Reused Water for Turf

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STRATEGIES TO REDUCE (POTABLE) WATER CONSUMPTION ON TURF

1. Use of adapted low-water use (turf)grass species
2. Increase irrigation efficiency
3. Irrigation with non-potable water

- A golf course in Southern California uses as much water in a month as a course in Maryland would use in a year (Platt, 1994)
- 37% of Southwestern golf courses are irrigated with recycled water (GCSAA, 2009)

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ALTERNATIVE WATER SOURCES FOR TURF IRRIGATION

1. Recycled (Effluent) Water
   - discharge from treatment plants
   - gray water
2. Saline Groundwater
3. Surface Water
   - Stormwater
   - Brackish water
   - Sea water
4. Reversed Osmosis Concentrate (Brine)
5. Coalbed Methane Produced Water

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Terminology

- Electrical conductivity (EC) [dS/m]
  - dS/m [deciSiemens m^{-1}] =
  - mmhos/cm [millimhos cm^{-1}] =
  - µmhos [micromhos cm^{-1}] x 1000
- Total dissolved salts (TDS) [ppm]
  - ppm [parts per million] =
  - mg/l [milligrams l^{-1}]
  - 1% = 10,000 ppm
- EC [dS/m] x 640 = TDS [ppm]

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Water Quality Comparisons

	Ground Water				Recycled Water		
	El Paso	Las Cruces	Carls-bad	Alamo-gordo	CA	Las Cruces	Sea Water
pH	7.8	7.2	7.7	7.7 – 7.8	7.0	7.5	
EC	2.6	4.0	6.4	1.7 – 5.0	2.0	2.3	50
TDS	1,644	2,560	3,925	1,217 – 5,845	1,266	1,410	34,500
SAR	11.5	10.5	6.4	4.2 – 9.3	4.8	6.7	39.8

Data from Assadian, 2006; Asano et al., 1985; Duncan et al., 2009, and Rice et al., 2000

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Types of salts

- Cations:
  - Na^{+}, Ca^{++}, Mg^{++}, K^{+}, NH_4^{+}
- Anions:
  - Cl^{-}, NO_3^{-}, SO_4^{--}, BO_3^{3-}, CO_3^{--}, HCO_3^{-}

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Sodium Adsorption Ratio (SAR)

- Sodium Adsorption Ratio (SAR) / adjSAR

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

$$meq/l = \frac{ppm\ (= mg/l)}{equivalent\ weight}$$

Equivalent weights:

Na: 23 Ca: 20

Mg 12.2

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Residual Sodium Carbonate (RSC)

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

- Irrigation water
- Precipitation potential of Calcium and Magnesium carbonates at the soil surface

Sodium hazard of irrig. water based on RSC (Harivandi, 1994)

RSC value (meq l^{-1})	Na- Hazard
< 0	None – no precip. of carbonates
0 – 1.25	Low – some removal of Ca and Mg from irrig. water
1.25 – 2.5	Medium – appreciable removal of Ca and Mg from irrig. water
> 2.5	High– most/all of Ca and Mg removed as precip. from irrig. water

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Las Cruces Recycled Water (1)

- EC = 2.3: moderately saline to saline
- SAR = 6.7: low to medium
- RSC = –2.7: none

Las Cruces Recycled Water (2)

- NO_3^- = 2.5 mg/l = 6.75 lbs N / acre foot
- 48” irrigation: 27 lbs N / acre & season

  0.6 lbs N / 1000ft^2
- PO_4^{2-} = below detection limit

Effects of salts on plants

- Salts in soil solution increase osmotic pressure
- Reduced water uptake (physiological drought), wilting and desiccation
- Affects nutrients balance
  - Susceptibility to drought
  - Reduction in top growth
- Tip die-back, loss of roots
- Death

Soil salinity classification

Classification	EC¶ (dS/m)	pH¶	SAR¶	ESP¶ (%)
Saline (White alkali)	> 4	< 8.5	< 13	< 15
Sodic (Black alkali)	< 4	8.5 - 10	> 13	> 15
Saline-sodic	> 4	< 8.5	> 13	> 15

