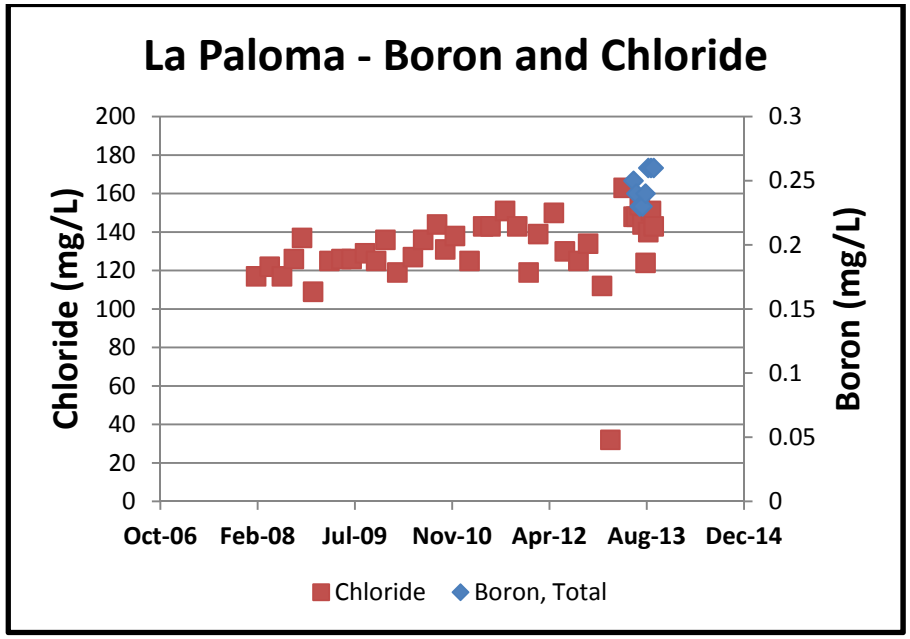

Star Pass- TN and TP
mg/L
30
25
20
15
10
5
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Total Nitrogen
Total Phosphate as P

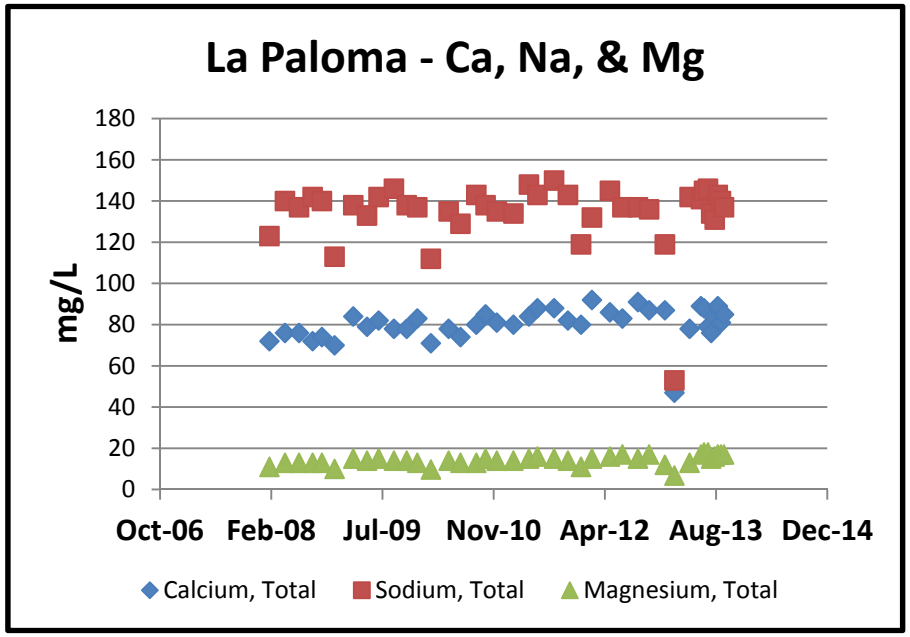

Thornydale - Boron and Chloride
Chloride (mg/L)
Boron (mg/L)
200
180
160
140
120
100
80
60
40
20
0
0.3
0.25
0.2
0.15
0.1
0.05
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Chloride
Boron, Total

