A NEW APPROACH:

IRRIGATION WITH SALINE RECLAIMED WASTEWATER PROVIDES INEXPENSIVE DISPOSAL SOLUTION

Presented by Marcus Theodore, CEO

EARTH
RENAISSANCE
TECHNOLOGIES, LLC

THANKS TO WEAU FOR THE OPPORTUNITY TO PRESENT THIS WATER RECLAMATION AND REUSE PRESENTATION.

I also want to dedicate this presentation to:

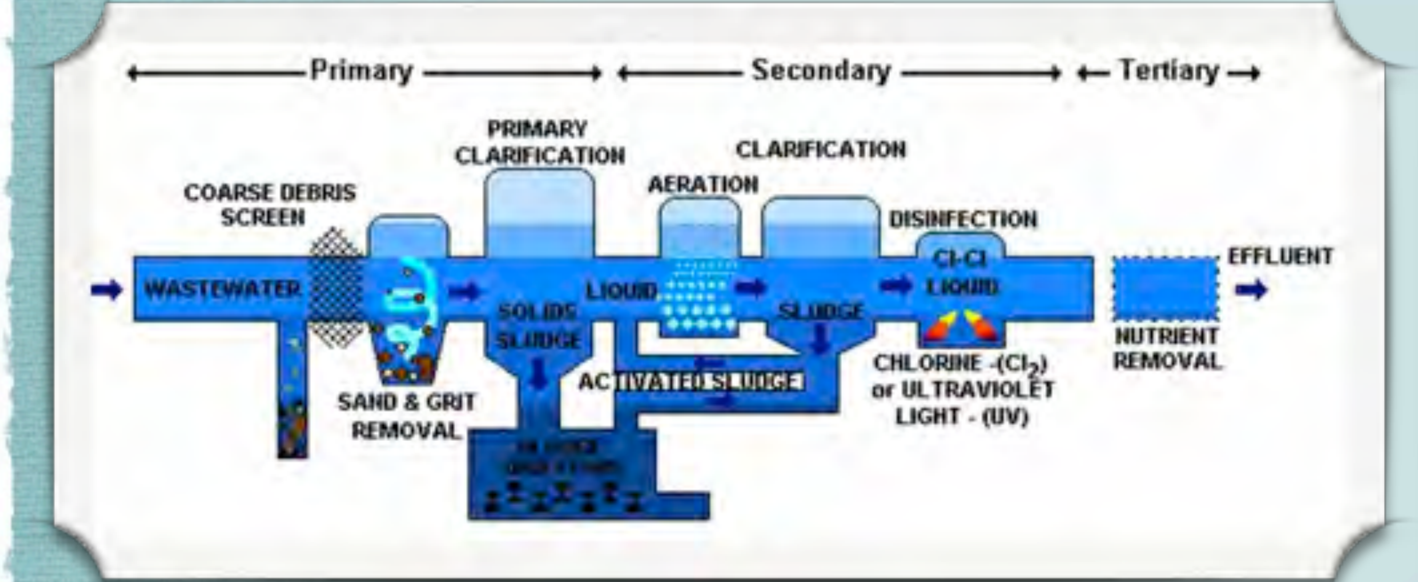
Thomas A. Ruehr, Ph.D., deceased
Professor Earth and Soil Sciences Dept.
Cal Poly State University
San Luis Obispo, California 83407

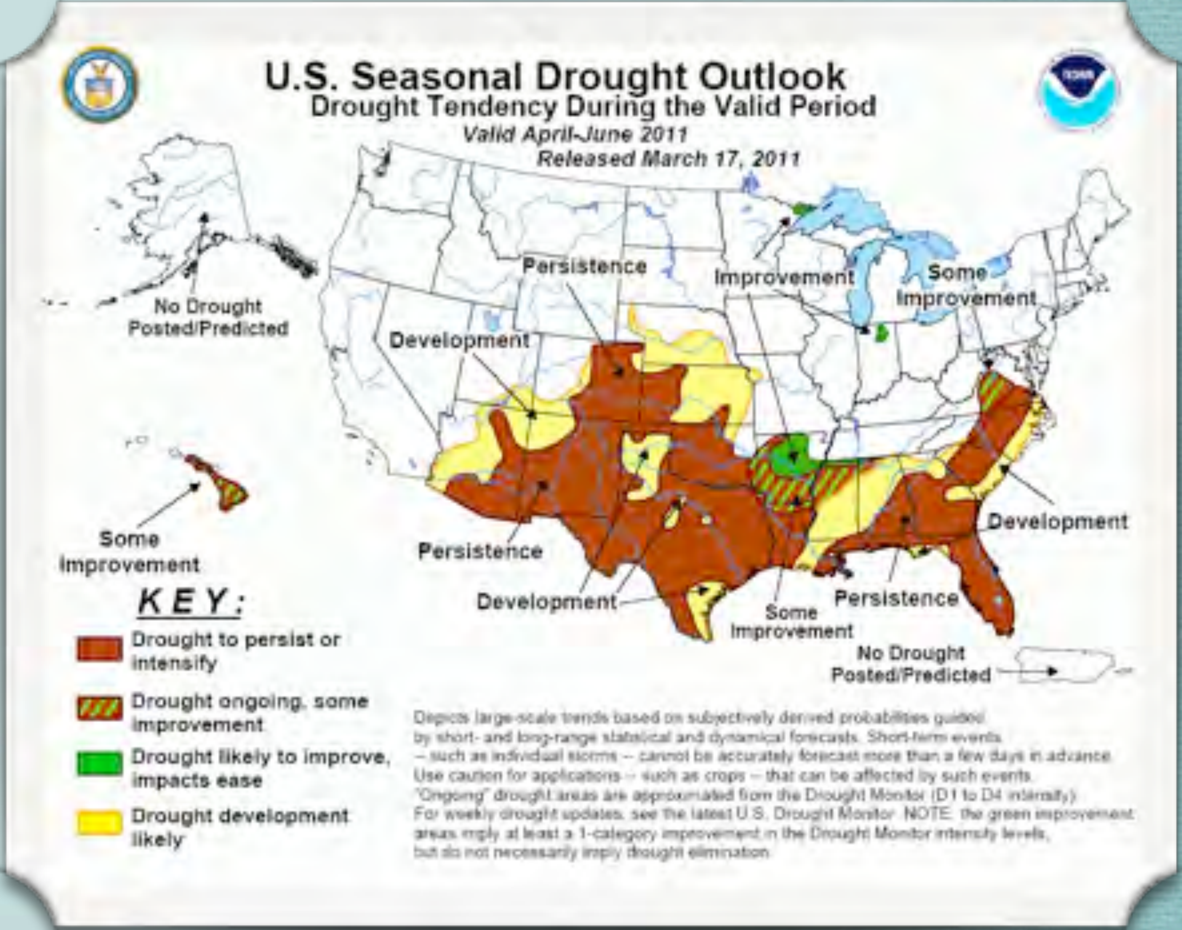
Kelly M. Polk, District Manager
Saticoy Sanitary District and
Montalvo Municipal Improvement District
3555 Ventura Road
Ventura, California 93003

who designed and authorized the testing of the salinity conditioning method discussed below.

Their Saticoy papers are found on the Earth Renaissance Technologies, LLC website: http://www.earthrenaissancetechnologies.com.

WWTP COSTS AND WATER NEEDS DRIVE DEMAND FOR RECLAIMED WATER




U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid April-June 2011

Released March 17, 2011

KEY:

- 🟥 Drought to persist or intensify
- ▨ Drought ongoing, some improvement
- 🟩 Drought likely to improve, impacts ease
- 🟨 Drought development likely

Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Short-term events -- such as individual storms -- cannot be accurately forecast more than a few days in advance. Use caution for applications -- such as crops -- that can be affected by such events. "Ongoing" drought areas are approximated from the Drought Monitor (D1 to D4 intensity). For weekly drought updates, see the latest U.S. Drought Monitor. NOTE: the green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.

WWTP BENEFITS FROM RECLAIMED WATER

- Revenues from sales of irrigation water
- Revenues from sales of fertilizers added
- Farmer receives reliable supply of water in times of drought
- Salt buildup in irrigation basins reduced when WWTP doesn’t remove nutrients with water loss processes concentrating salts, so farmers don’t add back fertilizers with more salts.