¶ saturated paste extract

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Correcting salinity problems

1. Reduce salt inputs
2. Remediate saline/sodic soils:
   Control calcium and sodium to avoid structural problems
3. Salt tolerant grasses

Correcting salinity problems

Reduce salt inputs

- Apply excess water to cause leaching:
  1. Leaching requirement (LR)
  2. Leaching fraction (LF)
- Improve drainage (infiltration and percolation)
  1. Sand topdressing
  2. Cultivation
  3. French Drains
  4. Sand capping

Leaching requirement $LR = \frac{EC_w}{5\,EC_{TS} - EC_W}$

Rhoades, 1974

	Tall fescue	*Bermuda-grass*
EC_{TS} (dS m^{-1})	7	15
EC_W (dS m^{-1})	4	4
LR	0.13 (13%)	0.06 (6%)
Water requirement (ET)	45”	35”
Irrigation requirement (ET + LR)	51”	37”

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Correcting salinity problems

Identify problem: Is soil saline or sodic?

- Sodic soils
  - Basic
    - If clayey or loamy: stabilize structure through Gypsum ($CaSO_4$)
    - Acidify irrigation water (e.g. sulfuric acid)
  - Acid
    - Lime ($CaCO_3$ / $MgCO_3$)
- Saline soils
  - Drainage!

Leaching!

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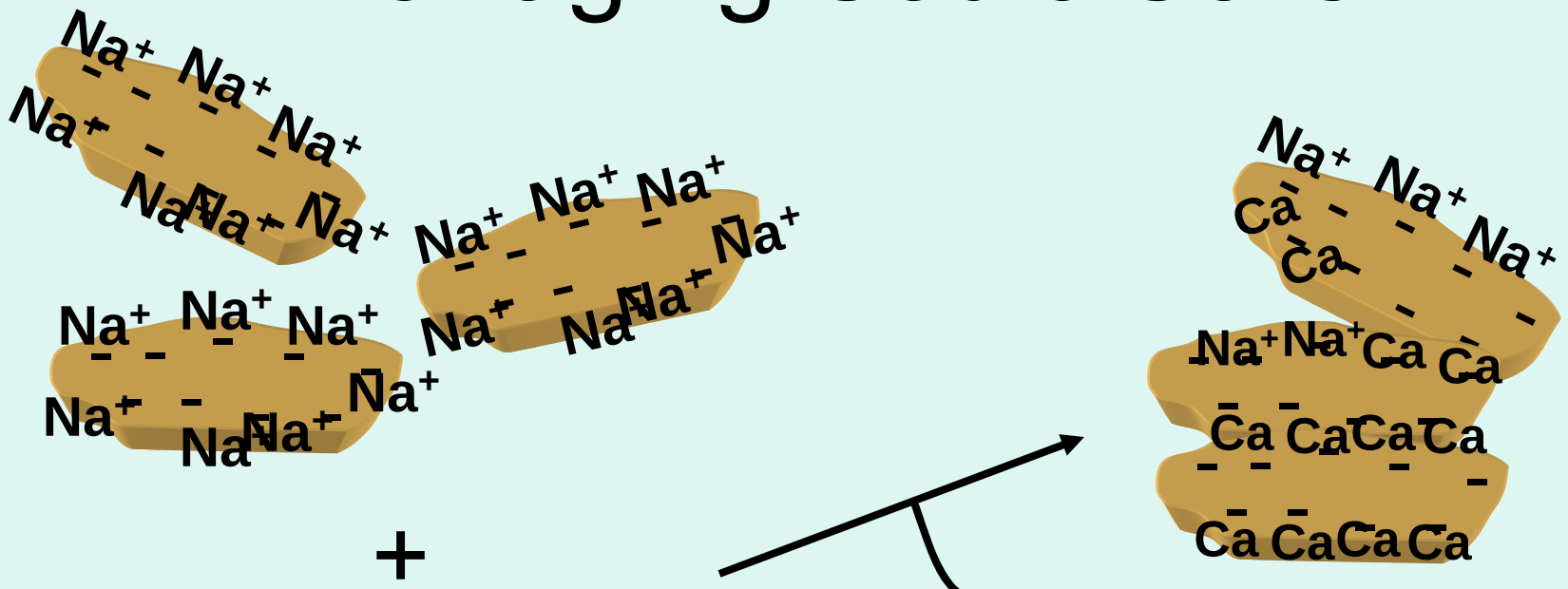
Managing Sodic Soils