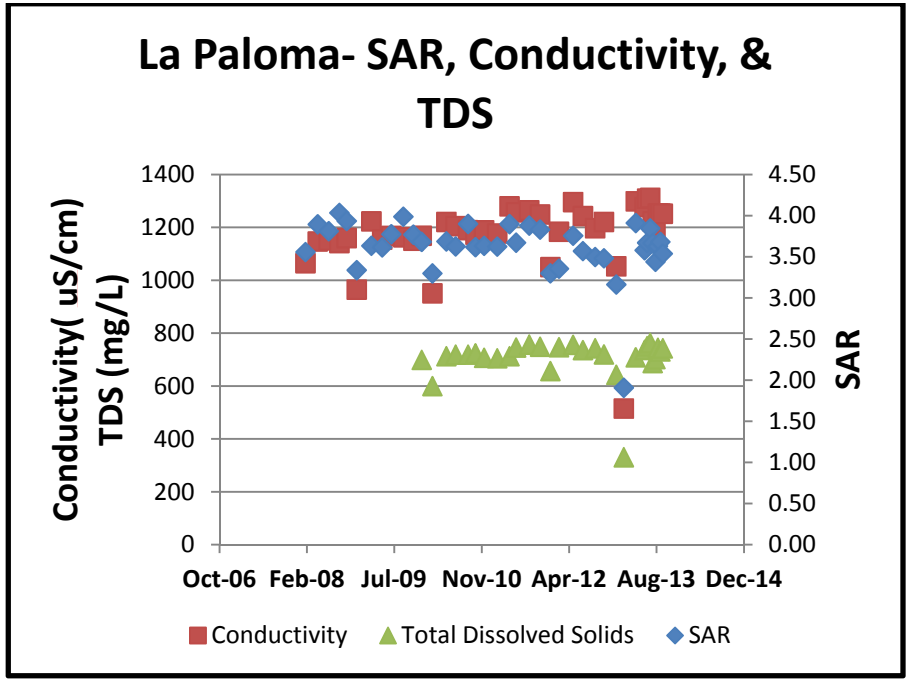

Thornydale - Ca, Na, & Mg
mg/L
180
160
140
120
100
80
60
40
20
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Calcium, Total
Sodium, Total
Magnesium, Total

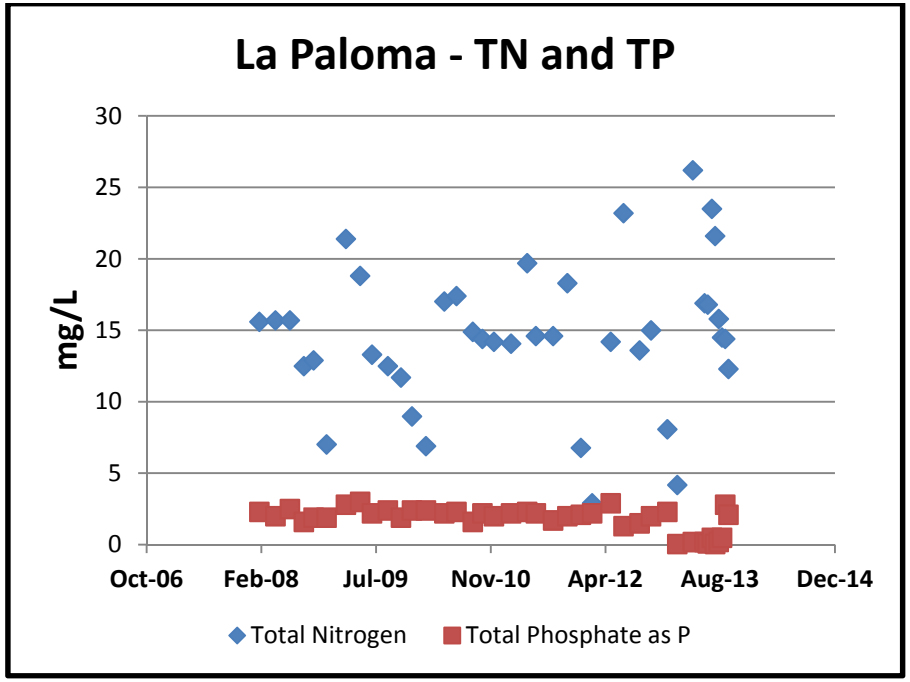

Thornydale - SAR, Conductivity & TDS
Conductivity( uS/cm)
TDS (mg/L)
SAR
1400
1200
1000
800
600
400
200
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Conductivity
Total Dissolved Solids
SAR