TYPICAL COMPOSITION OF UNTREATED DOMESTIC WASTEWATER

Contaminants in mg/L	Weak	Medium	Strong
Solids, Total (TS)	350	720	1200
Dissolved (TDS)	250	500	850
Suspended Solids (SS)	100	220	350
Settleable Solids	5	10	20
BOD at 20 degrees C	110	220	400
Total Organic Carbon (TOC)	80	160	290
Chemical Oxygen Demand (COD)	250	500	1000
Nitrogen (Total as N)	20	40	85
Organic	8	15	35
Free Ammonia	12	25	50
Nitrites	0	0	0
Nitrates	0	0	0
Phosphorus (Total as P)	4	8	15
Organic	1	3	5
Inorganic	3	5	10
Chlorides	30	50	100
Sulfate	20	30	50
Alkalinity (as CaCO3)	50	100	200
Grease	50	100	150
Total Coliforms (CFU 100 m/L)	10E6 - 10E7	10E7 - 10E8	10E8 - 10E9
Vololaile Organic Compounds (VOCs)	<100	100 - 400	>400

*Summary of Timothy G. Ellis' Table 8 adaptation from Metcalf and Eddy (1991) Wastewater Engineering. Treatment Disposal Reuse, G. Tchobanogious and F.L. Burton (Eds.), 1820 pp. New York: McGraw-Hill

FERTILIZER VALUE

CONSTITUENT	LBS/AF	CURRENT $ VALUE/AF
Total Nitrogen	**35.4**	**18.83**
Phosphorus	**14.14**	**8.47**
Calcium	**920**	**73.00**
Magnesium	**220**	
Potassium	**68**	**29.71**
Sodium*	**870**	
Sulfate	**1840**	**257.76**
Chloride	**120**	
TOTAL FERTILIZER VALUE		**387.81/AF**

**Not Dollar Valued* is printed as: **Not Dollar Valued*

Conditioned treated effluent at Saticoy contained 13 mg/L total Nitrogen and 5.2 mg/L total Phosphorous, 337 mg/L Calcium, 81 mg/L Magnesium, 25 mg/L Potassium, and 3319 mg/L Sodium, 1749 mg/L Sulfate, 120 mg/L Chloride, and 28 mg/L Nitrate. Assuming current prices for Nitrogen at $.532/lb, Phosphate at $.599/lb, Calcium at $.08/lb, Potash at $.437/lb, and Sulfuric acid at $.14/lb, the values of the fertilizers contained in the treated effluent would have a total fertilizer value of $387.81/AF.

IRRIGATION WATER PRICES/COSTS

Table 2.1.3 - Costs of irrigation water by source and category, 2003

Cost Category	Acres Incurring the Cost	State-Level Cost Range	National Average Cost	Total National Costs
	Million/Percent	Dollars/Acre	Dollars/Acre	$'s in Millions
Energy expenses for pumping ground water	32.34/61.5	7- 176	39.50	1,277.54
Energy expenses for lifting or pressurizing surface water	10.56/20.1	10 – 82	26.39	278.72
Water purchased from off-farm sources	13.87/26.4	5 – 86	41.73	578.75
Maintenance/repair expenses	40.01/76.1	4 – 80	12.29	491.77
Total variable costs				2,622.37
Average variable cost (including acres with no cost)			49.87	
Capital investment expenses[1] incurred in 2003	26.67/50.7	16 – 187	42.18	1,125.13

[1] Over $13,000 per farm, distributed based on average farm size to compute per-acre expenses.

Source: USDA, ERS, based on the 2003 Farm and Ranch Irrigation Survey, USDA (2004b)

RECLAIMED WATER CONCERNS

Table 1: Constituents of concern in wastewater and irrigation with reclaimed municipal wastewater

Constituents	Measured parameters	Reason for concern
Suspended solids	Suspended solids, including volatile and fixed solids	Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharge in the aquatic environment. Excessive amounts of suspended solids cause soil plugging in irrigation systems.
Biodegradable organics	Biochemical oxygen demand, chemical oxygen demand	Composed principally of proteins, carbohydrates and fats. If discharged to the environment, their biological decomposition can lead to the depletion of dissolved oxygen in receiving waters and to the development of septic conditions.
Pathogens	Indicator organisms, total and fecal coliform bacteria	Communicable diseases can be transmitted by the pathogens in wastewater: bacteria, virus, parasites.
Nutrients	Nitrogen Phosphorus	Nitrogen, phosphorus, and potassium are essential nutrients for plant growth, and their presence normally enhances the values of the water for irrigation. When discharged to the aquatic environment, nitrogen and phosphorus can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, nitrogen can also lead to the pollution of groundwater.
Stable (refractory) organics	Specific compounds (e.g. phenoic, pesticides,	These organics tend to resist conventional methods of wastewater treatment. Some organic compounds are toxic in the environment, and their presence may limit the suitability of the wastewater for irrigation.
Hydrogen ion activity	pH	The pH of wastewater affects metal solubility as well as alkalinity of soils. Normal pH range in municipal wastewater is 6.5 - 8.5, but presence of industrial waste can alter pH significantly.
Heavy metals	Specific elements	Some heavy metals accumulate in the environment and are toxic to plants and animals. Their presence may limit the suitability of the wastewater for irrigation.
Dissolved inorganics	Total dissolved solids, electrical conductivity, specific elements	Excessive salinity may damage some crops. Specific ions such as chlorides, sodium, boron are toxic to some crops. Sodium may pose soil permeability problems.
Residual chlorine	Free and contained chlorine	Excessive amount of free available chlorine (> 0.05 mg/L CL^2) may cause leaf-tip burn and damage some sensitive crops. However, most chlorine in reclaimed wastewater is in a combined form, which does not cause crop damages. Some concerns are expressed as to the toxic effects of chlorinated organics in regard to ground water contamination.

Source: Asano et al., 1985

WWTP OPERATOR
LAND APPLICATION CONCERNS

- **Meet WWTP Discharge Permit Requirements**
  - Disinfection, Heavy Metals Removal, Solids Removal
- **Protect Crops**
- **Protect Land by Compliance with Land Application Health Regulations:**
  - Federal EPA Guidelines for Water Reuse
    - EPA/625/R-04/108 Sept. 2004
  - State Regulations such as:
    - California Health Laws Related to Recycled Water “The Purple Book”, June 2001 Ed.
    - Nevada Administrative Code-Reuse Regulations (NRS 445A et seq.)
    - Utah Code R317-1-3.2, R317-1-43 and R317-1-4.4

