CENTRAL ARIZONA SALINITY STUDY – PHASE I

Technical Appendix L

Reported Impacts of High Salinity Water on Golf Courses in Central Arizona

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Golf courses are major users of Arizona's water supplies. Each golf course may consume between 400 to 500 or more acre feet of water annually. Issues associated with the use of water supplies that contain high levels of TDS' and other water contaminants constitute a potentially serious challenge to this important industry.

This water use corresponds to the significant component golf comprises to the Arizona lifestyle and tourism that are key to the economic well being of the State. A study conducted by the National Golf Foundation in the late 1990's showed that the golf industry contributed over $1 billion to the state's economy. The Tournament Player's Club in Scottsdale has stated that the annual Phoenix Open PGA golf tournament generates over $65 million alone.

In addition to direct economic benefits, golf courses provide a recreational amenity that is highly sought after in real estate development. Many of the advertising dollars that attract new residents to Arizona target the Arizona lifestyle and the golf component of that lifestyle. Golf provides not only recreation, but also a greenbelt amenity to many of the new residential communities benefiting from the surge of in-migration to Arizona.

This white paper provides a quick review of the historical regulatory trends in the source of golf course water and then describes some challenges that golf course operators have had to accommodate to when they use a water source whether it be well water or effluent that has poor water characteristics.

It is not intended to be a scientific study conducted to document the extent of the problem. Rather it is a first step to highlight some of the select golf courses that are having problems and to discover the nature of the problem for those facilities having problems. If justified, a subsequent investigation could enumerate the generalization of the issues identified herein.

Regulatory Incentives to Use Renewable Supplies

The Groundwater Act of 1980 began a series of steps to regulate the use of groundwater supplies in Active Management Areas within Arizona. It directed the Arizona Department of Water Resources (DWR) to develop Management Period Plans for achieving Safe Yield by the year 2,025. DWR became the front line of establishing regulatory guidelines on the use of groundwater and as major users of groundwater golf course operators were asked to make a significant attempt at increased conservation. At the same time, the growth in population and tourism placed golf courses on the most

wanted list for recreational facilities and the number of golf courses in Central Arizona grew accordingly.

Golf courses in the "older" areas of the metropolitan areas tended to be served by wells and/or by municipal systems that served a combination of their surface water or well-based supplies. In the SRP areas some of the golf courses were indirectly served water from SRP supplies.

DWR was tasked with developing a series of 10-year management plans, with the First Management Period Plan covering roughly the 1980's. By the time the Second Management Period Plan was crafted to provide regulatory guidelines in the 1990's, golf courses were the focus of a major effort to regulate water conservation. The stiff conservation requirements imposed by the Second Management Plan were based in part of scientific research on how much water was required to grow turfgrass in the arid Southwest. It is the belief of some golf course operators that those conservation requirements were below the level of water needed to grow a competitive product. There was an incentive to use 100% renewable supplies because those water sources were not directly regulated by DWR. In addition, there was an incentive to use effluent, in that only 80% of the effluent use counted against conservation limits.

When the Third Management Period Plan was being drafted. DWR and representatives of the golf industry agreed that a regulatory compliance approach was not yielding sufficient savings and a shift in philosophy occurred such that the emphasis was placed on inducing the use of renewable supplies. Effluent counted only as 60% toward conservation limits (a 40 %) reduction. Part of the rationale was an acknowledgement that golf course operators would need to flush the salts from the root zones more frequently.

During the same time period developers made major capital investments in infrastructure to move existing and future golf courses off of groundwater and onto renewable supplies. A leading example of this was the Reclaimed Wastewater Distribution System (RWDS) that was the result of a private-public partnership in north Scottsdale. The RWDS involved a system of reclaiming wastewater from north Scottsdale developments and eventually returning it up to 20 golf courses in the area – a groundwater saving of potentially 10,000 acre feet annually.

Initially the RWDS served CAP water until sufficient effluent supplies were available at the north Scottsdale wastewater treatment facilities. Some golf course operators made slight modifications in their agronomic practices to manage the salt content in this source of water.

Residential and commercial water users add salts to the sewage that flows into the wastewater treatment plants that serves the effluent. The result has been some concentration of salts and other chemicals in the effluent. That combination has proven to be the basis of much of the current challenges facing the golf facilities in the area and forms the basis of some of the analysis that follows herein.