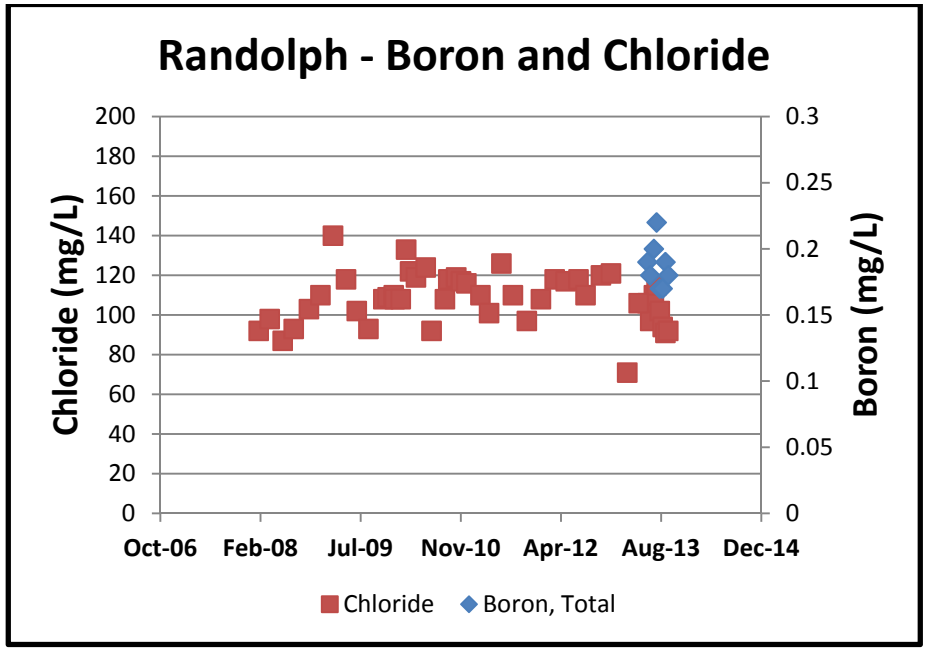

Thornydale - TN and TP
mg/L
30
25
20
15
10
5
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Total Nitrogen
Total Phosphate as P

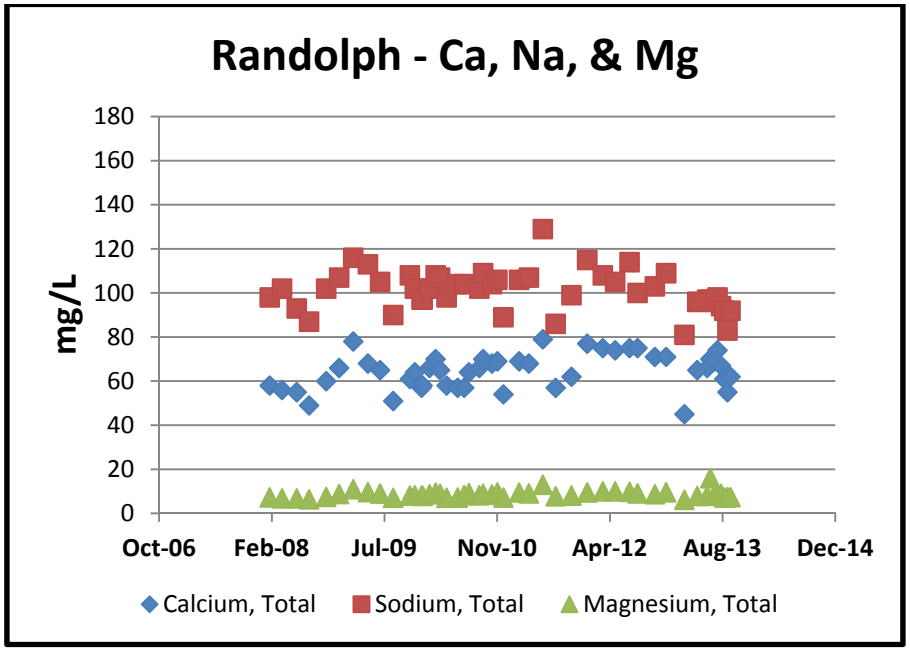

La Paloma - Boron and Chloride
Chloride (mg/L)
Boron (mg/L)
200
180
160
140
120
100
80
60
40
20
0
0.3
0.25
0.2
0.15
0.1
0.05
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Chloride
Boron, Total

