Pointers on reclaimed water contract negotiations

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The increasing urbanization of the arid Southwest has lead to conflicts for water between urban dwellers and other water users. When the conflict for water becomes severe, such as years when drought limits rainfall, irrigated landscapes, parks, and golf courses are the first targets for cutbacks in irrigation water supply. Because water is such an essential and limited resource, research has been directed at methods that allow the water to be recycled or reclaimed. Finding a market for the reclaimed water has resulted in heavy pressure on golf courses to accept reclaimed water if it is available. Although reclaimed water may be a good resource in some areas, reclaimed water typically has a lower quality than the domestic water that a golf course is using. This *PACE Pointers* will provide examples of reclaimed water use in Southern California and some ideas on how to manage the business and agronomic issues surrounding the successful use of reclaimed water on bermudagrass fairways.

In California and other areas in the arid Southwest, irrigation is the primary source of water for up to 8 months of the year. Without this water, the green landscapes of our communities would be barren wastelands or xeriscapes. Although we can keep plants alive using irrigation, it is sometimes difficult to maintain turfgrasses and golf courses in premiere condition due the elements dissolved in the irrigation water also termed “dissolved salts”.

Dissolved salts that are present in the irrigation water will ultimately end up in the soil. And as most of us know, plants can be killed and soils can be destroyed if salts are allowed to accumulate in soil. To prevent accumulation of salts to plant and soil damaging levels, irrigation volumes must be sufficient to move the salts from the surface of the soil to deeper soil profiles. The simple calculation of the percentage of water needed to prevent salt acccumulation over the minimum needed for growth of bermudagrass is approximately 12.5% increase in water volume applied for every increase of 640 ppm total dissolved salts – TDS (or 1 dS/m in water salinity measured as electrical conductivity - EC). In other words, if your current water source has a TDS of 320 ppm and the reclaimed water source has a TDS of 960 ppm (an increase of 640 ppm or 1 dS/m), you will need to use 12.5% more reclaimed water than you currently use to prevent accumulation of salts to turf damaging levels. With this in mind and the cost of reclaimed water frequently being coupled to current domestic water costs with a discount of about 15%, you will only be saving 2.5% of the current cost of water due the need to use more water to prevent salt accumulation in the soil to plant damaging levels. In addition to the added water, more aggressive and expensive soil management practices may be needed to prevent a decline in soil quality that would otherwise result in additional problems years after the reclaimed water was first applied. Expect more wet spots and bare areas when switching to a lower quality irrigation water.

Unfortunately, there are no simple formulas that you can use to determine the outcome of accepting reclaimed water on you course. In most cases, the water will have lower quality than current domestic water sources. This is well known because the reclamation process does not remove all of the elements that are added to the water during its first use by the community. There is typically about a 10% increase in total dissolved salts (Pettygrove, G. S., Asano, T., 1984). In some cases where the golf course is using high quality well waters, the switch to reclaimed water may be dramatic. This is possible if the community surrounding the course uses a relatively high salinity river water source for drinking water. Alternatively, it is possible that reclaimed water will provide a higher quality water source if the current source of water is a low quality well water. Each situation should be evaluated on a case-by-case basis.

Table 1. Relative tolerance of turfgrasses to soil salinity (Harivandi et. al. 1992).

Sensitive < 3 dS/m	Moderately Sensitive 3-6 dS/m	Moderately Tolerant 6-10 dS/m	Tolerant > 10 dS/m
Annual bluegrass	Annual ryegrass	Bent. cv. Seaside	Alkaligrass
Colonial bentgrass	Chewings fescue	Perennial ryegrass	Bermudagrass
Kentucky bluegrass	Creeping bentgrass	Tall fescue	Seashore paspalum
Rough bluegrass	Hard fescue	Buffalograss	St. Augustinegrass
Centipedegrass	Bahiagrass	Zoysiagrass	

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Figure 1. These photographs are from salt affected golf courses using reclaimed water for irrigation. The illustration on the left is from Dove Canyon Country Club where reclaimed water severely damaged bentgrass fairways regardless of management practices. To correct the problem, the turfgrass variety was changed to a more salt tolerant hybrid bermudagrass that now thrives under the same soil conditions. The photograph on the right is from a salt affected fairway at El Niguel Country Club, In this case, the kikuyugrass fairways could not tolerate the high soil salinity levels regardless of management practices. The fairway was converted to a salt tolerant paspalum and it also is now thriving.