At the same time, some of the urban dispersion has lead to golf courses being developed in areas not served by readily available renewable supplies from effluent or from surface waters. Instead they have been reliant on groundwater, or at least dependent of groundwater until such future time that development occurs is reasonable proximity to provide a source of effluent. Because some of these golf courses are being developed in areas where the groundwater is high in TDS' to begin with, it is also instructive to examine their situation and challenges resulting from the quality of their groundwater.

A further regulatory development has occurred during the approval process for new golf courses within city governments. A number of municipalities are either requiring new golf facilities to irrigate with effluent and/or requiring golf courses to follow the DWR golf course water conservation standards even when Arizona law may not require such.

The net affect is that many if not most golf courses that have been built in the last decade and are likely to be built in metropolitan areas of Central Arizona are targeted to be using supplies of water that are considered renewable supplies or are of a poorer quality because of location.

In order to gain an initial look at the nature of the problems faced by golf courses with operational challenges posed by high salinity water sources, the author of this white paper contacted the Executive Director of Cactus and Pine, the professional organization of golf course superintendents in Arizona. The Executive Director and two past Presidents of Cactus and Pine who are familiar with Arizona golf course operations gave contact names and addresses of 10 golf course facilities that were experiencing some challenges with high salinity water. The golf course superintendents of those facilities were contacted and asked some basic questions about their water source and any problems they were having. Seven responses were received, including one from a Superintendent with oversight responsibility for a total of 7 separate golf facilities himself. Another superintendent oversaw 5 golf courses and a number of other superintendents manage more than 1 golf course.

The initial set of written responses were reviewed and compiled to gain an understanding of the nature of the problem. Several superintendents were recontacted to clarify or expand on their remarks.

Generally, older golf courses that are on well water and municipal systems in the Valley were note included because in the opinion of the golf course superintendents association they did not typify facilities experiencing current problems. Likewise, golf course facilities purely on CAP supplies were not included due to the adaptations that most golf courses have been making to use of that water. Many golf course superintendents consider direct use of the CAP supplies to be one of the better water sources with which they work.

Patterns that emerged from the inquiries serve as the basis for the following discussion. It should be cautioned that these results are not intended to be a scientific sample subject to statistical treatment from which larger generalizations should be made. Nevertheless the

reported information was consistent across facility and across location with regards to the nature of the high salinity water problem and the current treatment programs.

Selected Golf Facilities with Water Quality Problems

To condense the individual discussions into a meaningful presentation the facilities have been grouped into similar types.

North Scottsdale RWDS Facilities. Several golf courses on Scottsdale's RWDS were contacted and provided responses. As a group, these courses are new courses subject to the most stringent DWR water conservation standards. They are also some of the premier golf course facilities internationally and are required to meet the highest standards of play and look. Many were built and served originally with groundwater and/or CAP water, and then have recently been switched to effluent as the primary water source. As noted above, the effluent in large part originates as Scottsdale municipal service water and to a large extent is reused CAP supplies. As a group, these courses may represent the most intriguing problems associated with the current cross-pressures of market demand for goods and services, the requirement to conserve water, the pressure to use renewable supplies, and the challenges associated with specific renewable supplies, especially effluent.

To corroborate the challenges presented by the use of effluent a Tucson facility was also contacted.

Southwest Valley Groundwater. One new golf course facility from the Southwest valley was included because it has been built in an area of high salinity groundwater and has no other water source at the current time than well water. In fact, it was designed with foreknowledge of the poor quality water and is an instructive case study. Similarly another facility in the Southwest Valley was included because it is on high TDS well water. Like the Scottsdale facilities, these golf courses target a high-end market and must meet the expectations of an international clientele.

The North Scottsdale/Tucson Effluent Experience

Golf courses on the RWDS had been using CAP water delivered by Scottsdale through the RWDS pipelines until 1998. Generally the challenges they faced with keeping their facilities in top shape were primarily ones of growing green grass year-round with an absolute minimum of water. Because of the high-end nature of the facilities, these courses overseed in winter with ryegrass and most tend to have bentgrass greens. The base grass is one of a variety of bermudagrass. At the level of the water conservation standards included within the Third Management Period Plan, some portions of browning out of fairways was inevitable and did occur, often in conjunction with mounding and edge effects. However, owners and guests still had the expectation of a lush green carpet.

