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# Golf Course Irrigation Using Recycled Water in Reno-Sparks, Nevada: Implementation and Compliance Guide

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## Introduction

Water scarcity remains a persistent challenge in arid regions such as Nevada, where limited precipitation, recurring drought and increasing water demand place pressure on available freshwater resources. The Reno-Sparks metropolitan area has experienced steady population growth in recent years, largely driven by high-tech and advanced manufacturing industries. In this high-desert environment, where water resources are finite, this growth further emphasizes the need for alternative water sources for nonpotable uses (Ormerod et al., 2019).

Golf courses are among the most water-intensive irrigated landscapes in urban settings. Maintaining healthy turfgrass in Nevada's dry climate requires substantial irrigation, particularly during the summer months. An increasing number of courses across the United States have adopted recycled water as a sustainable alternative to potable supplies (Harivandi, 2004). This transition can conserve freshwater and, when appropriately managed, supply nutrients such as nitrogen and phosphorus to turfgrass, potentially reducing some fertilizer requirements. This "fertigation" approach integrates water and nutrients through irrigation and offers economic advantages by decreasing the need for synthetic fertilizers while potentially lowering energy demands at treatment facilities (Taghvaeian and Fox, 2016; U.S. Environmental Protection Agency, 2012).

In the Reno-Sparks area, recycled water is managed by municipal organizations such as Washoe County, the City of Reno, and the City of Sparks. It is produced at three regional facilities: the South Truckee Meadows Water Reclamation Facility, Truckee Meadows Water Reclamation Facility, and Reno-Stead Water Reclamation Facility. These facilities treat wastewater to a high standard suitable for irrigation and distribute it through a dedicated "purple pipe" system to prevent cross-connection with drinking water supplies (Figure 1). Several local golf courses are already connected to this system. For example, ArrowCreek, Wolf Run and Hidden Valley were supplied by the South Truckee Meadows Water Reclamation Facility in 2025, while D'Andrea and Wildcreek Golf Courses receive water from the Truckee Meadows Water Reclamation Facility, and Sierra Sage Golf Course receives recycled water from the Reno-Stead Water Reclamation Facility. Using recycled water helps conserve freshwater from the Truckee River and regional groundwater sources, particularly during the hot summer months when irrigation demand is highest. However, golf course managers must also be aware of potential agronomic challenges associated with recycled water irrigation. Nevertheless, extensive research-based literature on landscape irrigation with recycled water has helped address many of the social and environmental concerns that were raised in earlier years (Harivandi, 2004).

This guide provides a comprehensive framework for using recycled water for northern Nevada's golf course and park landscapes. It evaluates recycled water irrigation from three perspectives: water quality, soil health and vegetation growth. Designed for decision-makers managing large green spaces such as golf courses or public parks, the guide includes real-world case studies and fact sheets based on regulations by Nevada Administrative Code (NAC-445A), providing a road map for maintaining high-quality landscapes through safe and sustainable water reuse.




**Figure 1. Purple pipe pump station at the South Truckee Meadows Water Reclamation Facility.**

## Nevada Regulations for Recycled Water Use

"Recycled water" is defined as wastewater that has been treated by a physical, biological or chemical process, which is intended for a use identified in NAC-445A.2762 – 445A.2771. Reuse categories A, B and C (NAC-445A.2762–445A.2766) apply to irrigation of commercial lawns, golf courses, greenbelts and parks, whereas categories D and E are not suitable for landscape irrigation applications. Table 1 summarizes approved uses of various categories of recycled water.

**Table 1. Categories of reuse and approved uses of recycled water in Nevada (categories A-C).**

| Recycled water category | Approved uses |
|---|---|
| A | • Spray irrigation of cemetery, commercial lawn, golf course, greenbelts and parks<br>• Impoundment and outdoor decorative water features<br>• Snowmaking (may require additional treatment)<br>• Commercial toilet and urinal flushing<br>• Commercial window washing or pressure cleaning<br>• Any activity approved for reuse categories B, C, D or E |
| B | • Spray irrigation of cemetery, commercial lawn, golf course, greenbelts and parks if public access is restricted<br>• Cooling water for industrial processes<br>• Firefighting in urban areas<br>• Commercial chemical mixing<br>• Street sweeping<br>• Any activity approved for reuse categories C, D or E |
| C | • Spray irrigation of cemetery, golf course and greenbelts with 100 feet buffer zone and restricted public access<br>• Establishment, restoration or maintenance of wetlands, if public access to the wetland is restricted.<br>• Firefighting of forest or other wildland fires<br>• Any activity approved for reuse categories D or E |