SALT REDUCTION METHODS

- Reverse Osmosis Salt Removal
  - Energy intensive
  - Brine disposal problems

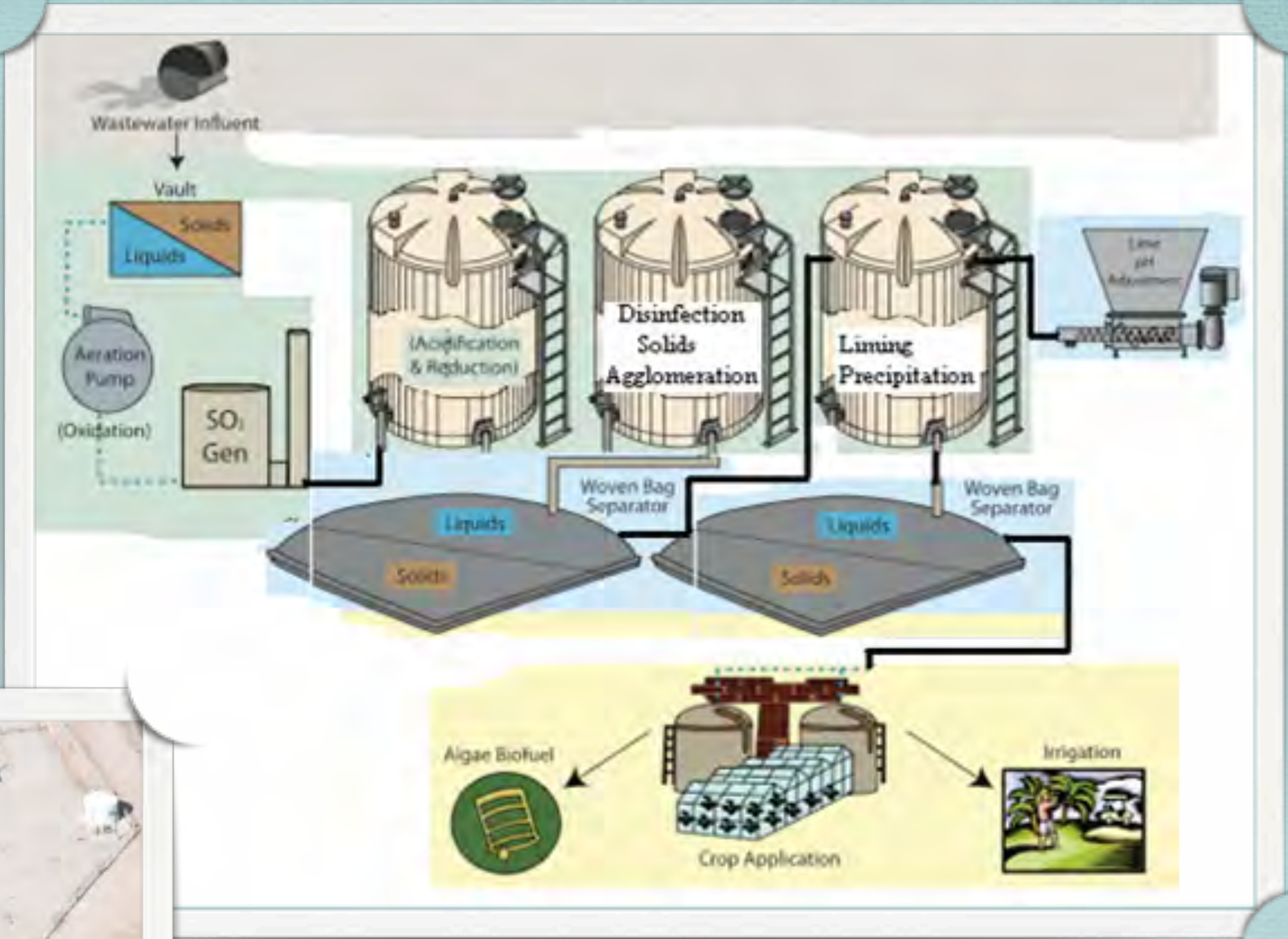
- Dilution — Poor Quality Water

- Distillation
  - Energy intensive
  - Salt disposal problems

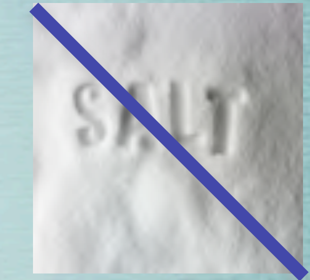
- Salt Balancing — Biobrimstone™ Method

THE BIOBRIMSTONE™ SOLUTION

Reclaimed Water



Nutrient Rich



Adjusts Salinity & Alkalinity

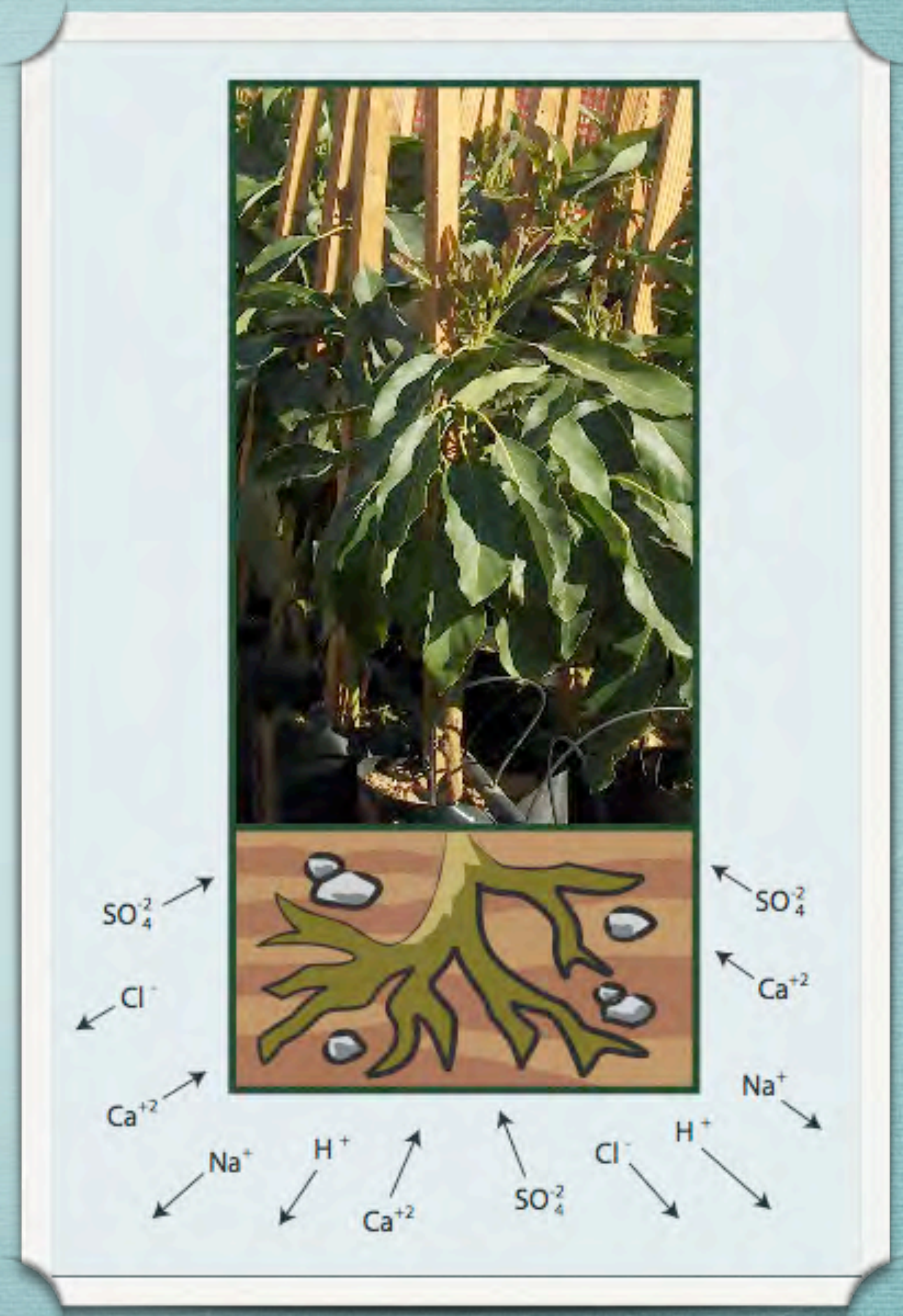
Low Cost

Lightning Fast

Saticoy Sanitary Improvement District

CROP PROTECTION – SALT BALANCING

- ***Roots osmotically absorb nutrients and act similar to ion exchange columns when adsorbing and absorbing nutrients.***
  - Root salinity Cation Exchange Capacity
- ***Solutions Incorporate WWTP processes producing bi-valent ions (Ca^{+2}, SO_4^{-2})***
  - Bivalent ions more strongly attracted aiding plant growth
  - Harmful monovalent Chloride and Sodium ions repelled and leached away from roots with acid
- ***Reduce plant risk exposure by***
  - Using reasonable irrigation practices where ECw< 0.7.
  - Raising more salt resistant plants.



WHAT'S ECw?

- Electrical conductivity is a measure of the capacity of water to conduct electrical current and is directly related to the concentration of salts dissolved in water (TDS).
    - ***The Effect of the Electrical Conductivity on Plants***

- Excessively high salinity can affect plants in the following ways:
    - Specific toxicity of a particular ion (such as Sodium)
    - Higher osmotic pressure around the roots prevents an efficient water absorption by the plant.

- While the electrical conductivity is a good indicator of the total salinity, it still does not provide any information about the ion composition in the water.
    - ***The <u>same electrical conductivity</u> values can be measured in <u>low quality water</u> (e.g. water rich with Sodium, Boron and Fluorides) <u>as well as in high quality irrigation water</u> (e.g. adequately fertilized water with appropriate nutrient concentrations and ratios.)***

UTAH REGS.