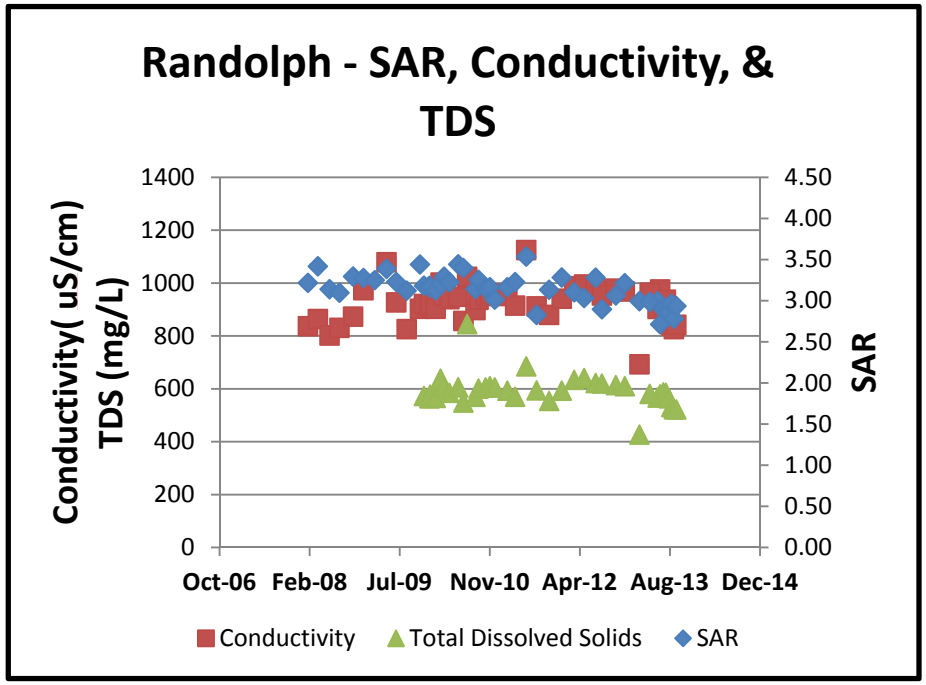

La Paloma - Ca, Na, & Mg
mg/L
180
160
140
120
100
80
60
40
20
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Calcium, Total
Sodium, Total
Magnesium, Total

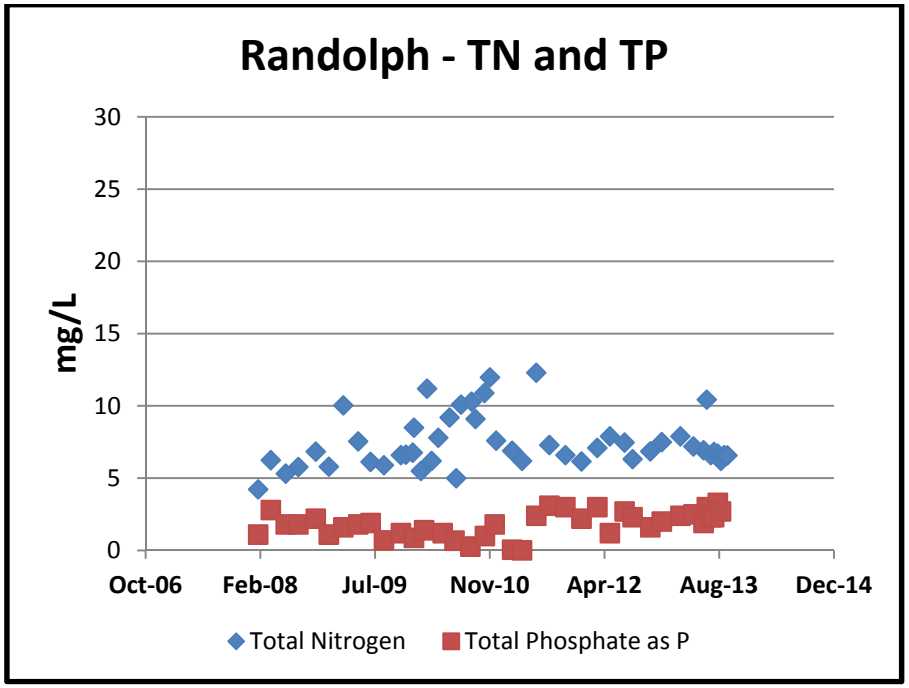

La Paloma- SAR, Conductivity, & TDS
Conductivity( uS/cm)
TDS (mg/L)
SAR
1400
1200
1000
800
600
400
200
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Conductivity
Total Dissolved Solids
SAR