Table 2. Comparison between average domestic water quality and reclaimed water quality from sources used at several golf courses in Southern California. Electrical conductivity values (EC) are reported in dS/m. Bicarbonate (HCO3), boron (B), chloride (Cl), and sodium (Na) are reported in parts per million (ppm, mg/l). SAR and SARadj are ratios that are not reported with units of measure. Red shading indicates that the reclaimed water exceeds recommended guidelines (see table 5). Yellow indicates the value is within 10% of the recommended guideline. Green shading indicates that the value falls within recommended guidelines. Note the dramatic differences in reclaimed water quality from different sources.

Factor	Average Domestic	Big Canyon	Dove Canyon	Laguna Hills	Bear Creek	El Niguel	Oakmont
EC (dS/m)	0.8	1.6	1.0	1.2	1.0	1.6	1.1
SAR	1.9	5.3	2.8	3.6	4.6	3.7	3.4
SARadj	3.4	11.2	5.3	6.1	7.5	6.6	6.12
HCO3	173.8	243	134	125	156	134	203
B	0.17	0.52	0.26	0.41	0.62	0.42	0.64
Cl	81.7	244	122	228	158	211	106
Na	70.0	194	112	151	147	168	115

Table 3. Comparison between domestic and well water sources used at several golf courses in Southern California. Electrical conductivity values (EC) are reported in dS/m. Bicarbonate (HCO3), boron (B), chloride (Cl), and sodium (Na) are reported in parts per million (ppm, mg/l). SAR and SARadj are ratios that are not reported with units of measure. Note that in several cases (Fairbanks Ranch, Vista Valley, and San Diego) well water quality is inferior to reclaimed water quality values reported in Table 2. Red shading indicates that the reclaimed water exceeds recommended guidelines (see table 5). Yellow indicates the value is within 10% of the recommended guideline. Green shading indicates that the value falls within recommended guidelines. Note the dramatic differences in reclaimed water quality from different sources.

Factor	Average Domestic	Fairbanks Ranch	Vista Valley	San Diego	Arrowhead	Friendly Hills	Oakmont
EC (dS/m)	0.8	2.8	2.8	4.0	0.5	0.7	0.9
SAR	1.9	3.2	2.8	5.2	0.8	1.2	1.6
SARadj	3.4	8.2	6.7	13.3	1.4	2.4	3.1
HCO3	173.8	366.1	389.5	363.9	189.5	244.1	185.4
B	0.17	0.05	0.21	0.41	0.15	0.13	0.13
Cl	81.7	322.7	609.3	1004.2	9.8	59.6	73.2
Na	70.0	195.0	194.8	406.5	24.6	44.4	65.3

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Table 4. Comparison of water quality parameters. Desired range is a compilation from values published in the scientific literature and experience at PACE Consulting. The average domestic and reclaimed values were compiled from the PACE soil and water database for golf courses. Overall, reclaimed waters are inferior to domestic water for turfgrass irrigation.

Parameter	Desired range	Average Domestic	Average Reclaimed
Electrical Conductivity EC (dS/m)	< 1.2	0.8	1.1
Sodium Absorption Ratio SAR	< 6.0	1.9	3.1
Adjusted SAR	<11	3.4	5.7
Bicarbonate HCO3 (ppm)	<90 (1.5 meq/l)	173.8	194.4
Boron B (ppm)	<0.50	0.17	0.44
Chloride Cl (ppm)	<100 (2.8 meq/l)	81.7	129.6
Sodium Na (ppm)	<160 (7 meq/l)	70.0	114.2
pH	6.5 - 8.4	7.7	7.1
Total Dissolved Salts TDS (ppm)	<768	616.7	729.2
Calcium Ca (ppm)	<100 (5.0 meq/l)	67.3	63.9
Magnesium Mg (ppm)	<40 (3.0 meq/l)	24.4	22.9
Potassium K (ppm)	<160 (4.1 meq/l)	3.9	25.5
Carbonate CO3 (ppm)	<50	2.7	0.0
Sulfate SO4 (ppm)	<200 (4.2 meq/l)	171.3	196.0
Iron Fe (ppm)	<0.30	0.16	0.20
Manganese Mn (ppm)	<0.15	0.01	0.03
Copper Cu (ppm)	<0.05	0.04	0.03
Zinc Zn (ppm)	<2.00	0.12	0.08

Table 5. Maximum reclaimed water quality guidelines – suggested contractual limits for use on sand based bermudagrass fairways. These limits do not insure that the water may be used in a sustainable fashion for turfgrass irrigation. They only prevent the reclaimed water quality from exceeding reasonable guidelines and reduce the hidden costs of using reclaimed water. Reclaimed water with quality factors falling within these guidelines may not provide a high quality golfing experience.