- Total Suspended Solids
- BOD’s
- Total Coliforms
- pH
- Disinfection

TABLE 11

Utah Water Quality Limits

	Utah constituent limit after secondary treatment			Utah constituent limit for Type II effluent			Utah constituent limit for Type I effluent		
	30 day Period	7 day period	Other req.	30 day	7 day	Other req.	30 day	7 day	Other req.
Total suspended solids (TSS), mg/L	25[a]	<35[a]	15% of municipal influent SS maximum.	25[c]	<35[e]	Daily Sampling	--[*]	<5[*]	Continuous Sampling, 2 NTU[a]; Daily No Sample >5 NTU[*]
Biochemical oxygen demand, (BOD), mg/L	25[a]	<35[a]	15% of municipal influent BOD maximum.	25[d]	--	Weekly Sampling	10[c]	--	Daily Sampling
Total coliform bacteria (# / 100mL)	2000[b]	<2500[b]	--	--	--	--	--	--	--
Fecal coliform bacteria (# / 100mL)	200[b]	<250[b]	--	--	200[f]	Daily Grab, No Sample >800	--	None Detected[f]	Daily Grab, No Sample >14
pH	6.5 to 9.0	6.5 to 9.0	Continuous or Daily Grab	6.0 to 9.0	6.0 to 9.0	Continuous or Daily Grab	6.0 to 9.0	6.0 to 9.0	Continuous or Daily Grab
Disinfection	Not Required			Required			1mg/L chlorine residual after 30 minutes or equivalent		

Alternatively CBOD may be monitored in place of BOD for secondary treatment			
Carbonaceous Biochemical Oxygen Demand, (CBOD), mg/L	25[a]	<35[a]	15% of influent CBOD maximum.

[a] Arithmetic mean, daily sampling

[b] Geometric mean, daily sampling

[c] Arithmetic mean, daily composite sampling

[d] Arithmetic mean, weekly composite sampling

[e] Weekly mean

[f] Weekly median

[*] Because Type I standards do not require testing for TSS, the values shown are for turbidity requirements.

Composite sampling = six flow proportionate samples, taken over a 24 hour period.

Source: *Utah Code R317-1-3.2, R317-1-4.3,* and *R317-1-4.4*

NEVADA REGS.

- Total Suspended Solids
- BOD’s
- Total Coliforms
- pH
- Disinfection
- ***SAR***
- ***Electrical Conductivity (EC)***

REQUIREMENTS:

A. <u>Reclaimed Water Quality Data to Provide</u>

1. BOD and TSS.

Reuse water must meet secondary treatment standards (NAC 445A.275.2). This is 30 mg/l BODs and 30 mg/l TSS, unless specifically exempt for "treatment equivalent to secondary treatment". Please consult the Division for anticipated permit limits.

2. Fecal Coliform or Total Coliform

Limits on Fecal Coliform and Total Coliform levels are based on the method of irrigation and site buffer zones as described in NAC 445A.275-280. (Refer to Appendix Seven and specific guidance sections for more details).

3. Nitrogen Speciation

Nitrogen concentrations and nitrogen forms (Ammonia, nitrate, organic) in the reclaimed water.

RECOMMENDATIONS:

B. Reclaimed Water Quality Data that the Division recommends be evaluated

1. Metals

Examine the concentrations of metals in the reclaimed water that may be present. Certain metals will inhibit plant growth and may also pose a risk to ground water quality if leached.

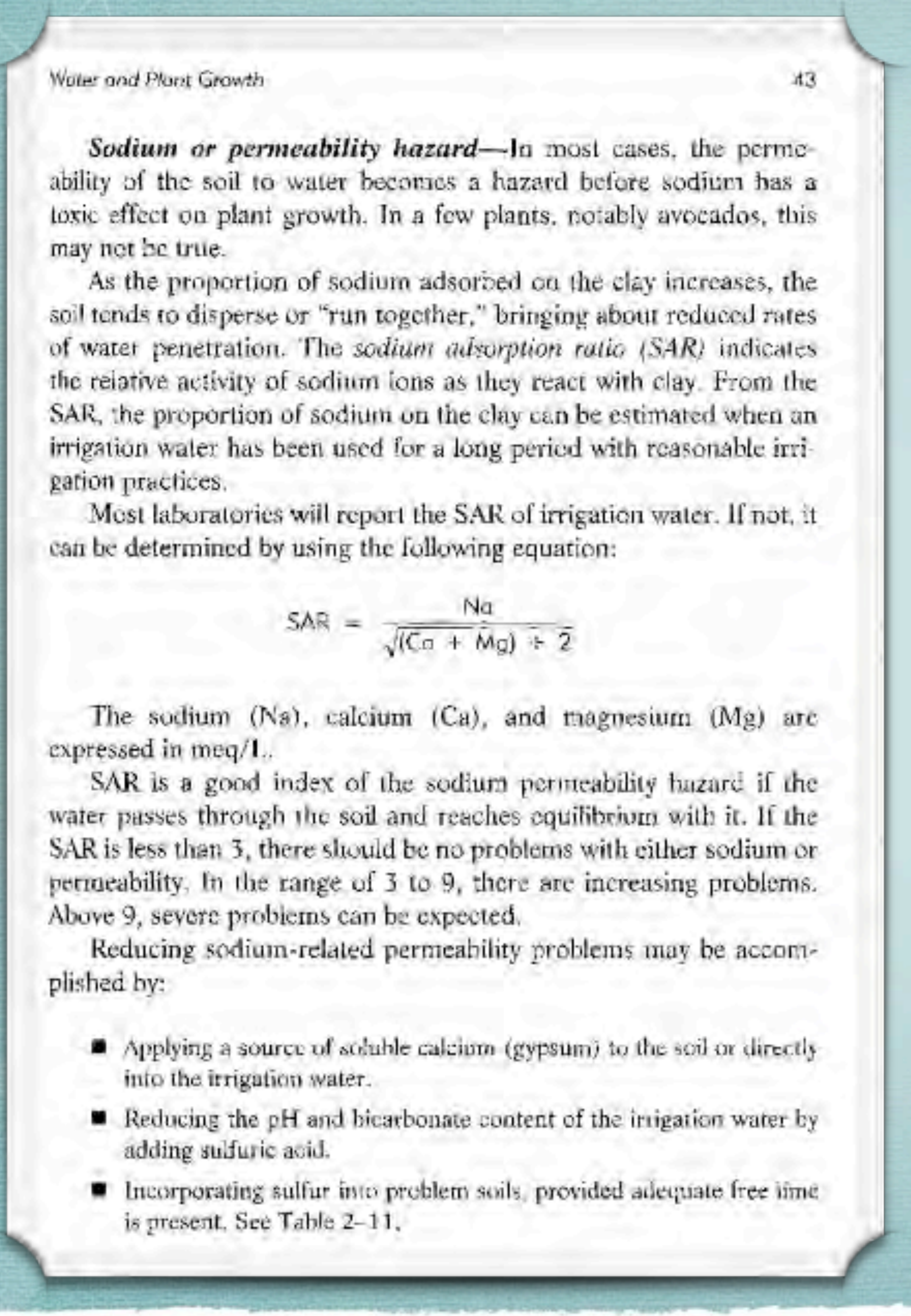
2. ***Sodium Adsorption Ratio***

Check the SAR or Adjusted SAR of the reclaimed water.

3. Significant Inorganics

Electrical Conductivity, pH, Sodium, Chloride, Boron, Phosphorus, TDS, and other pertinent inorganics as related to plant growth should be evaluated.

SAR SODIUM/CALCIUM IMBALANCE



Water and Plant Growth 43

Sodium or permeability hazard—In most cases, the permeability of the soil to water becomes a hazard before sodium has a toxic effect on plant growth. In a few plants, notably avocados, this may not be true.

As the proportion of sodium adsorbed on the clay increases, the soil tends to disperse or "run together," bringing about reduced rates of water penetration. The *sodium adsorption ratio (SAR)* indicates the relative activity of sodium ions as they react with clay. From the SAR, the proportion of sodium on the clay can be estimated when an irrigation water has been used for a long period with reasonable irrigation practices.

Most laboratories will report the SAR of irrigation water. If not, it can be determined by using the following equation:

$$\mathrm{SAR} = \frac{\mathrm{Na}}{\sqrt{(\mathrm{Ca} + \mathrm{Mg}) \div 2}}$$

The sodium (Na), calcium (Ca), and magnesium (Mg) are expressed in meq/L.

SAR is a good index of the sodium permeability hazard if the water passes through the soil and reaches equilibrium with it. If the SAR is less than 3, there should be no problems with either sodium or permeability. In the range of 3 to 9, there are increasing problems. Above 9, severe problems can be expected.

Reducing sodium-related permeability problems may be accomplished by:

- Applying a source of soluble calcium (gypsum) to the soil or directly into the irrigation water.
- Reducing the pH and bicarbonate content of the irrigation water by adding sulfuric acid.
- Incorporating sulfur into problem soils, provided adequate free lime is present. See Table 2–11.