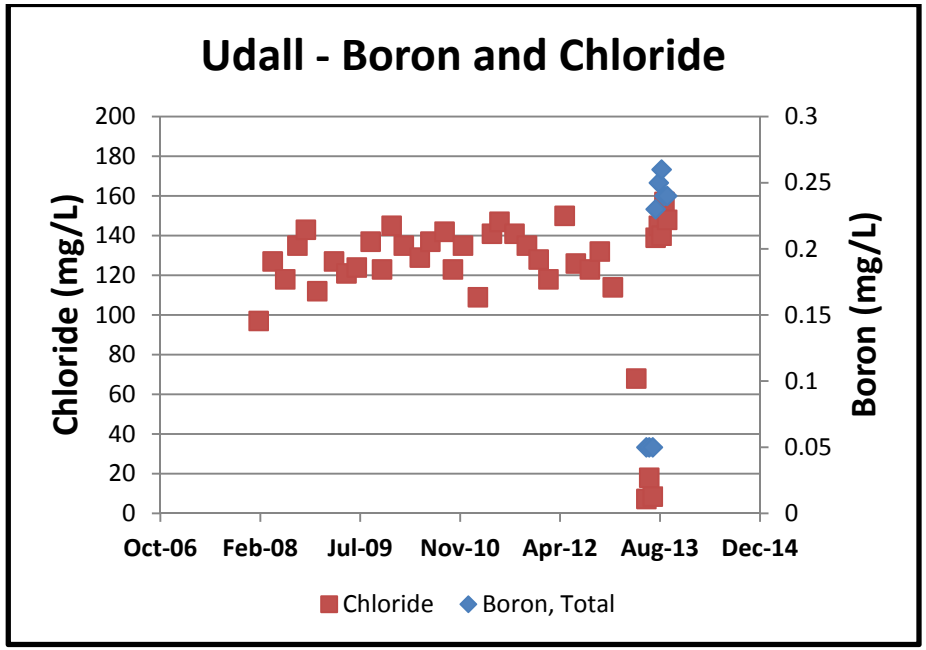

La Paloma - TN and TP
mg/L
30
25
20
15
10
5
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Total Nitrogen
Total Phosphate as P

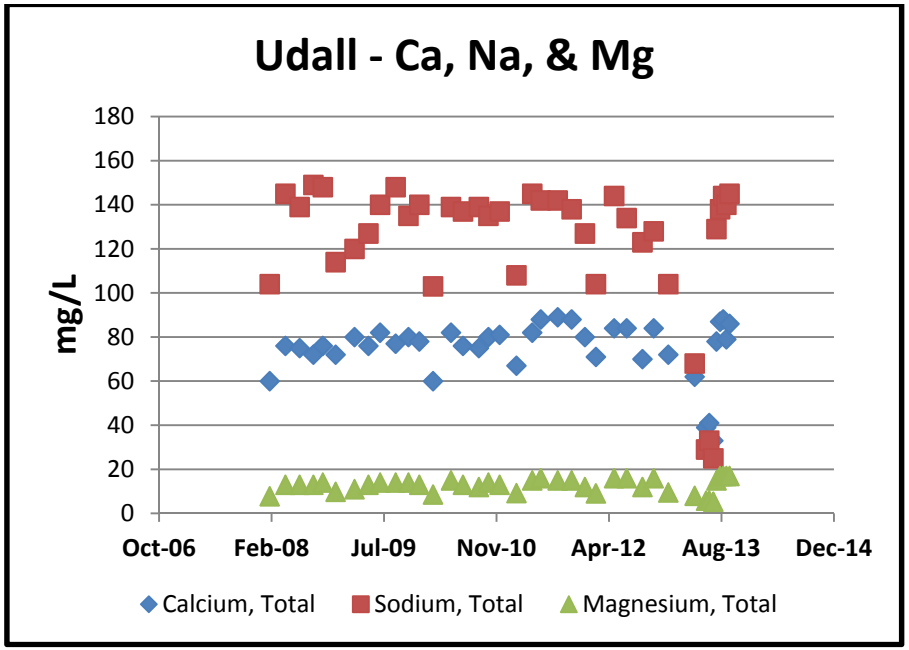

Randolph - Boron and Chloride
Chloride (mg/L)
Boron (mg/L)
200
180
160
140
120
100
80
60
40
20
0
0.3
0.25
0.2
0.15
0.1
0.05
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Chloride
Boron, Total