For golf course applications, Category A is the most suitable class for recycled water. Golf courses involve unrestricted public access, with players, caddies and maintenance staff in regular direct

contact with irrigated turf. Spray irrigation systems also generate aerosols that can reach people in the vicinity. These conditions make the higher pathogen reduction and treatment reliability of Category A water beneficial from a public health standpoint.

The South Truckee Meadows Water Reclamation Facility employs an advanced five-stage Bardenpho process (Figure 2) to produce Category A recycled water that meets the strict NAC 445A standards. Water quality is continuously monitored and tested to ensure compliance with regulatory requirements and to maintain consistent treatment performance. This ongoing monitoring ensures consistent water quality and regulatory compliance for irrigation use. Table 2 summarizes the recycled water quality of the South Truckee Meadows Water Reclamation Facility effluent (2025-26).



**Figure 2. Five-Stage Bardenpho treatment system at The South Truckee Meadows Water Reclamation Facility.**

**Table 2. South Truckee Meadows Water Reclamation Facility effluent (recycled water) quality parameters.**

| Parameter | Units | Value |
|---|---|---|
| **Electrical Conductivity (ECw)** | dS/m | 0.73 |
| **Total Dissolved Solids (TDS)** | mg/L | 455 |
| **Sodium Adsorption Ratio (SAR)** | – | 3.85 |
| **Bicarbonates (as $CaCO_3$)** | mg/L | 150 |
| **Residual Sodium Carbonate (RSC)** | meq/L | 0.63 |
| **Adjusted SAR (Adj. SAR)** | – | 4.39 |
| **Boron** | mg/L | 1.4 |
| **pH** | – | 7.8 |
| **Total Nitrogen** | mg/L | 3 |
| **Total Phosphorous** | mg/L | 2 |
| **Potassium** | mg/L | 19 |
| **Sodium** | mg/L | 97 |
| **Calcium** | mg/L | 26 |
| **Magnesium** | mg/L | 13 |
| **Chloride** | mg/L | 105 |

**Note:** Values are averages of two most recent quarterly effluent quality monitoring reports provided by the South Truckee Meadows Water Reclamation Facility for 2025–2026.

## Recycled Water for Golf Course Irrigation: Water, Soil and Vegetation Considerations

Recycled water has become a significant and growing source of irrigation water for golf courses across the United States. A 2020 survey by the Golf Course Superintendents Association of America found that 21% of U.S. golf course irrigation uses recycled water, making it the third most common source after wells (32%) and lakes (23%) (Shaddox et al., 2022). While these percentages reflect national averages, the adoption of recycled water for golf course irrigation is strongly constrained by location, as the survey of facilities not currently using recycled water found that 51% reported no available recycled water source, 14% cited a lack of infrastructure to transport the recycled water to the golf course, and 31% indicated that its use was unnecessary due to sufficient alternative sources.

These findings suggest that the primary limitation is availability rather than preference, and that recycled water use is more common in urban and suburban areas where treatment and purple pipe distribution systems are in place. This is the case in Washoe County, where three golf course facilities utilized South Truckee Meadows Water Reclamation Facility recycled water for irrigation during 2025, with their seasonal utilization patterns illustrated in Figure 3. Therefore, it is important to understand this practice from three key interconnected lenses: water, soil and vegetation. The remaining recycled water is supplied to other reuse customers applying to landscape and park irrigation.