- Apply Calcium via lime, etc.
- Add Sulfur Acid
- Western Fertilizer Handbook, page 43

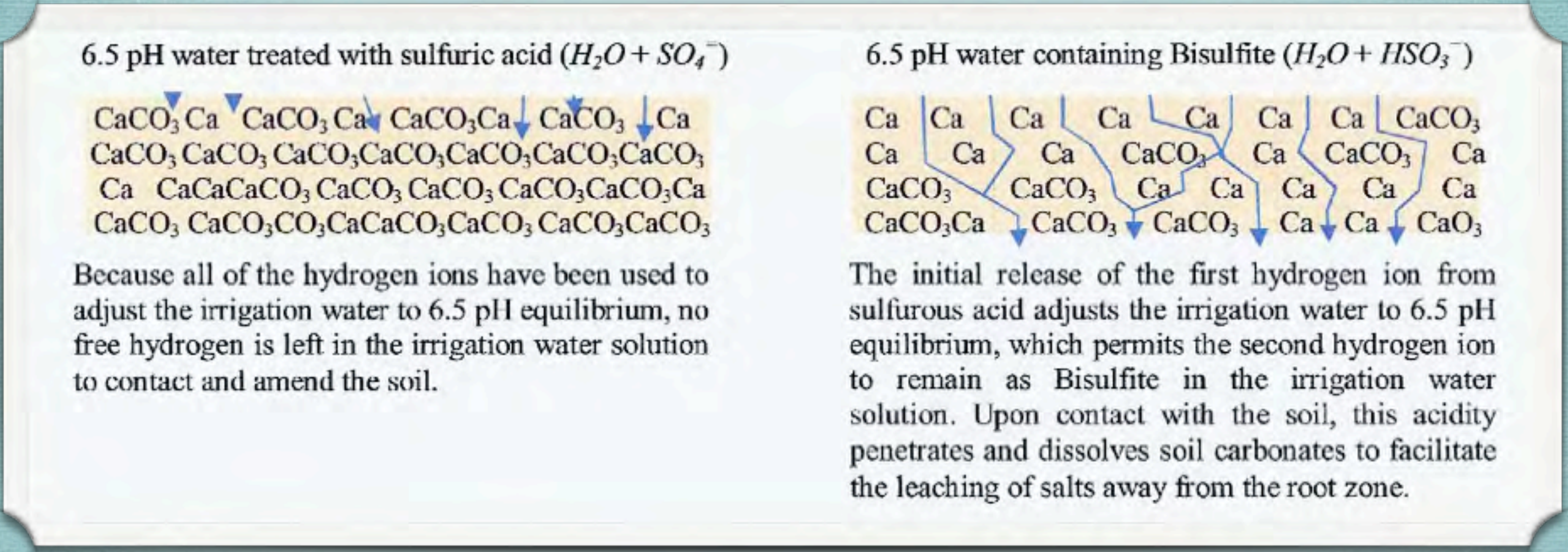
CALCIUM, ACID ADDITION

- Soils that are high in sodium ions are dispersed and resist water infiltration, while those with a high percentage of calcium ions are well aggregated and have high infiltration rates. *(Western Fertilizer Handbook, page 14)*

- ***A Sulfur Acid opens bicarbonate plugged soil pores, while providing the plant sulfur nutrients.***

- Lime adds Ca^{+2} to lower SAR protecting roots from Na^{+} ions and reduces Hydroxide ions to produce water when interacting with the acid.

SULFURIC ACID VS. SULFUROUS ACID



6.5 pH water treated with sulfuric acid ($H_2O + SO_4^-$)

Because all of the hydrogen ions have been used to adjust the irrigation water to 6.5 pH equilibrium, no free hydrogen is left in the irrigation water solution to contact and amend the soil.

6.5 pH water containing Bisulfite ($H_2O + HSO_3^-$)

The initial release of the first hydrogen ion from sulfurous acid adjusts the irrigation water to 6.5 pH equilibrium, which permits the second hydrogen ion to remain as Bisulfite in the irrigation water solution. Upon contact with the soil, this acidity penetrates and dissolves soil carbonates to facilitate the leaching of salts away from the root zone.

ELECTRICAL CONDUCTIVITY ECww (WASTEWATER)

- Generally, TDS can be estimated by the following equation:
    - ***TDS (mg/l) = 0.5 x EC (dS/m or mmho/cm)***
    - ***or = 0.5 * 1000 x EC (mS/cm)***

- The above relationship can also be used to check the acceptability of water chemical analyses.

- ***IT DOES NOT APPLY TO WASTEWATER.***
  As the solution becomes more concentrated (TDS > 1000 mg/l, EC > 2000 ms/cm), the proximity of the solution ions to each other depresses their activity and consequently their ability to transmit current, although the physical amount of dissolved solids is not affected. At high TDS values, the ratio TDS/EC increases and the relationship tends toward TDS = 0.9 x EC.

- Have regulators identify ECww concerns by types of salts/solids and use other testing methods for high TDS.

Formulas taken from: http://www.lenntech.com/applications/ultrapure/conductivity/water-conductivity.htm#ixzz1HSQPtbae

SOIL ELECTRICAL CONDUCTIVITY

Salinity is a soil property referring to the amount of soluble salt in the soil. It is generally a problem of arid and semiarid regions. Electrical conductivity (EC) is the most common measure of soil salinity and is indicative of the ability of an aqueous solution to carry an electric current. Plants are detrimentally affected, both physically and chemically, by excess salts in some soils and by high levels of exchangeable sodium in others. Soils with an accumulation of exchangeable sodium are often characterized by poor ***tilth*** and low ***permeability*** making them unfavorable for plant growth.

By agricultural standards, soils with an EC greater than 4 dS/m are considered saline. In actuality, salt-sensitive plants may be affected by conductivities less than 4 dS/m and salt tolerant species may not be impacted by concentrations of up to twice this maximum agricultural tolerance limit. Thus, the reclamation scientist must exercise care in interpretation of salinity standards. Salinity should be defined in terms of the predisturbance land use potential, the proposed postdisturbance land use, and the plant species to be seeded on the site (Munshower, 1994).

Montana State University of Bozeman "Ecosystem Restoration", September 1, 2004

****Bicarbonates easiest to remove with bivalent sulfite/sulfate acid addition producing water, bivalent sulfites/sulfates, and carbon dioxide vented to atmosphere while opening up soil pores.***

SODIUM/CHLORIDE HAZARDS

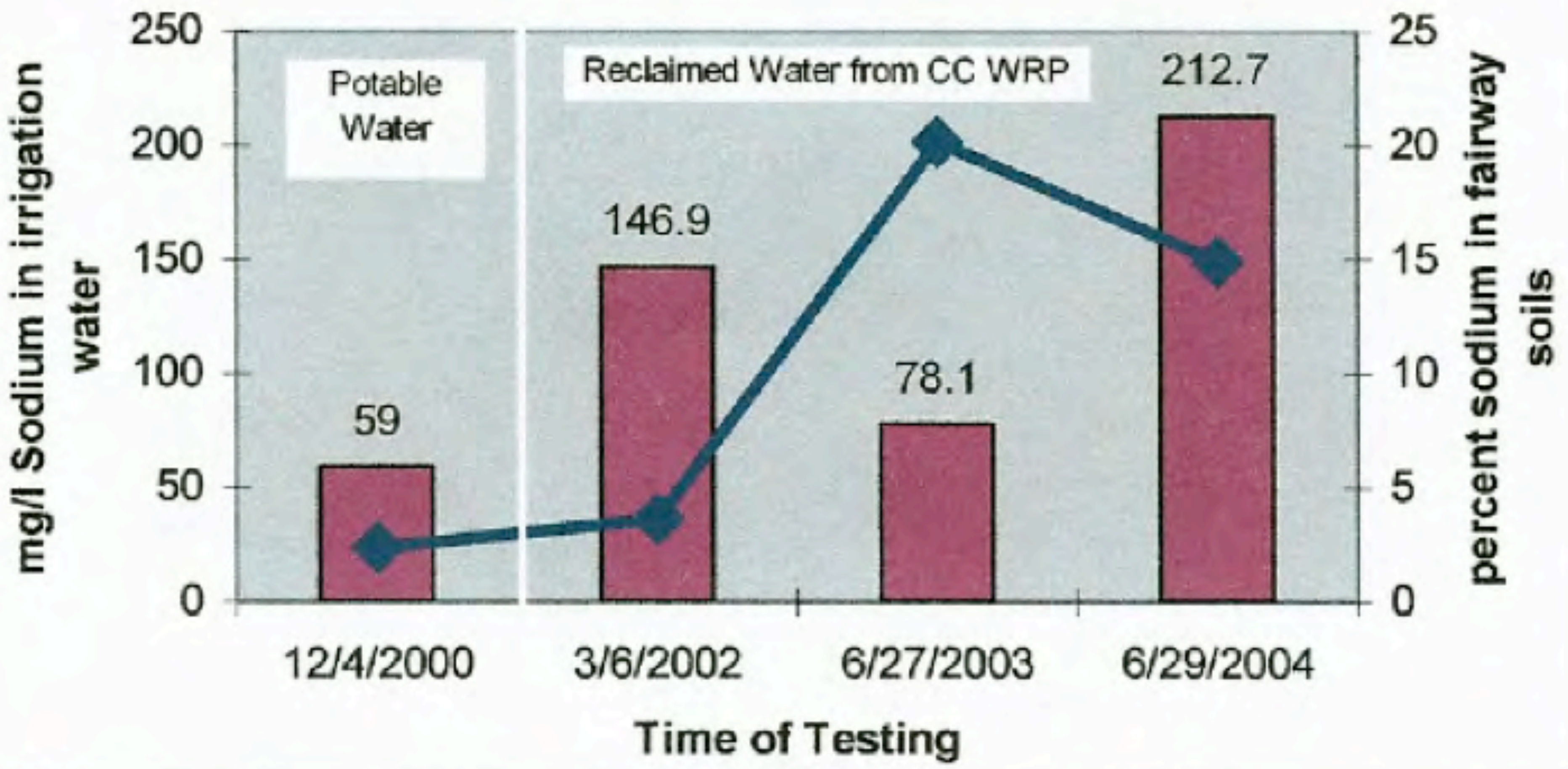
- ***Trees, vines, and woody ornamentals may be sensitive to excessive sodium. SAR values above 9 may severely impact growth as well as soil permeability.*** *(p-59 Western Fertilizer Handbook)*