Gypsum

$Ca^{++}SO_4^{=}$ $Ca^{++}SO_4^{=}$ $Ca^{++}SO_4^{=}$

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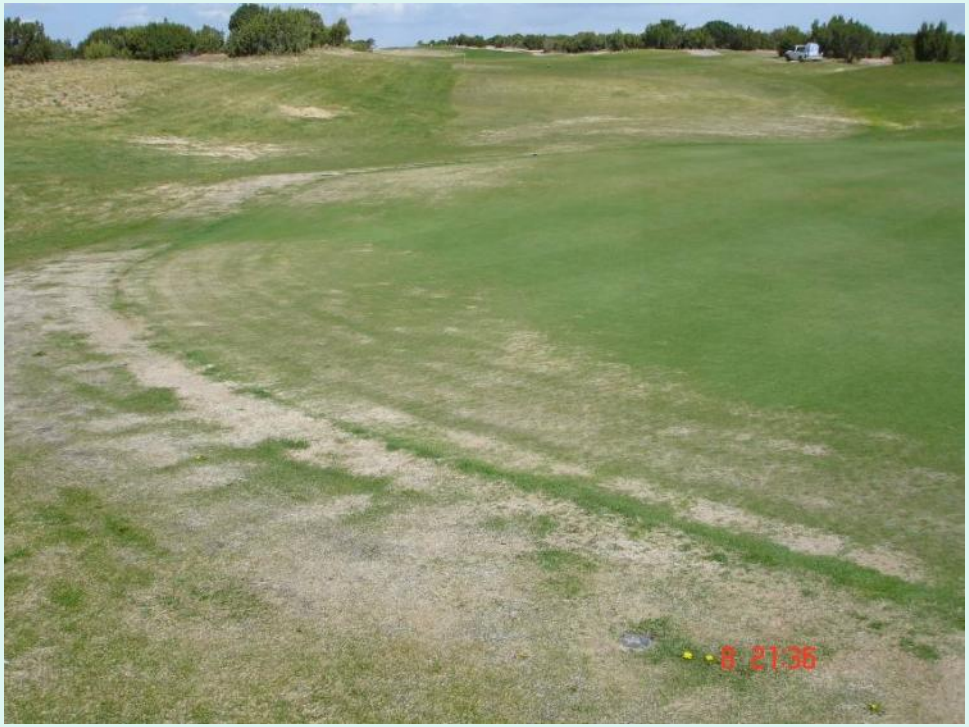
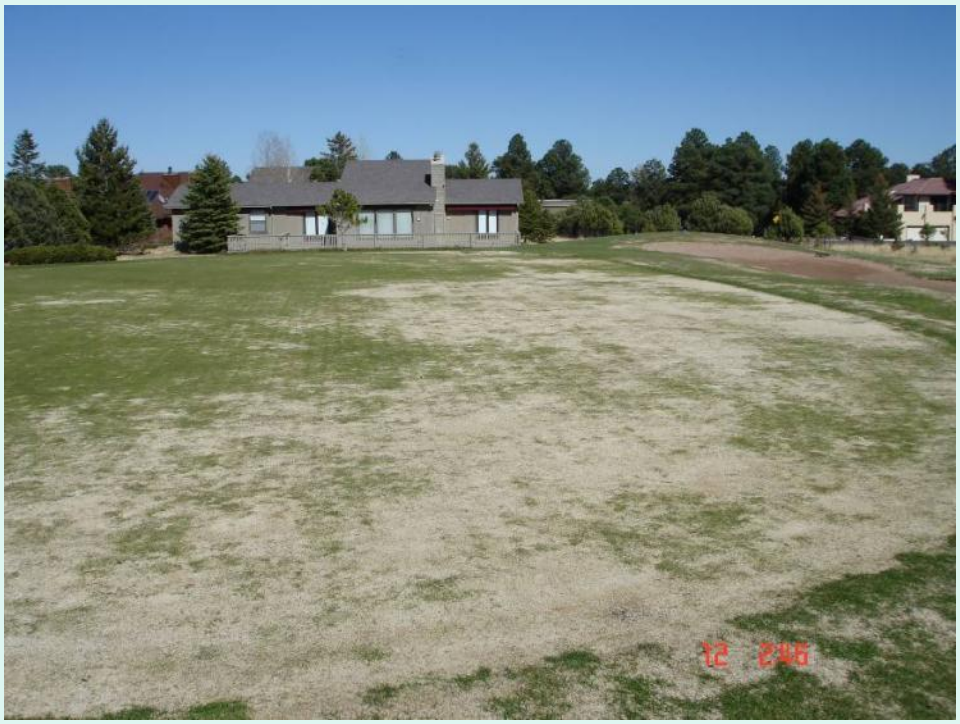
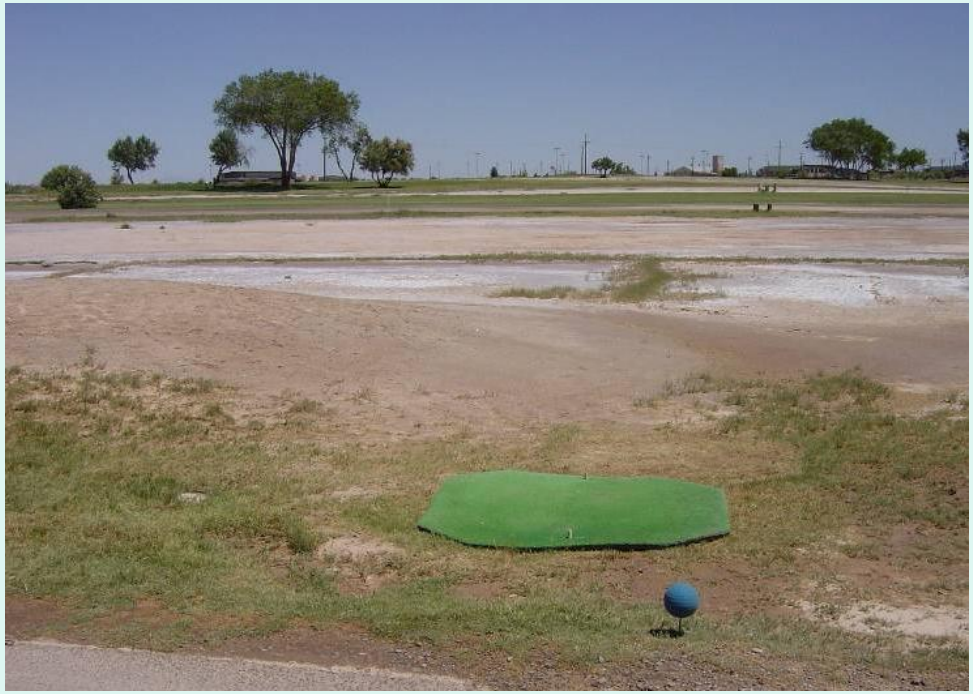