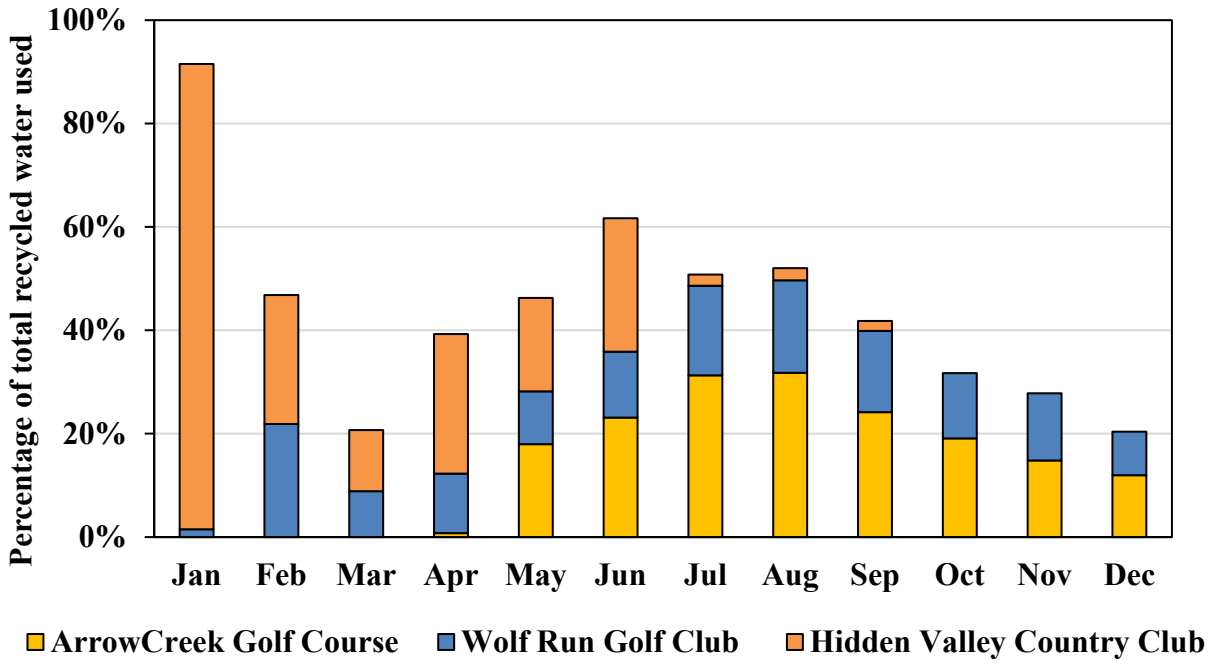



**Figure 3. Seasonal variation in South Truckee Meadows Water Reclamation Facility recycled water utilization across three golf facilities in 2025.**

### Water Quality

The most important first task in irrigating golf courses using recycled water is evaluating water quality. Salinity, sodium, carbonates and bicarbonates, nutrients, pH, and potential turfgrass stressors from trace elements should be key parameters examined in water quality reports (United States Golf Association, 2024). Table 3 summarizes the main water quality considerations when using recycled water for golf course irrigation ((United States Golf Association, 2024).

**Table 3. Key water quality parameters for turfgrass irrigation using recycled water.**

| Parameter | No risk | Low risk | Medium risk | High risk |
|---|---|---|---|---|
| **ECw (dS/m)** | <0.75 | 0.75 – 1.5 | 1.5 – 3.0 | >3.0 |
| **TDS (mg/L)** | <450 | 450 – 2,000 | >2,000 | NR |
| **SAR** | <10 | 10 – 18 | 18 – 26 | >26 |
| **RSC (meq/L)** | <1.25 | 1.25 – 2.5 | >2.5 | NR |
| **Boron* (mg/L)** | <1 | 1 – 2 | 2 – 10 | >10 |
| **Chloride (mg/L)** | <70 | 70 – 100 | 100 – 355 | >355 |

ECw – Electrical conductivity of water; TDS – Total dissolved solids; SAR – Sodium adsorption ratio; RSC – Residual Sodium Carbonate; NR – Not reported. * Boron is toxic to ornamental plants at concentrations >2 mg/L, and to turfgrass at concentrations >10 mg/L.