- ***… high concentrations of chloride are toxic to some plants, particularly woody species with Avocados being some of the most sensitive experiencing leaf damage at 5.0-7.5 meg/L*** *(p-57-58 Western Fertilizer Handbook)*

EVIDENCE OF SALT IMBALANCE CAUSED BY USE OF RECOVERED WASTEWATER

CENTRAL ARIZONA SALINITY STUDY SEPTEMBER 2006

Figure 4.0 Rising Salinity in Turf Fairway



CALCIUM/SODIUM SALINITY IMBALANCE

CAVE CREEK WATER RECLAMATION PLANT WATERING
DESERT MARRIOT GOLF COURSE

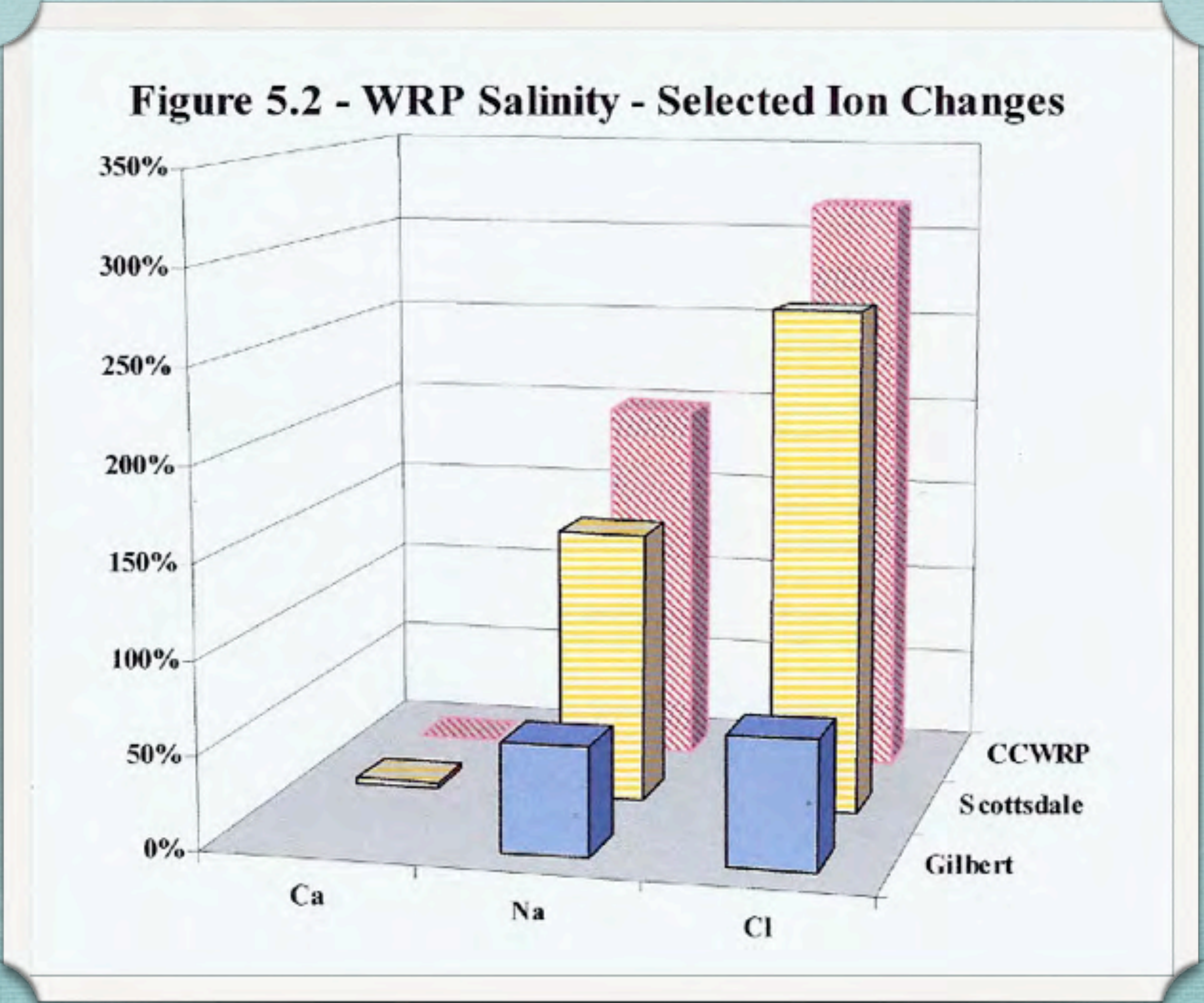
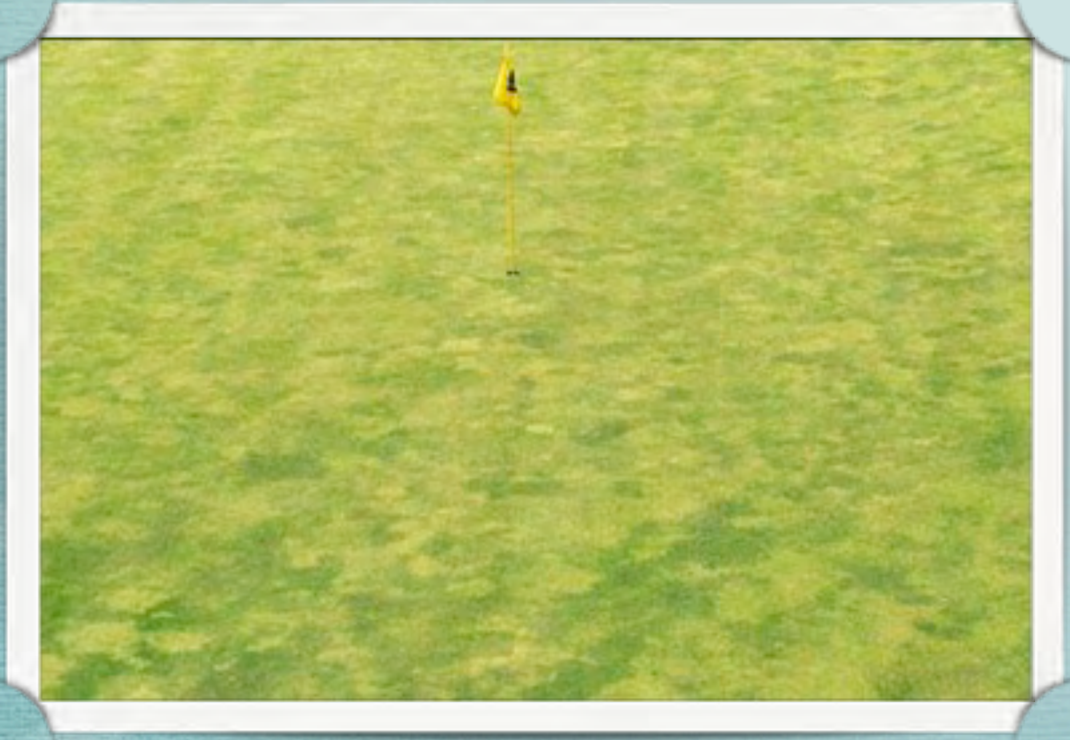


Figure 5.2 - WRP Salinity - Selected Ion Changes

OTHER SALT IMBALANCE LOCATIONS



PEBBLE BEACH

- **Symptoms**: Slight discoloration (browning) of rye turfgrass. Mottled Greens Poa Annu (blue grass)

- **Diagnosis**: The golf-course superintendent attributes the browning of the turfgrass to recycled water containing high sodicity. The Poa Annu grass was selected for use with recycled wastewater.