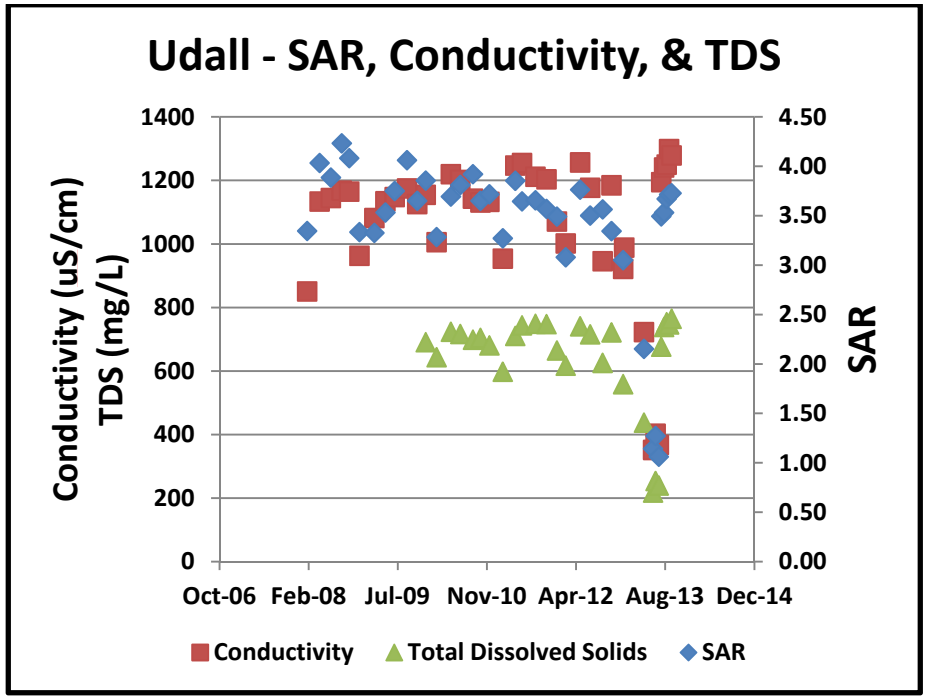

Randolph - Ca, Na, & Mg
mg/L
180
160
140
120
100
80
60
40
20
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Calcium, Total
Sodium, Total
Magnesium, Total

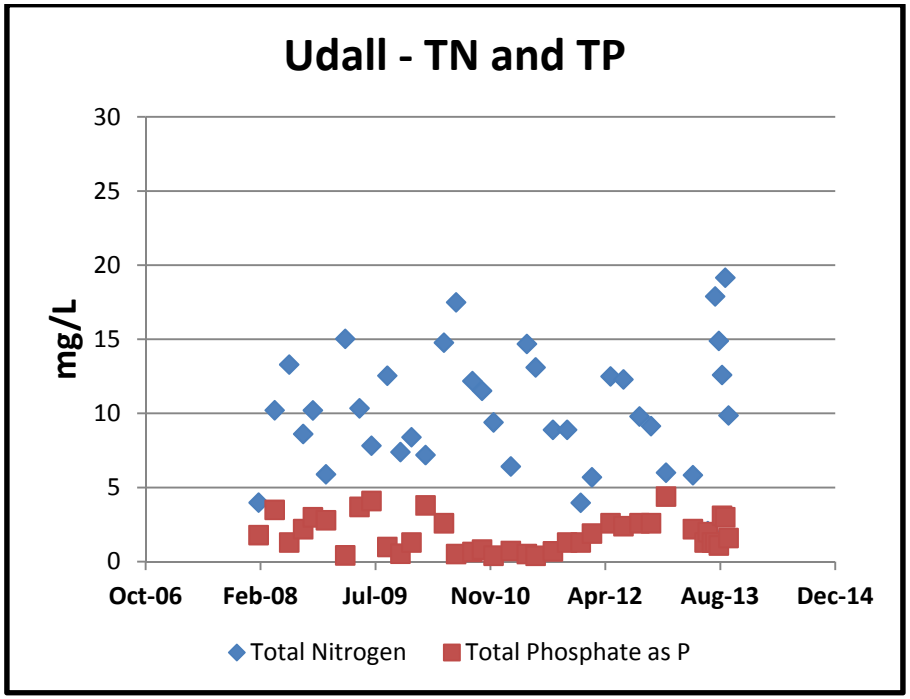

Randolph - SAR, Conductivity, & TDS
Conductivity( uS/cm)
TDS (mg/L)
SAR
1400
1200
1000
800
600
400
200
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Conductivity
Total Dissolved Solids
SAR