**Salinity:** Salinity refers to the "total salts" present in irrigation water and is reported as total dissolved solids (TDS) in units of milligrams per liter (mg/L) or as electrical conductivity of water (ECw) in units of millimhos per centimeter (mmhos/cm) or decisiemens per meter (dS/m). It should be noted that mmhos/cm and dS/m are equivalent units of measurements. TDS measures the total amount of dissolved material in water, whereas ECw reflects only the dissolved ions that contribute to electrical conductivity, and the relationship between the two measurements is not linear. Salinity affects plant health by limiting water uptake in the root zone. As salinity increases, plants must exert more energy to absorb water, leading to physiological stress and reduced growth.

**Sodium Adsorption Ratio (SAR):** Sodium ($Na^+$) in irrigation water is referred to as sodicity. Although high sodium concentrations can affect plant growth, its most common detrimental effect occurs through changes in soil structure. $Na^+$, in relation to other cations such as calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$), influences soil structure and can affect soil permeability and water infiltration capacity. This influence is commonly evaluated using an index called the sodium adsorption ratio (SAR).

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

**Carbonates and Bicarbonates:** Carbonates ($CO_3^{2-}$) and bicarbonates ($HCO_3^-$) influence soil chemistry and can affect soil permeability over time. Water with elevated $CO_3^{2-}$ (>15 mg/L or >25 mg/L as $CaCO_3$) and $HCO_3^-$ (>120 mg/L or >98 mg/L as $CaCO_3$) can increase soil pH and promote precipitation of $Ca^{2+}$ and $Mg^{2+}$ as carbonate solids, which reduces the availability of these stabilizing cations in the soil solution, leading to increased sodium ($Na^+$) accumulation and a decline in soil permeability. Their combined effect is evaluated using residual sodium carbonate (RSC), expressed in milliequivalents/liter (meq/L). When $HCO_3^-$ concentrations exceed 120 mg/L (>98 mg/L as $CaCO_3$), adjusted SAR (Adj. SAR) should be used instead of standard SAR, as it accounts for the additional effects of $CO_3^{2-}$ and $HCO_3^-$ on $Ca^{2+}$ availability in the soil solution (Carrow et al., 2008).

$$\mathbf{RSC} = (\mathbf{HCO_3}^- + \mathbf{CO_3}^{2-}) - (\mathbf{Ca^{2+}} + \mathbf{Mg^{2+}})$$

$$\mathbf{Adj.SAR} = \frac{\mathbf{Na^+}}{\sqrt{(\mathbf{Cax} + \mathbf{Mg^{2+}})/2}}$$

where Cax is the adjusted calcium concentration (meq/L), estimated based on bicarbonate levels and electrical conductivity to account for calcium precipitation in the soil solution.
For the South Truckee Meadows Water Reclamation Facility water, a RSC value of approximately 0.63 meq/L (<1.25 meq/L) and a SAR value of 3.85 (<10) indicates no risk. However, since the $HCO_3^-$ concentration (as $CaCO_3$) exceeds 98 mg/L, Adj. SAR should be considered when evaluating sodium and carbonate-related soil risks. Adj. SAR for the South Truckee Meadows Water Reclamation Facility water value is 4.39. This value is also below the SAR threshold of 10 (Table 3).

**Boron:** Boron is an essential micronutrient needed for plant growth, and it is required in trace quantities; however, if boron concentrations exceed 2 mg/L, it becomes phytotoxic to ornamental plants, causing leaf burns. Turfgrasses can withstand boron concentrations of up to 10 mg/L without significant adverse effects (Harivandi, 2004).

**pH:** pH of recycled water typically falls within the 6.5 – 8.4 range, which is close to neutral and generally suitable for turfgrass irrigation.

**Nutrients:** Recycled water typically contains enough macronutrients such as nitrogen (N), phosphorus (P) and potassium (K) required for fertilization of golf course turf ((United States Golf Association, 2024). High N concentrations may promote excessive turf growth, leading to increased clipping production, scalping, reduced putting speeds on greens, greater thatch accumulation, succulent tissue and increased susceptibility to turf diseases, particularly in putting greens located in warm climates. Turfgrasses generally tolerate elevated P, but excessive P in recycled irrigation water can stimulate algal growth and eutrophication if the water is stored in ponds or discharged into nearby water bodies. K improves turf stress tolerance and vigor, yet high K concentrations can increase water salinity, potentially necessitating additional soil management (Carrow et al., 2008).