- **Solution**: Apply to turfgrass a calcium amendment, such as gypsum, then leach. Use different grass for greens without variegated coloring.

TURFGRASS SALT SENSITIVITY

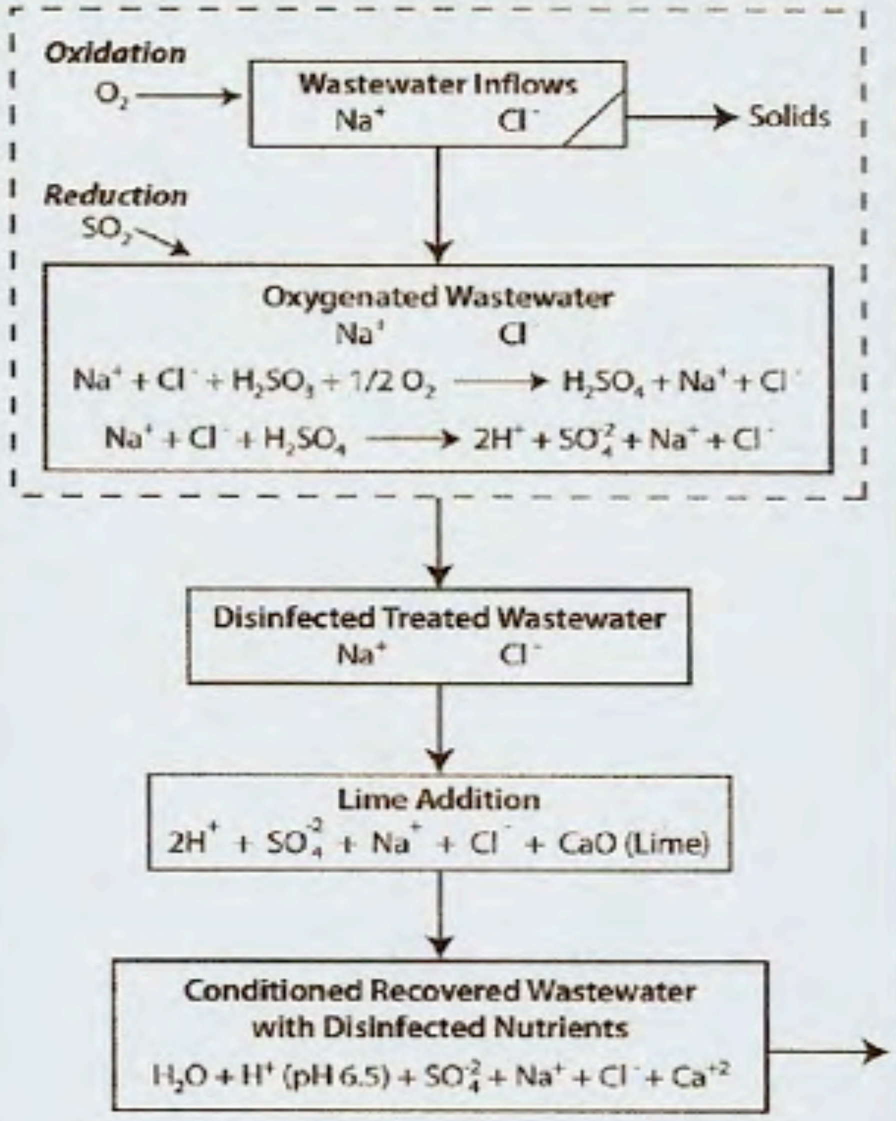
Table 1. Approximate salt tolerance of turfgrass species.

Turfgrass Species	Salt Tolerance* (mmhos/cm)	Growth Habit
Kentucky Bluegrass	3-6	Sod-forming grass
Buffalograss	3-6	Sod-forming grass
Blue Grama	5-6	Bunch grass
Smooth Bromegrass	6-8	Sod-forming grass
Perennial Ryegrass	8-10	Bunch grass
Tall Fescue	8-10	Bunch grass
Red Fascue	8-12	Sod-forming grass
Crested Wheatgrass	8-12	Weak sod-forming grass
Bermudagrass	16-18	Sod-forming grass
‘Fults’ alkaligrass	20-30	Bunch grass

*Salt levels above which noticeable plant growth reduction and management problems normally occur; mmhos/cm is an expression of the salt content of the soil. This number increases as the salt content of the soil increases and is easily determined by a soil test.

“Growing Turb on Salt-Affected Sites” Col. State U. Extension by C.E. Swift et al

BIOBRIMSTONE™ SALT BALANCING ALTERNATIVE



The acid prevents the formation of gypsum ($CaSO_4 \cdot 2H_2O$) which could clog the soil pores and allows the soluble bivalent sulfate (SO_4^{2}) cations to exchange on the soil Cation Exchange sites. This pushes the sodium ions (Na^+) off and allows them to leach downward along with the chloride ions (Cl^-).

- All natural chemicals: air, acid rain, lime
- Solids agglomeration w/o polymers
- Disinfection w/o chlorine
- Lime heavy metals removal
- Fast 1 hour treatment time
- Safe/Operator friendly

SATICOY AVOCADO PLANT COMPARISON

Wastewater

Nursery

SATICOY TESTING RESULTS

- All but two of the test avocado plants raised on saline recovered conditioned treated effluent survived through the critical test transplanting and secondary growth periods.
- The test avocado plants were raised exclusively by saline recovered treated effluent as no rain occurred during the test period and the plant leaves were not washed.
- The need for fertilizer supplements added to the saline conditioned treated effluent was reduced significantly.
- The plant soils were acidified slightly to reduce bicarbonate/carbonate buildup for better water penetration and reduce the amount of water required for crop propagation.
- The saline recovered conditioned treated effluent was disinfected without chlorine to the fecal coliform level required by Health Department recovered treated wastewater regulations.
- None of the test avocado plants showed salt buildup in the leaves requiring the test plants to be sprayed with culinary water to remove salt buildup, or the conditioned treated effluent diluted with culinary water.
- The test avocado plants were somewhat behind in growth compared to those control avocado plants raised under controlled nursery conditions.
- The test avocado plants survived being watered with the conditioned saline treated effluent through the end of the test period.

Table 1. Plant nutrient data for wastewater irrigation at the Saticoy - Jose Flores Treatment Facility in the Spring and Summer of 2008.

Avocado Plant Tissue Analysis

September 2008

Nitrogen %	Phosphorous %	Calcium %	Magnesium %	Potassium %	Sodium %	Sulfur %	Boron ppm
2.54	0.19	1.03	0.38	1.29	0.01	0.35	73
			Copper ppm	**Iron ppm**	**Manganese ppm**	**Zinc ppm**	
			13	166	177	39	

Table 2. Avocado plants were transplanted on May 12, 3008 and subsequent height and appearance during the Summer of 2008.

Date	Height (inches)	Appearance	Comments
May 12, 2008	7	New clonal seedlings	
May 21, 2008	12	Healthy	
May 28, 2008	16	Healthy	
June 4, 2008	16	Wind tip damage	
June 15, 2008	16	Starting to second growth	
July 9, 2008	18	Healthy second growth	NH4OH added
July 24, 2008	19	Healthy second growth	NH4OH added
August 5, 2008	19 to 22	Healthy second growth	NH4OH added
September 17, 2008	24	Healthy second growth	NH4OH added

Table 3. Nutrient Data for Irrigation Water at the Saticoy - Jose Flores Treatment Facility in the spring and summer of 2008.