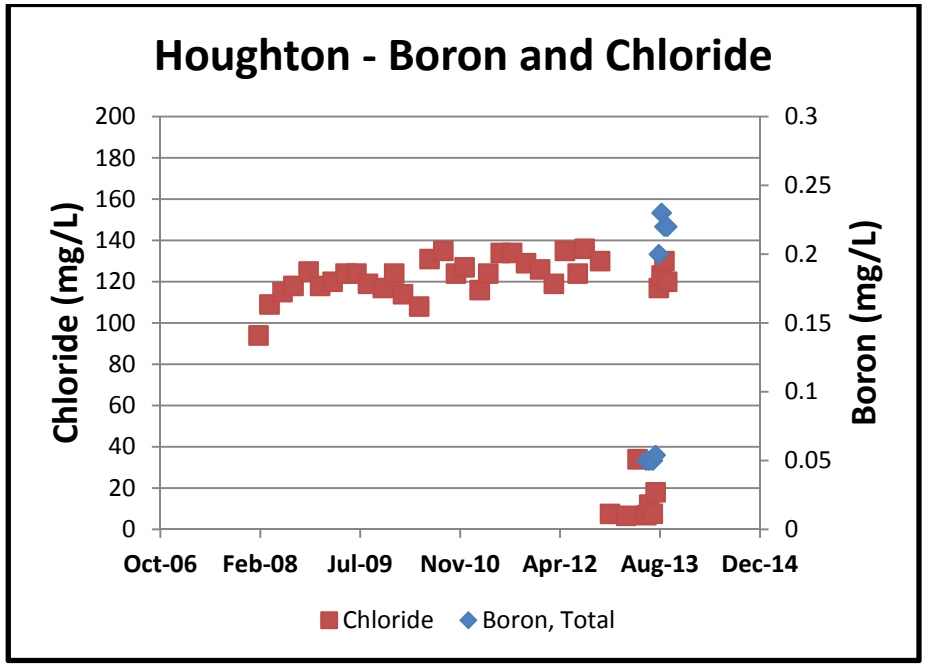

Randolph - TN and TP
mg/L
30
25
20
15
10
5
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Total Nitrogen
Total Phosphate as P

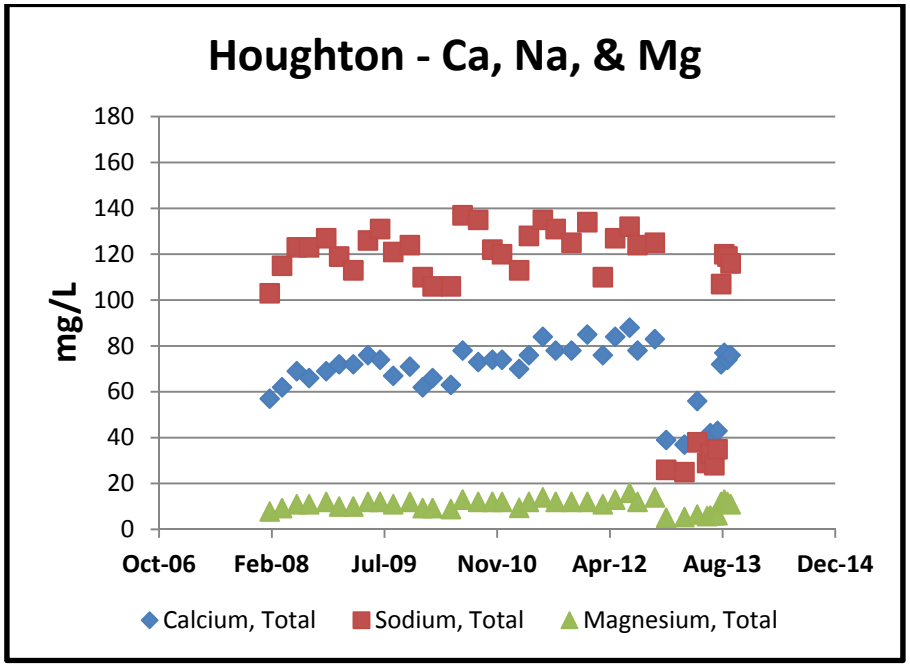

Udall - Boron and Chloride
Chloride (mg/L)
Boron (mg/L)
200
180
160
140
120
100
80
60
40
20
0
0.3
0.25
0.2
0.15
0.1
0.05
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Chloride
Boron, Total