In September/October of 1998 the RWDS began to supply effluent from the north Scottsdale water campus located at roughly Pima and Union Hills roads. The percentage

of reclaimed effluent supplied through the RWDS system varies greatly throughout the year, with a median split of 70% effluent/30 % CAP water being typical. As capacity at the reclamation plant increases, this figure will increase until effluent becomes the exclusive water source for these facilities.

Generally the golf courses use between 400 and 500 acre feet of irrigation water annually. Because the City of Scottsdale delivers the water, city staff takes regular readings of the chemical constituents in the water.

Problem issues reported from the selected facilities will be outlined and then mitigation steps discussed, but it should be noted that this paper has not attempted to sample the breadth of the problem and it is likely that some facilities are not having problems to the degree reported herein. Please note also that the problems described herein are also reported to some degree according to the subjective experience of the golf course superintendents reporting the problems.

TDS runs between 700 and 1000 ppm. One superintendent felt that TDS readings above 650 slowed grow-in during overseeding. He also felt that at readings near 1,000 ppm the applications of nutrients were less effective. In general, the superintendents who manage golf facilities in central Arizona seem to feel that TDS problems emerge with readings of 1,000 ppm or greater.

While bermudagrass is fairly salt tolerant, the other normal grasses used for either overseeding (ryegrasses) or tees and greens (typically bentgrasses) do less well with high TDS water.

There are reported high readings of sodium/sodium bi-carbonate. At readings near 300 ppm the normal leaching procedures of flushing the salts through the turfgrass and root zone become problematic. Scottsdale WWTP representatives report that the effluent produced at the campus tends to run around 175 ppm Na, with alkalinity usually running less than 150 mg/L.

Nitrates are the biggest concern, especially on the bentgrass greens. If the levels of nitrates being delivered by the RWDS reach 10 ppm or greater serious problems begin to emerge. High nitrate levels cause the growing crown of the bentgrass greens to thicken and cutting the greens to normal playing height leads to scalping the crown; therefore killing the greens. Nitrate levels will vary depending on the treatment protocol employed in the wastewater treatment facilities; a nitrate problem with effluent in one city may not mean a nitrate problem in another city, other things being equal. Scottsdale WWTP representatives state that future expansion plans will address the nitrate issue.

The Tucson experience paralleled that reported for north Scottsdale effluent use. It's TDS readings are about 700 ppm and its sodium bi-carbonates running about 300 ppm. As will be noted again below, Tucson water rates are much higher than corresponding water rates in the Scottsdale courses (about $435/AF versus $250/AF).

Southwest Valley Well Fed Courses – Water Quality

TDS. The two reporting high-end golf facilities from the Southwest Valley are served by well water. In one case the TDS readings range from 1,900 to 3,000 ppm. In the other case the well water has readings close to 4,000 ppm. Generally there are constant challenges, even with bermudagrass, but certainly with any overseeding and with almost all landscape vegetation associated with the courses. As will be discussed below in more detail, diseases of overseeded turfgrasses are a constant challenge due the high TDS.

Nitrates are of somewhat less concern because effluent reuse is not currently the primary water source.

More discussion will follow in the agronomic procedures employed to be discussed below, but these facilities must use a front-end treatment of the water (sulfur burners and gypsum injection) and in fact one facility hauls water for its greens.

Problems Associated with the High Salinity Water

The following problems appear wherever high salinity water is used for turfgrass irrigation.

TDS

High TDS water tends to limit the ability of certain species of turfgrasses to grow and flourish. Salt build-up in the root zone is endemic and must be flushed. Flushing the salts in principle involves applying more water than normal, dissolving the existing salts in the plant's growing zone, and "flushing" those salts further into the earth. In addition to the related problem of creating a soil profile that is conducive to the movement of the salts, the problems that are cited are due to difficulty moving the water through the plant profile in a way that actually flushes the salts. In practice this frequently leaves major areas of turf saturated.

High TDS water stains the facilities that receive any overspray. Given the market demand for aesthetically pleasing facilities, buildings and cartpaths must be cleaned.

High TDS water creates a shorter useful life for sandtraps. It contributes to the "clumping" and unplayability of sand.

Sodium

One particular element of the TDS's that requires specific attention is sodium. High sodium causes the soil to disperse, filling in the small gaps in the material, leading to a somewhat impermeable layer and poor infiltration for water.

Nitrates

High nitrate levels cause the growing crown of the bentgrass greens to thicken and cutting the greens to normal playing height leads to scalping the crown; therefore killing the greens.

Sulfur

While this chemical is used as a treatment for high TDS problems and to balance water pH, the unintended consequence of its use is a deterioration of certain types of manufactured sand used in bunkers.