Factor	Average Domestic	Aveage Reclaimed	Recommended Maximum
EC (dS/m)	0.8	1.1	**1.5**
SAR	1.9	3.1	**5.7**
SARadj	3.4	5.7	**11.6**
HCO3	173.8	194.4	**250.0**
B	0.17	0.44	**0.50**
Cl	81.7	129.6	**250.0**
Na	70.0	114.2	**200.0**

Water Management Guidelines:

- Implement a periodic irrigation distribution monitoring program to insure that optimum distribution is maintained at the course (greater than 80% DU).
- Implement a leaching fraction for all areas where the reclaimed water is used to prevent accumulation of salts to turf damaging levels. Increase this value in areas where uniformity is inadequate and salts are accumulating.
- Install a water flow meter on one fairway to enable an accurate leaching fraction calculation to be derived from the weather station ET data and actual water applied to the fairway. This baseline leaching fraction will help determine if the recommended leaching fraction is being applied.
- If negative trends in soil indicators, electrical conductivity, percent extractable sodium, boron or other factors are observed, increased leaching will be needed. These effects may not be observed for several, possibly three to five years, depending upon annual rainfall conditions.
- The water district should provide access to daily, weekly and monthly summary values for water quality indicators. Of particular interest is water electrical conductivity, sodium, chloride and boron levels. Independent water testing may be conducted by the golf courses for more complete periodic evaluations of the reclaimed water.

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Soil Sampling Guidelines:

- Implement an annual aerial photography program to aid in identification of turf "hot-spots" and declining trees. Photographs should be obtained in August when turfgrass stress is at its maximum.
- Initiate an annual soil sampling and laboratory analysis program that entails collecting pairs of samples from 10 fairways that represent good performing turf and poor performing turf as identified in aerial photographs. Parameters to be measured and maintained in a data base include: salinity, pH, organic matter, sulfur, exchangeable Ca-Mg-K-Na, Bray II phosphorous, manganese, zinc, boron, copper, iron and aluminum.
- Monitor soil salinity using a TDS-4 EC meter (or equivalent) in-house using golf course personnel during the growing season and apply leaching irrigation to prevent accumulation of salts to above EC 8 dS/m or when turf stress can be linked to elevated salinity. This will require adjustment of the irrigation system and also use of manually placed sprinklers where needed throughout the course.

Cultural Practices Guidelines:

- Based upon soil testing results, apply amendments to compensate for accumulation of sodium or other elemental deficits that may occur during leaching (possibly potassium leaching). For example, gypsum applications will almost surely be needed to maintain soil sodium at levels below 8% of the total extractable cations.
- Aerate fairways twice annually (after first fall rainfall of 1 inch and in the spring) using a vertidrain to 9 inches. Apply amendments in the fall only in conjunction with aeration.
- Tree foliage may need to be trimmed to prevent contact with the irrigation spray if detrimental effects on the foliage is observed. This will prevent most foliar damage caused by the elevated chlorine content reclaimed water. Some plants may be damaged after use of reclaimed water for several years and accumulation of boron in the soil. These plants should be replaced with boron and salt tolerant varieties. Trends in decline will also be identified using aerial photographs.

If the above management program does not provide effective salinity management for the soil-turfgrass system, it may be necessary to switch fairway turfgrass varieties to more salt tolerant paspalum (5 - 10 years in the future).

Economic Guidelines:

1. Price of water should keyed to current water prices and also water quality factors. Expect a 15 – 25% cost per unit reduction compared to current domestic water sources.
2. Define maximum acceptable water quality limits. If water quality limits are exceeded, the contract may be voided without penalty to the golf course.
3. Delivery guarantees – include access to pump area to allow restarts and guaranteed pump repair times. What happens if the pumps stop working – can you use domestic water and how will it be plumbed for use?
4. Include costs of fairway cultivation and amendment to prevent soil damage from long term use of the reclaimed water.
5. Exclude greens in all discussions for reclaimed water use unless the current source of water is worse than reclaimed water source and higher quality water is not available.
6. Include the costs of monitoring equipment – in-line conductivity monitoring and flow meters.
7. Include the cost of soil testing and management consultation.

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