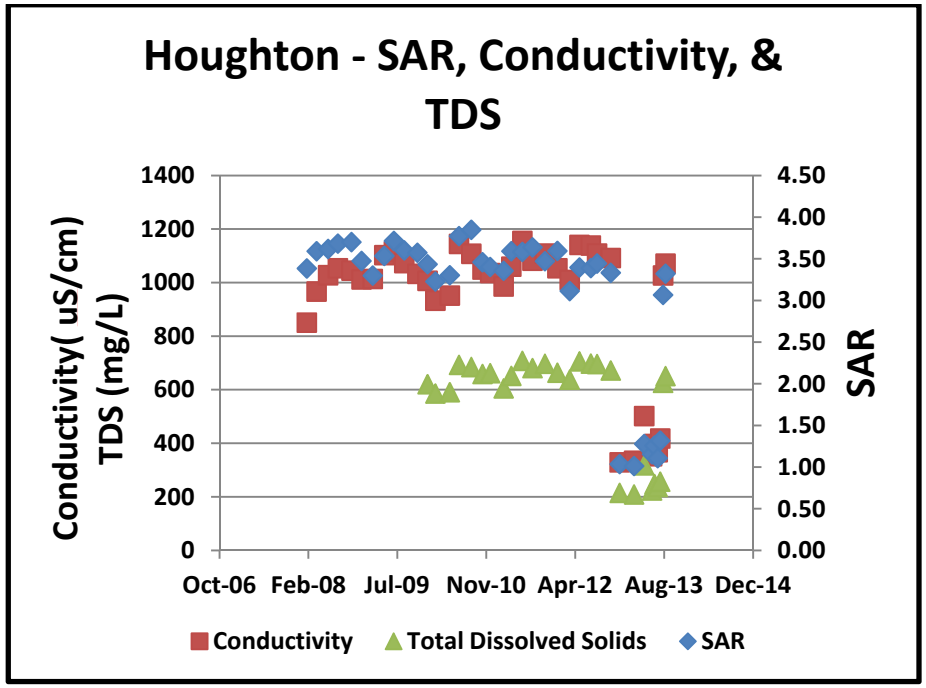

Udall - Ca, Na, & Mg
mg/L
180
160
140
120
100
80
60
40
20
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Calcium, Total
Sodium, Total
Magnesium, Total

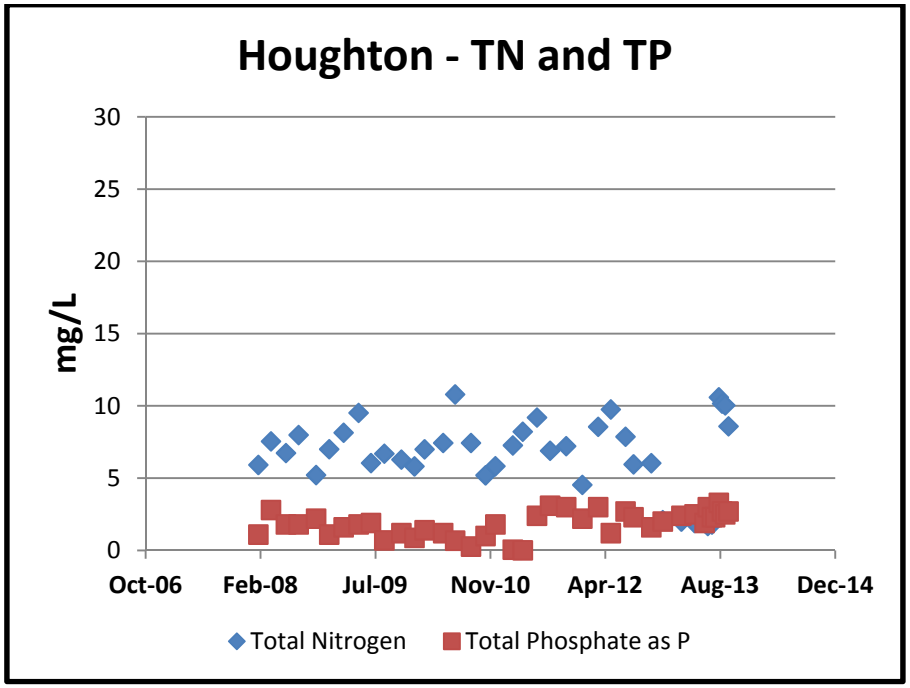

Udall - SAR, Conductivity, & TDS
Conductivity (uS/cm)
TDS (mg/L)
SAR
1400
1200
1000
800
600
400
200
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Conductivity
Total Dissolved Solids
SAR


Udall - TN and TP
mg/L
30
25
20
15
10
5
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Total Nitrogen
Total Phosphate as P


Houghton - Boron and Chloride
Chloride (mg/L)
Boron (mg/L)
200
180
160
140
120
100
80
60
40
20
0
0.3
0.25
0.2
0.15
0.1
0.05
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Chloride
Boron, Total


Houghton - Ca, Na, & Mg
mg/L
180
160
140
120
100
80
60
40
20
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Calcium, Total
Sodium, Total
Magnesium, Total


Houghton - SAR, Conductivity, & TDS
Conductivity( uS/cm)
TDS (mg/L)
SAR
1400
1200
1000
800
600
400
200
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Conductivity
Total Dissolved Solids
SAR


Houghton - TN and TP
mg/L
30
25
20
15
10
5
0
Oct-06
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
Total Nitrogen
Total Phosphate as P