**Chloride and Chlorine:** Chloride ($Cl^-$) is typically less harmful to turfgrass but may negatively affect other vegetation commonly found on golf courses, including trees and ornamental plants. When chloride levels exceed 100 mg/L, plants may exhibit leaf burn and necrotic symptoms, while concentrations above 355 mg/L may lead to toxicity in the root zone. Chlorine toxicity generally occurs only when plant foliage is exposed to high chlorine concentrations (>5 mg/L). Free chlorine is chemically unstable and decays quickly when water is stored even briefly before irrigation. Moreover, irrigation systems used on golf courses typically disperse water through sprinkler heads that spray water into the air, allowing additional chlorine loss through atmospheric exposure. South Truckee Meadows Water Reclamation Facility recycled water contains an average chloride concentration of 105 mg/L (Table 2), which is slightly above the 100 mg/L level at which chloride-sensitive plants may begin to exhibit leaf burn or necrotic symptoms. While turfgrass is generally tolerant of chloride at this concentration, golf course managers should recognize that chloride-sensitive trees and ornamental plants may be more susceptible than turfgrass, particularly where overhead irrigation results in foliar exposure. Based on the risk thresholds in Table 3, South Truckee Meadows Water Reclamation Facility recycled water falls within the no-risk category for ECw, SAR and RSC, and within the low-risk category for TDS. These classifications provide an initial water-quality assessment; continued soil and turf monitoring is needed to evaluate site-specific conditions.

**Soil**

In addition to monitoring irrigation water quality, effective irrigation practices at golf courses require regular assessment of soil quality. Soil properties (particularly soil texture and drainage capacity) influence water movement through the soil profile, as well as how salts and other dissolved constituents behave within the root zone.

**Soil Salinity**: Soil Salinity is commonly evaluated using the electrical conductivity of the soil saturation extract (ECe), expressed in decisiemens per meter (dS/m). ECe reflects the salinity conditions experienced by plant roots and is therefore the primary parameter used to assess plant response and tolerance. Irrigation water salinity (ECw) represents the salinity of the applied water and serves as an input parameter for evaluating potential salt accumulation in the root zone and guiding leaching management to maintain soil salinity ECe within acceptable limits (<3 dS/m) (Harivandi, 2004). Over time, salts introduced through irrigation can accumulate in the root zone,

causing ECe to exceed ECw depending on site conditions. Well-drained sandy soils allow salts to leach, maintaining ECe at acceptable levels even when ECw is moderately elevated. In contrast, poorly drained or clay-rich soils promote salt accumulation, leading to increased Ece levels. For example, irrigation water with ECw of 1.5 dS/m may be suitable under conditions of adequate drainage and leaching, but the same water may result in excessive soil salinity (high ECe) in poorly drained soils, leading to turf stress (Harivandi, 2004). Therefore, while ECw is useful for initial water quality assessment, ECe should be monitored regularly to evaluate actual root-zone conditions and guide irrigation management decisions. Leaching is the practice of applying irrigation water in excess of crop demand so that water percolates through and below the root zone, carrying accumulated salts with it. The fraction of applied water that passes the entire root zone and percolates below is termed the leaching fraction (LF).

$$\mathrm{LF} = \frac{\text{Depth of water leached below the root zone}}{\text{Depth of water applied at the surface}}$$

Ayers and Westcot (1985) showed that higher LF reduce salt accumulation in the root zone. The salt concentration of the water draining past the root zone ($EC_{dw}$) can be estimated by dividing $EC_w$ by LF.

$$\mathrm{EC_{dw}} = \frac{\mathrm{EC_w}}{\mathrm{LF}}$$

Leaching decisions should not be applied uniformly across a golf course. Rather, the decisions should be based on root-zone ECe, irrigation-water ECw, turfgrass salt tolerance, soil texture, drainage, infiltration, and irrigation uniformity. Additional water should be applied only when monitoring indicates that leaching is needed and drainage is adequate.

**Sodium Hazard:** Sodium accumulation can degrade soil structure, particularly in clay-rich soils. Soils are typically considered sodic when SAR >13. High sodium levels can lead to soil dispersion, surface sealing, reduced infiltration, and poor aeration. Visible indicators include ponding, algal growth, and black layer formation.