Protozoa

The RWDS water now that it is largely effluent has nutrients that feed protozoa and golf course irrigation systems once infected with protozoa can develop severe problems and even shutdowns during the Spring. These living organisms grow and thrive in the effluent and literally clog the mainlines, though this problem can be pretty common in any Arizona surface water source due the presence of organic carbon and nutrients not typically found in groundwater.

Algae, snails, and fresh water clams

Effluent and/or CAP water seems susceptible to additional organisms that must be controlled for effective irrigation to occur, though again this may be common in other surface water sources.

Agronomic practices, chemical additives and other treatments

Regardless of the location, the treatment regimens for specific challenges are similar and have a similar function – to help move the irrigation water through the turfgrass plant profile and generally to improve the drainage characteristics of the facilities.

Sulfur burners or sulfur injection systems tend to be used to place concentration of sulfur into high TDS water to lower the salt content. Sulfur is added to the water supply to counteract the negative affects of the TDS/Sodium. When combined with the local soils, the sulfur facilitates the formation of calcium carbonate (gypsum) and reduce the sodium levels in the soil, helping the water move through the turfgrass profile.

Gypsum is added either by injection into the water supply or as an additive through surface dispersion. (This treatment is also used for the specific TDS, sodium, discussed below)

Wetting agents are used to help push the water through the grass plant profile.

Leaching the soil by flushing the salts out with more water is a standard practice. Most facilities now do it every two weeks, which means a much higher water use.

Almost all facilities have to engage in much higher and intense levels of aerification to break-up the topsoil and enhance the infiltration of the irrigation water in order to try to get the salts to flush through the root zone.

Major capital investments have been made to re-profile the turfgrass growing region of the soil to enhance its percolation. Generally this is done by adding a major of layer of sand to the fairways (around 3 inches). In addition, each year the facilities that are facing the drainage challenges are adding a layer of sand in the topdressing cycle wherein added soil constituents are added to the turfgrass.

In addition, due to the tendency of areas of play to become and stay wet, whole sections of golf courses have had to be redesigned and modified to increase drainage.

A potentially economic side affect of this wetness is that some facilities have to limit the ability of golfers to drive their golfcars on the fairways. This may be seen as a negative on the premier golf experience those golfers expect and will have some economic or intangible impacts on the facility and its owners or members who has designed and promised a different golfing experience.

Special fertilizer devoid of nitrates has to be used when the effluent nitrates are elevated.

Chlorine is added to wet wells to control snails, fresh water clams, midges, and protozoa.

Aggressive treatments with an oxygenating compound (potassium permanganate) kill the protozoa. However, during the crisis period when irrigation lines are shut down, huge numbers of man-hours entailing a significant labor expense must be employed to manually water the shut-down sections of the golf courses.

Fish species are added to golf course lakes to control algae and to increase the impermeability of the lake bottom and to mitigate water loss to the aquifer.

These problems may exist whether the water source is effluent, surface water, or groundwater, depending on the facility and the specifics of the water source itself.

Cost Impacts of High Salinity Water

It should be emphasized that not all golf facilities will experience each and every cost factor because not all of the problems occur at each facility. Indeed, this paper has made no attempt whatsoever to address the breadth or generalizability of the problems to other facilities. However, when a problem arises, a facility will likely be faced with similar costs. What follows are general guidelines; however, the actual costs will vary from facility to facility depending on its unique characteristics.

Labor

Each of the following factors tends to increase annual labor costs. This has proven to be a difficult factor to break out as a separate item.

Compared to previous decades of golf course operation, recent changes in regulatory oversight and compliance has led to greater levels of golf course superintendent concern. The educational process associated with understanding the nature of the new problems and learning new procedures to deal with high salinity water adds additional costs from a human resource perspective.

Monitoring and Testing

High salinity water supplies require a higher care in terms of awareness of the chemical constituents in the water supply. While most municipal water providers conduct regular tests, even golf course facilities on municipal supplies will do at least monthly monitoring. For facilities that do not have other agencies test their water supply, the testing of the water can generate regular water testing costs.

Chemicals

Wetting agents have typical annual costs for chemicals run around $15,000 per 18-hole facility.

Sulfur, gypsum, and other chemicals used to lower salt levels in irrigation water cost about $61,000 annually for an 18-hole facility. An unintended side effect of the sulfur usage is a shortened useful life of golf course bunker sand and irrigation infrastructure. These consequences are noted below.