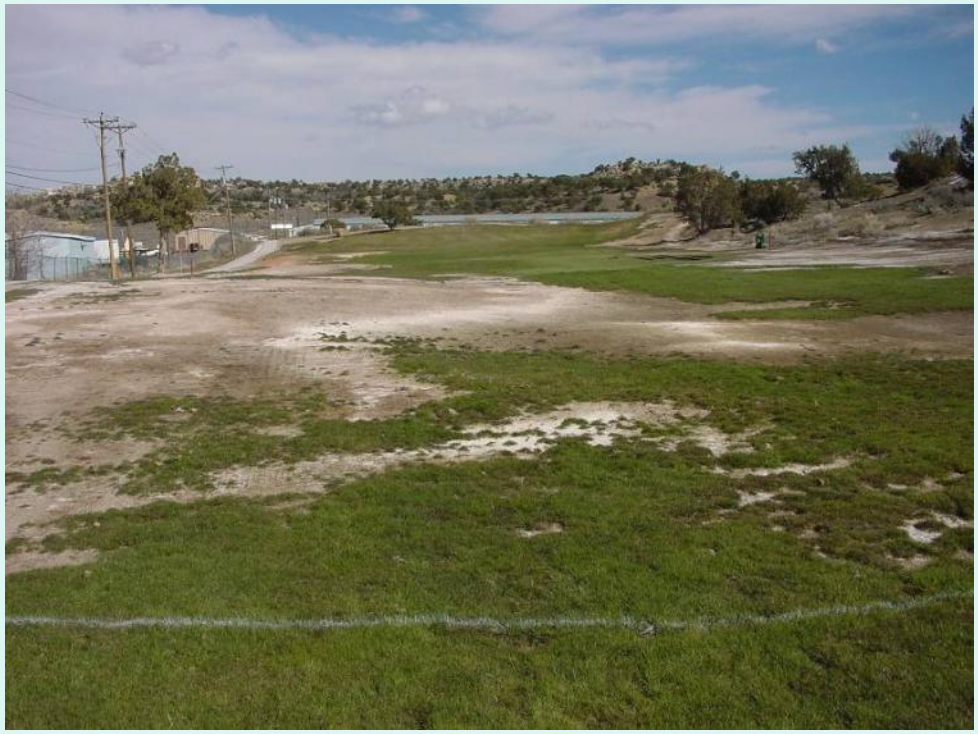
Soil type	ph	EC (mmhos/cm)	SAR	Problem
Green (sand)	7.4	1.2	9.0	likely



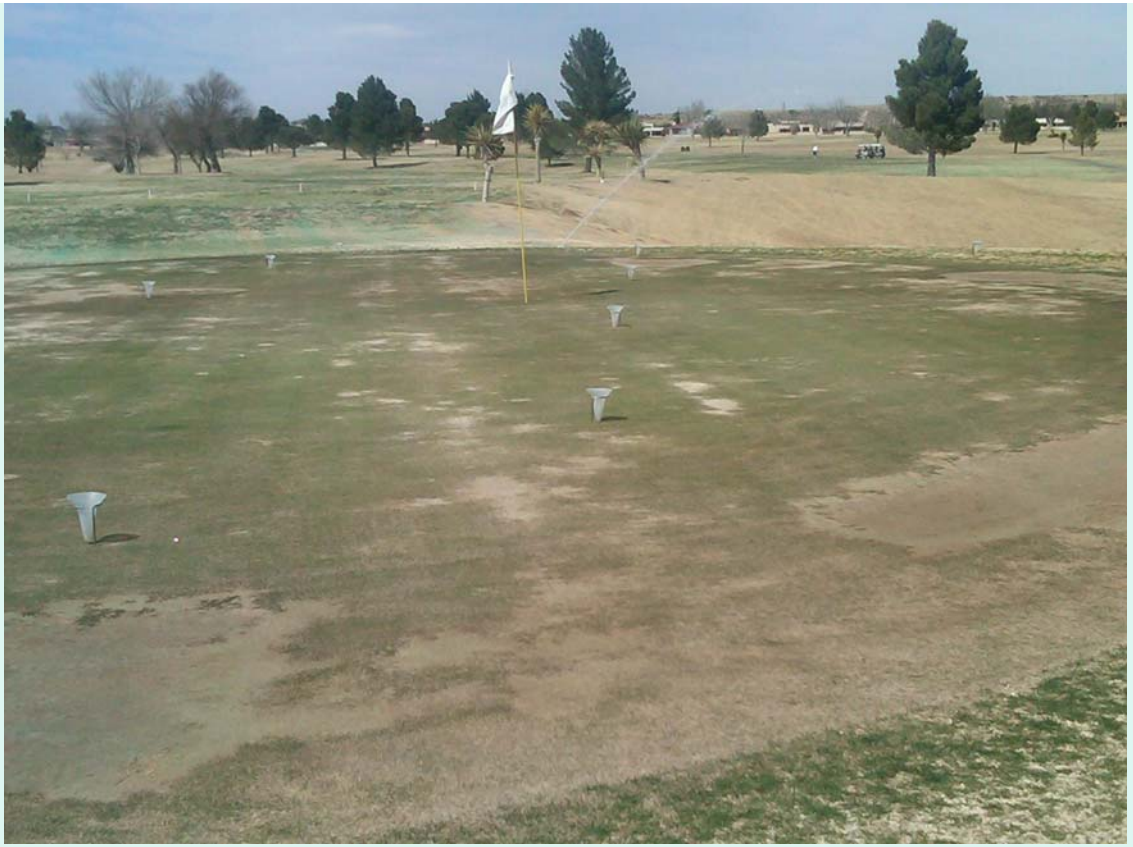
Soil type	ph	EC (mmhos/cm)	SAR	Problem
Green (sand)	7.3	3.8	2.1	unlikely