**Soil pH and Soil Permeability:** High levels of $HCO_3^-$ in irrigation water can increase soil pH and reduce soil permeability. As discussed earlier, precipitation of $Ca^{2+}$ and $Mg^{2+}$ reduces soil stability and enhances sodium-related impacts. The soil properties described above, particularly salinity buildup, sodium hazard, and changes in pH, influence the turfgrass health, making turfgrass species selection and maintenance equally important to the initial water and soil quality decisions.

**Vegetation**

Turfgrass health is essential across the entire golf course, especially on putting greens, which are the most expensive and sensitive surfaces to manage. In the U.S., turfgrass selection typically follows climate: cool-season grasses (e.g., tall fescue, ryegrass Kentucky bluegrass) are used in the north, warm-season species (e.g., hybrid bermudagrass, zoysiagrass, buffalograss, seashore paspalum and St. Augustine grass) in the south, and a combination of both in the central transitional zone. Turfgrass salt tolerance is typically expressed in terms of soil salinity (ECe). Soils with ECe <3 support most turfgrasses, 3 – 6 support moderately sensitive species, 6 – 10 support moderately tolerant species, and >10 support highly tolerant grasses (Table 4).

**Table 4. Soil salinity tolerance of turfgrass species.**

| Soil salinity ECe (dS/m) | Tolerance | Turfgrass species |
|---|---|---|
| <3 | Sensitive | Annual bluegrass, bahiagrass, carpetgrass, centipedegrass, colonial bentgrass, hard fescue, Kentucky bluegrass, rough bluegrass |
| 3 – 6 | Moderately sensitive | Annual ryegrass, buffalograss, creeping bentgrass, slender creeping, red and chewing fescues |
| 6 – 10 | Moderately tolerant | Perennial ryegrass, creeping bentgrass (mariner and seaside cultivars), coarse-leaf zoysiagrasses (japonica), tall fescue |
| >10 | Tolerant | Alkaligrass, bermudagrass, fine-leaf zoysiagrasses (matrella), saltgrass, seashore paspalum, St. Augustine grass |

**Sources:** Harivandi, 2004; USGA, 2024

In Nevada, turfgrass selection depends on regional climate zones. Southern Nevada falls within a transitional zone where both warm- and cool-season grasses can persist. On golf courses in this region, hybrid bermudagrass is widely favored as a warm-season option due to its fine texture, superior color, low mowing height, and suitability for overseeding with perennial ryegrass for winter color. In Northern Nevada, including Reno-Sparks, tall fescue is a popular grass species because of its tolerance to high summer temperatures, relatively low maintenance, and persistence of its green color through the winter months (Morris and Devitt, 2011). Creeping bentgrass is the preferred species for putting greens because of its high salt tolerance (Carrow et al., 2008). Given Nevada's arid climate, limited precipitation and increasing reliance on recycled water for irrigation, water-use efficiency and salt tolerance are critical considerations in turfgrass selection and long-term management.

Effective golf course management requires balancing nutrient inputs with irrigation water quality. Overfertilization with nitrogen (N) can damage low-N-requirement species (e.g., red fescue, seashore paspalum). Typical annual N thresholds are 4–6 lb/1,000 ft² for cool-season species and 8–12 lb/1,000 ft² for warm-season species. Turfgrasses tolerate up to 2 lb/1,000 ft² of $P_2O_5$ from irrigation, but excess phosphorus can stimulate aquatic plants if runoff reaches water bodies. Disease susceptibility varies among turfgrass species, with cool-season grasses generally more prone to stress- and salinity-associated diseases than warm-season species. Recycled water irrigation or poor soil condition can create conditions such as elevated salinity, moisture and nutrient inputs that increase the risk of turfgrass diseases. Rapid blight is particularly associated with saline irrigation, while other diseases such as pythium blight and brown patch may occur under prolonged changes in soil moisture and chemistry. In addition, recycled water and elevated nutrient inputs can promote thatch accumulation, a layer of accumulated organic material at the soil surface, which reduces water infiltration, limits root growth, and creates conditions favorable for turf stress and disease. Maintaining overall turf health therefore requires proactive management of water and soil conditions.