Sample Date	Nitrogen	Nitrogen Total	Nitrogen Nitrate + Nitrite	Phosphorous Kjeldahl N	Calcium	Magnesium	Potassium	Sodium
	mg N/L	mg N/L	mg N/L	mg N/L	mg N/L	mg N/L	mg N/L	mg N/L
Treated Effluent								
June 12, 2007	5	3	2	2	177	68	23	315
May 12, 2008	12.9	40	9	158	85	18	350	
Batches with SO_2								
1. May 12, 2008	80	5.1	70	10	241	131	20	379
2. May 21, 2008	17	2.4	15	5	393	96	23	350
Leftover water:								
2. June 4, 2008					456	109	26	321
3. June 18, 2008	13	5.5	8	4	434	71	24	344
5. August 8, 2008	129	49.7	70	8	343	86	24	374
6. Sept. 13, 2008	70	53.9	70	5	837	75	25	201
7. Sept. 17, 2008	90	58	30	5	395	51	23	200
Batch Averages								
	59	25.8	38	6	426	84	23	310

Table 4. Anion Nutrient Data for Water at the Saticoy - Flores Treatment Facility in the spring and summer of 2008.

Sample Date	Carbonate	Bicarbonate	Sulfate	Chloride	Nitrate	Fluoride	Boron
	mg CO_3 / L	mg HCO_3 / L	mg SO_4 / L	mg Cl / L	mg NO_3 / L	mg F / L	mg B / L
Treated Effluent							
June 12, 2007	< 10	390	840	110	13.5	0.2	0.85
May 12, 2008	ND	140	1180	100	81	0.3	1.1
Batches with SO_2							
1. May 12, 2008	ND	ND	1710	109	22.3	0.4	1.2
2. May 21, 2008	<10	<10	1780	120	10.4	0.4	0.9
Leftover water:							
2. June 4, 2008	<20	<20	2410	120	10.5	0.4	1.0
3. June 4, 2008	<10	<10	1840	120	28	0.5	1.0
4. June 18, 2008	ND	50	1250	120	26.6	0.6	1.0
5. August 8, 2008	<10	110	1570	130	219	0.5	1.1
6. Sept. 17, 2008	ND	70	970	110	262	0.3	0.9
7. Sept. 17, 2008	<10	60	920	110	259	0.1	0.7
Batch Averages							
	10.0	51.7	1255.7	117.0	118.2	1.4	1.0

Table 5. Micronutrient Metal Data for Water at the Saticoy - Jose Flores Treatment Facility In the spring and summer of 2008.

Sample Date	Copper mg Cu / L	Iron mg Fe / L	Manganese mg Mn / L	Zinc mg Zn / L
Treated Effluent				
June 12, 2007	0.02	0.1	0.02	0.08
May 12, 2008	ND	110	70.00	ND
Batches with SO_2				
1. May 12, 2008	ND	220.00	150.00	40.00
2. May 21, 2008	0.04	1.40	0.06	0.04
Leftover water:				
2. June 4, 2008	0.05	1.30	0.07	0.05
3. June 4, 2008	<0.01	0.59	0.03	0.03
4. June 18, 2008	<0.01	0.27	0.03	0.05
5. August 8, 2008	<0.01	0.16	0.06	<0.02
6. Sept. 13, 2008	20.00	560.00	70.00	100.00
7. Sept. 17, 2008	<0.01	0.25	0.02	0.04
Batch Averages				
	3.35	111.81	31.46	20.03

Table 6. Water Quality Data for Irrigation Water at the Saticoy - Jose Flores Treatment Facility in the spring and summer of 2008.

Sample Date	pH	Alkalinity mg / L	Total Hardness mg / L	E.C. ‡ mmhos / cm dS / m	TDS § mg / L	SAR ¶
Treated Effluent						
June 12, 2007	7	320	720	2.46	2000	5.1
May 12, 2008	7.2	110	744	3.11	2110	5.6
Batches with SO_2						
1. May 12, 2008	6.2	ND †	1140	3.72	2610	4.9
2. May 21, 2008	7.9	ND	1380	3.57	2770	4.1
Leftover water:						
2. June 4, 2008	3.2	ND	1590	4.34	3450	3.5
3. June 4, 2008	6.4	ND	1170	3.64	2750	4.0
4. June 18, 2008	6.9	40	1370	3.18	2320	4.0
5. August 8, 2008	6.3	90	1210	4.06	2860	4.7
6. Sept. 13, 2008	6.4	60	2400	2.94	2550	1.8
7. Sept. 17, 2008	6.6	60	1410	3.39	2554	3.7
Batch Averages						
	6.6	60	1410	3.39	2554	3.7

- ND † = Not Detected
- E.C. ‡ = Electrical Conductivity
- TDS § = Total Dissolved Solids
- SAR ¶ = Sodium Adsorption Ratio

Table 7. Microbiological Evaluation for Irrigation Water at the Saticoy - Jose Flores Treatment Facility in the Spring and Summer of 2008.

Sample	Characteristic	Date	Coliforms Total MPN † / 100 mL	Coliforms Fecal MPN / 100 mL
Treated Effluent				
		April 15, 2008	<2	<2
		May 12, 2008	50	<2
		June 18, 2008	158	6
Batches with SO_2				
1		May 12, 2008	119	2
2		May 21, 2008	27	< 1
2	Leftover water	June 4, 2008	> 2420	2
3		June 4, 2008	16	< 1
4E	Raw Effluent	June 18, 2008	158	6
4		June 18, 2008	16	< 1
5E	Raw Effluent	August 8, 2008	> 2420	18
5		August 8, 2008	649	5E
6E	Raw Effluent	September 13, 2008	> 2420	> 2420
6		September 13, 2008	1410	1
7E	Raw Effluent	September 17, 2008	> 2420	> 2420
7		September 17, 2008	> 2420	30**
Batch Averages				
			665	2

- † MPN = Most Probably Number of microorganisms

ADVANTAGES OF BIOBRIMSTONE™ SALINITY/ACID BALANCING

- Uses treated wastewater without salt removal or dilution blending.
- Uses sulfur dioxide to reduce the pH to 2 allowing disinfection without chlorine.
- Reduces significantly the need for fertilizer addition to potable water.
- Reduces or eliminates the need for flushing plants, or purging, thereby saving gal/plant/ wk.
- Delivered cost for sulfurous acid reclaimed wastewater is equal to or comparable to that of domestic potable water priced at approx. $180/ acre foot.
- Delivered sulfur treated reclaimed wastewater @ 6.5 pH opens soil pores and allows greater depth of water penetration reducing the amount of water usage. Three gal/plant/wk to only two gals/plant/wk.
- Reduces the amount of fertilizer or eliminates the need for additional nutrients; therefore reducing annual salt addition to ground water.
- Allows greater water penetration to soil eliminating the run off from irrigation.
- Reclaimed sulfur treated wastewater is a new water source with priority water rights that can be delivered in times of drought on a consistent uninterrupted basis.
- Equipment and operation is simple for consistent, cost effective delivery of treated wastewater for re-use.
- Reduces air emissions from bacteria breakdown of conventional treated conditioned treated wastewater and solids due to chemical kill.
- Inactivates many pharmaceutical and chemical species.

CALIFORNIA EXPERIENCES USING SALINE WATER / WASTEWATER

- Broadview Water District, San Joaquin Valley uses re-cycled drainage water blended to produce degraded in quality water for raising crops more tolerate to salinity.
- Imperial Irrigation District, Imperial Valley uses tile drainage to collect saline drainage water from the Colorado applied to raise wheat and cotton for discharge into the Salton Sea.
- Fresno wastewater treatment facility discharges 150,000 gpd treated wastewater to raise cotton, barley, alfalfa, almonds, grapes, oats, wheat, sorghum, seed beens and silage maize grown on adjacent lands.
- Bakersfield in the San Joaquin Valley uses treated wastewater for raising barley, maize, alfalfa, sorghum, and permanent pasture per a crop rotation plan changing crops when salinity levels permit.
- Tuolumine Regional Water District treats urban wastewater for conveyance to private landowners for irrigation of 500 hectares of seed crops, forage and pasture land.
- Santa Rosa, California operates an extensive wastewater irrigation system to supply twenty farms with reclaimed wastewater used to raise maize, sudan grass, oats and winter feed for livestock.

See FAO Corporate Document Repository, "Water Quality for Agriculture," http://www.fao.org/docrep/003/t0234e/TO234E09 for more details.