General pesticides cost around $16,000 per year to deal with the variety of infestations and build-ups that occur in the poorer quality water. Protozoa infestations can cost around $4,000 per event in both materials and labor. The additional labor costs to manually water during a shut down due to the infestation can be very expensive.

Additional Agronomic Practices

Increasing the movement of water through the root zone to help flush out the salts requires additional treatments using heavy equipment. Aerification and verticutting can remove Thatch build-up. Under high salinity water conditions these agronomic practices have to be done on a more frequent basis.

For facilities that buy or lease their own aerification equipment, the capital costs can be in the range of $100,000 over 5 years. The costs related to aerification alleviation of high salinity problems include $5,000 to $10,000 each year for employee labor just to run the aerification equipment. Every 3 or 4 years the fairways require an additional deep aerification with an outside contractor costing about $8,000 per year (rotate around 4 fairways per year).

Additional Water

The cost of additional water to flushing salts from the turfgrass constitutes a considerable expense. Most facilities on effluent probably use as much of their 40% overage allowance as they can, or an additional 200 acre feet annually to flush the salts. At Tucson pricing this could add about $87,000 a year to operational costs and at RWDS pricing this would add about $50,000 in operational costs. Even those not on effluent but with high TDS content must flush as much as possible and may encounter similar expense.

Increased Operations and Maintenance Expenses

Sulfur burners to treat high TDS/sodium laden water cost about $25,000 to install and about $15,000 annually to run.

Top dressing the golf courses annually with sand to increase drainage characteristics of the soil costs about $12,000 per year for each 18-hole facility, with an additional labor component of approximately $3,000 per year.

Annual resodding to replace turfgrass that is irretrievably damaged by salts costs about $8,000/year.

Cleaning out wet wells and lakes costs about $10,000/year.

Capital Replacement

Replacing a bentgrass green can cost around $56,000.

Laying down 3 inches of bedding sand on a golf course to increase the percolation of water through the soil profile can cost from $150,000 to $300,000 per 18-hole facility.

Some facilities will have to redesign and reconstruct portions of their courses to increase drainage from areas that are tending to stay wet due to the salinity problems.

Premature wearing out of the irrigation infrastructure due to the use of sulfuric acid treatments costs about $5,000/year.

One fairly severe side affect of this is that in addition to the normal earlier replacement of sandtraps due to the TDS, the sulfur actually causes an even more severe clumping. Whereas typically the national standard useful life of sandtrap sand is near 5 years, with the addition of a sulfur treated water supply, the useful life of bunker sand is cut to 2 years, or by 50%.

Fish species costs run about $2,000.

Design

Facilities designed for high salinity water use can find additional design and construction costs running about $1,000,000 to provide sufficient additional drainage.

Lost Revenues/Downtime/Aesthetics

Modifying golfers choices due to operational practices to counter-act effects of high TDS water supply include keeping golf cars on cartpaths which results in lengthened rounds of golf and lower revenues as well as lowered golfer enjoyment.

Employee Safety and Health

Many of the chemicals used to treat high salinity water are regulated and can only be applied by a licensed operator. Nevertheless, there is a constant concern that given how labor intensive the operational side of the golf business is employees are constantly working in close proximity to harmful substances. Many employees may not be English language proficient, which also places a burden on golf course operators to make sure warnings are communicated effectively.

Suggestions for the Future

Among golf course superintendents there is some recognition that with current turfgrass species the industry is about at the limit of water conservation that can be accomplished. Any further tightening of conservation standards would drastically alter the product offered, e.g., it is likely that overseeding could not be done with less water. In addition, the primary remedy for the problems associated with high salinity water sources involves the application of greater amounts of water to flush the salts out of the root zone.

The reporting golf course superintendents would argue that any increase in salt content of golf course irrigation water would have a corresponding negative impact on this important component of the Arizona economy. At this point the full impact of the current problem and any future increase in salts is unknown. Further research will be needed to see the generalizability of the current findings across a broader cross-section of golf courses and to predict the generalized economic impact.

Some reporting golf course superintendents would argue for changing the wastewater reuse regulations in the state to be more conducive to the end user, i.e., lowering the permissible TDS and nitrate output from wastewater treatment plants. This debate would have to be joined by regulators and regulated entities.

An even tougher but perhaps better solution would be to find ways to reduce the sodium chloride use in homes.