## Best Management Practices

Best management practices for golf courses are science-based strategies to conserve water while maintaining high-quality playing surfaces. Best management practices are flexible and tailored to site-specific factors such as soil conditions, microclimate factors, turfgrass species, and irrigation water quality and availability (Carrow et al., 2008). Table 5 provides a practical decision-making

framework for recycled water irrigation at golf courses, linking key water and soil quality parameters to recommended management actions.

**Table 5. Management actions for recycled water irrigation under varying water and soil quality conditions.**

| Parameter | Threshold/ | |
|---|---|---|
| | | |
| **ECw** (dS/m) | <0.75 | No action needed |
| | 0.75 – 1.5 | Monitor soil salinity (ECe). Consider periodic leaching only if root-zone ECe indicates salt accumulation and drainage is adequate. |
| | >1.5 | Evaluate ECe, soil texture, drainage, turf salt tolerance and irrigation uniformity. Apply additional irrigation for leaching only when monitoring indicates it is needed and drainage is adequate. |
| **TDS** (mg/L) | <450 | No action needed. |
| | 450 – 2,000 | Monitor salinity buildup; consider leaching if ECe begins to rise |
| | >2,000 | Blend with lower-salinity water. Improve drainage. |
| **SAR** | <10 | No action needed. When $HCO_3^-$ exceeds 98 mg/L as $CaCO_3$, consider Adj. SAR for evaluating sodium-related permeability risk. |
| | 10 – 18 | Monitor infiltration and use Adj. SAR when bicarbonate/carbonate concentrations warrant adjustment. |
| | >18 | Evaluate soil permeability and drainage. Consider calcium amendments (gypsum) to displace sodium only when soil and water testing indicate they are warranted. Follow with intensive leaching. |
| **RSC** (meq/L) | <1.25 | No action needed. |
| | 1.25 – 2.5 | Monitor for “sealing” of soil surface. Apply wetting agents to aid water movement. |
| | >2.5 | Inject acidic solution (sulfuric/carbonic) to neutralize carbonates and prevent Ca precipitation. |
| **Boron** (mg/L) | <2 | No action needed. |
| | 2 – 10 | Avoid overhead irrigation on sensitive trees/shrubs. Check for leaf margin burn. |
| | >10 | Blend with potable water to dilute concentration. |
| **Nitrogen*** (mg/L) | <5 | Apply standard fertilization, while accounting for irrigation N. |
| | 5 – 10 | Deduct N-loading from annual fertilizer plan. Monitor for thatch buildup. |
| | >10 | Reduce synthetic N. Watch for rapid Blight and pythium disease outbreaks. |
| | | |
| **ECe** (dS/m) | <3 | No action needed. |
| | 3 – 6 | Increase leaching. Monitor turf response. |
| | 6 – 10 | Improve drainage. Consider salt-tolerant species. |
| | >10 | Intensive leaching. Switch to highly tolerant species (e.g., seashore paspalum or Bermudagrass). |
| **Soil physical condition** | Poor drainage | Implement core aeration, venting, and sand topdressing (60 –100 tons/acre/year). Install subsurface drainage if water logging persists. |

| | | |
|---|---|---|
| **Turf condition** | Patchy/ uneven growth | First evaluate the irrigation system (sprinkler operating pressure, nozzle condition and compatibility, head spacing, arc adjustment, alignment, obstructions, precipitation rate, and distribution uniformity). Then, check ECe, nutrients and irrigation uniformity. Address identified cause: leach if saline, fertilize if nutrient deficient. Consider micro sprinklers to improve irrigation uniformity only if the system evaluation confirms a distribution uniformity problem. |

*Nitrogen loading (lb/acre-ft of N) = N (mg/L) X 2.72; Total seasonal N loading depends on both nitrogen concentration and total irrigation volume applied. Managers should calculate seasonal N loading from actual applied irrigation depth and deduct it from the annual fertility target (4–6 lb/1,000 ft² for cool-season species; 8–12 lb/1,000 ft² for warm-season species), rather than relying on water nitrogen concentration alone.