Soil type	ph	EC (mmhos/cm)	SAR	Problem
Fairway (clay loam)	7.7	17.3	13.6	Highly likely

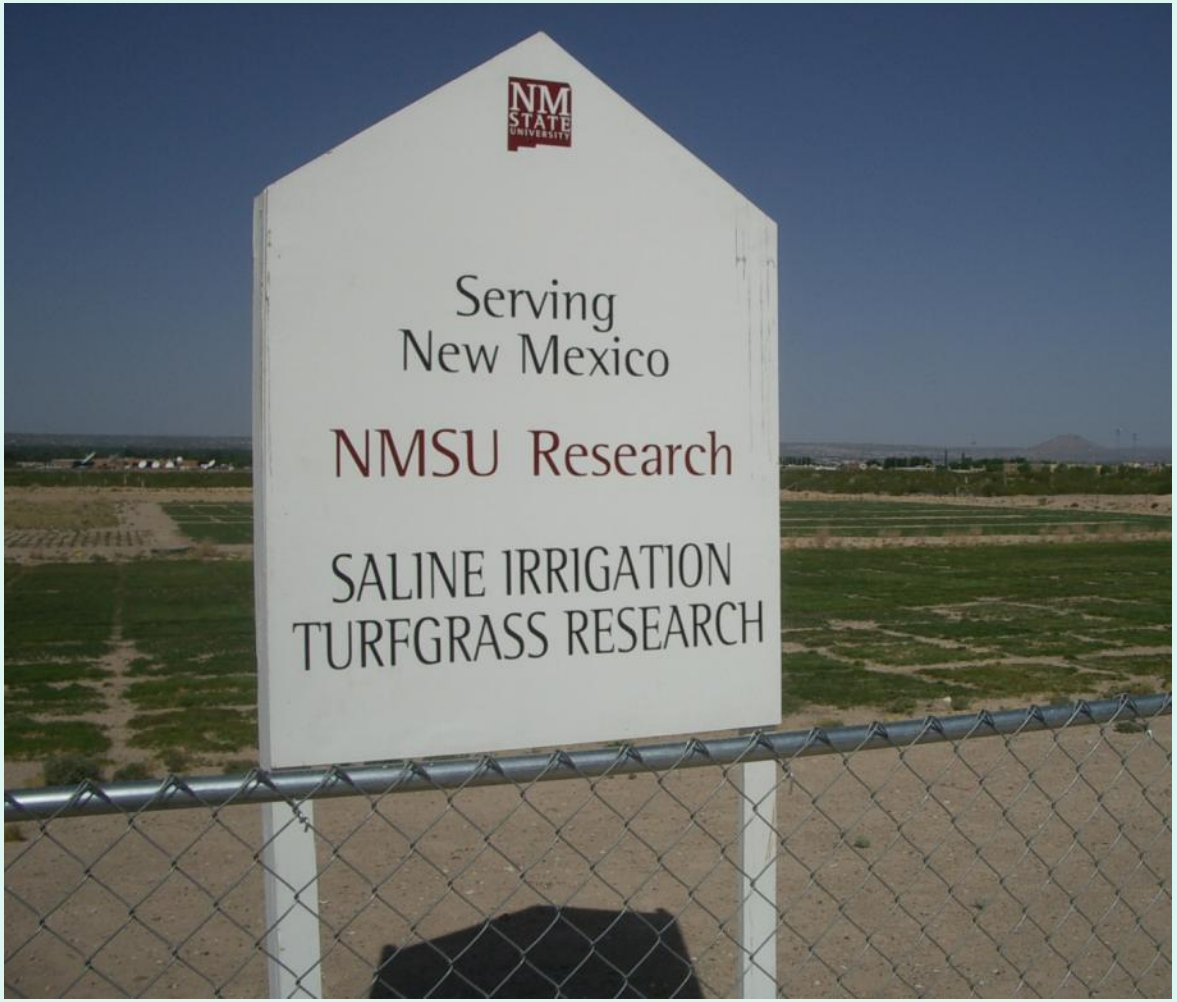


Soil type	ph	EC (mmhos/cm)	SAR	Problem
Fairway (sandy clay loam)	8.5	11.9	84.6	Highly likely



Soil type	ph	EC (mmhos/cm)	SAR	Problem
Green (sand)	7.5	16.8	14.0	Highly likely

Screening for Salinity, Heat, Drought and Cold Tolerant Turfgrasses



Estimated Relative Salinity Tolerances 1 (Marcum, 1999)

Species	Grass type	EC_e (dS/m) for 50% growth reduction
Disticlis sp. var. *stricta*	Warm	>35
Sporobolos virginicus		
Paspalum vaginatum	Warm	25
Zoysia matrella, tenuifolia		
Puccinella spp.	Cool	
Stenotaphrum secundat.	Warm	18
Cynodon spp.	Warm	15
Zoysia japonica	Warm	12
Agrostis stolonifera	Cool	9
Festuca arundinacea	Cool	7

Estimated Relative Salinity Tolerances 2 (Marcum, 1999)

Common name	Grass type	EC_e (dS/m) for 50% growth reduction
Lolium perenne	Cool	5
Buchloe dactyloides	Warm	
Bouteloua spp.	Warm	
Poa pratensis	Cool	3
Poa trivialis	Cool	
Festuca longifolia /elatior /ovina	Cool	
Lolium multiflorum	Cool	
Axonopus spp.	Warm	
Eremochloa ophiuroides	Warm	
Agrostis tenuis/canina	Cool	2
Paspalum notatum	Warm	

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Salinity Tolerance

Shoot saline ion exclusion central to salinity tolerance

- Salt sensitive plants:
  accumulate saline ions to toxic levels
- Salt tolerant plants:
  excrete excess saline ions from shoots

Cool and Warm Season Turfgrass Quality under Saline Irrigation

Grasses:

- Bermudagrass: 45 cvs.
- Zoysiagrass: 12 cvs.
- Seashore paspalum: 12 cvs.
- Tall fescue: 108 cvs.
- Kentucky bluegrass: 120 cvs.

Irrigation

- Warm season: 80% / 100% ET
- Cool Season

Tall fescue: 100% / 120% ET

- Kentucky bluegrass: 100% / 150% ET

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Management of Salt Affected Sites

- Monitoring strategy:
  Soil and water testing
- Cultural practices:
  Soil cultivation
  Irrigation uniformity
- Leaching of salts:
  adding leaching fraction to irrigation
- Amendments:
  e.g. Gypsum (sodic soils)
- Grass selection

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