**Case Studies of Recycled Water Golf Course Irrigation**

i. **Long-term salinity dynamics in an arid climate - Las Vegas (Lockett et al., 2008)**
This study monitored nine golf courses in the Las Vegas valley over 4.5 years across bermudagrass, perennial ryegrass and bentgrass surfaces irrigated with recycled water. While near-surface soil salinity was observed to spike sharply during hot summer months, the researchers observed no systematic decline in turf color or overall plant quality. A multi-tiered monitoring approach (soil–plant–atmospheric conditions) revealed that plant stress was driven by individual course management and restricted irrigation volumes rather than water quality alone. A key takeaway occurred on a course that skipped winter overseeding. Without winter irrigation, it suffered severe salt accumulation across all soil depths due to a lack of seasonal leaching. The researchers found that salt balances could be maintained at acceptable levels in arid Nevada climates if irrigation volumes were not restricted and golf course managers use data-driven management rather than passive observation.

ii. **Soil chemical changes over decades of recycled water use - Colorado (Qian and Mecham, 2005)**
This study compiled soil test data from 10 golf courses in Colorado over a 33-year timeline to assess how long-term domestic recycled wastewater irrigation impacts fairway soil chemistry. While the recycled water had relatively moderate electrical conductivity (ECw = 0.84 dS/m), long-term use caused a significant accumulation of chemical constituents in the topsoil (sampled to 11.4 cm depth) compared to courses using surface water. Specifically, recycled water-irrigated fairways exhibited a 0.3 unit increase in soil pH, 187% increase in ECe and 481% surge in SAR, alongside elevated levels of extractable sodium, boron and phosphorus. The researchers concluded that while recycled water provides a reliable supply in arid regions, its long-term viability requires active, site-specific soil monitoring and chemical management to mitigate sodium and salt accumulation before they compromise soil structure.

iii. **Soil and turfgrass response in a humid climate - Virginia Golf (Evanylo et al., 2010)**
This study examined recycled water irrigation effects on two turfgrass species (Hybrid bermudagrass and creeping bentgrass) and soil in Virginia, a more humid environment than Nevada. While the recycled water contained moderate to high salinity (0.9 – 2.8 dS/m), both conditions successfully produced high-quality turfgrass surfaces. However, a key finding revealed that recycled water irrigation significantly reduced bermudagrass growth and nitrogen uptake during the early spring green-up phase, pointing to potential early season vulnerabilities. Both grasses efficiently assimilated high amounts of nitrogen and phosphorus with minimal risk of groundwater leaching. Further, natural rainfall in humid regions provides freshwater leaching that helps manage salt accumulation, an advantage that Nevada courses

do not have. This comparison highlights why leaching and drainage practices are particularly critical in Nevada's dry conditions.

**iv. Turfgrass and soil response in a semi-arid climate - Oklahoma (Hopkins, 2015)**
This study examined the implications of recycled water irrigation on golf course soil properties in Oklahoma, along with public acceptance of recycled water use. The researchers demonstrated that while long-term recycled water use significantly increased ECe and SAR in the root zone, the overall salt accumulation remained manageable by adopting best management practices. The study also found that public acceptance of recycled water for golf course irrigation was generally positive when people were adequately informed.

**Summary and Conclusion**

Recycled water in Reno-Sparks meets the requirements for water quality set in NAC-445A for reuse Category A, which can be safely used for golf course irrigation. However, long-term agronomic suitability depends on site-specific water quality, soil conditions, irrigation performance, drainage and turf response. In summary:

- South Truckee Meadows Water Reclamation Facility recycled water meets Category A reuse standards and can supply the nutrients that large turf areas require, potentially reducing reliance on potable water and synthetic fertilizers.
- Regular monitoring of water quality and soil parameters (ECw, SAR, RSC, boron, nitrogen and ECe) is necessary to identify problems and take corrective action.
- Turfgrass species should be selected for salt tolerance appropriate to regional climate. Salt-tolerant species such as bermudagrass (warm-season) or creeping bentgrass (cool-season) offer greater resilience where salinity risk is elevated.
- Effective management includes maintaining good drainage, periodic salt leaching, applying amendments to address sodium and carbonate buildup, and diluting with other freshwater sources only when constituent levels exceed recommended limits.

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