United States Department of Agriculture
NATURAL RESOURCES CONSERVATION SERVICE
Plant Materials Technical Note No. MT-61
September 2007

PLANT MATERIALS TECHNICAL NOTE

TESTING AND INTERPRETING SALT-AFFECTED WATER FOR TREE AND SHRUB PLANTINGS

Joseph Scianna, Research Horticulturist, USDA, NRCS, Plant Materials Center, Bridger, Montana
Tom Pick, Water Quality Specialist, USDA, NRCS, Bozeman, Montana
Robert Logar, State Staff Forester, USDA, NRCS, Bozeman, Montana

SALTY IRRIGATION WATER INJURY ON AMERICAN PLUM

INTRODUCTION

In many parts on the arid and semi-arid West, it is necessary to provide supplemental water to trees and shrubs to enhance their survival and growth. The quality of this water can dramatically influence plant survival and growth, and high levels of dissolved salts in irrigation water and soil are common, and frequently injurious to woody plants. Although it is relatively easy to classify irrigation water as "suitable" or "non-suitable" for most plants on good quality or well-defined soil, suitability becomes more subjective when predicting the effect of marginal quality irrigation water on marginal or undefined soil. Furthermore, water quality is only one of several factors to be considered when using salt-affected water. Other considerations include the salinity (saltiness) of the soil, soil texture (relative amounts of sand, silt, and clay), the plant species in question, the local climate, and the types of cultural practices that will be implemented. **In order to make meaningful water quality interpretations, it is necessary to consider both water and soil quality factors simultaneously.** For soil salinity testing and interpretation, see *Testing and Interpreting Salt-Affected Soil for Tree and Shrub Plantings*, Plant Materials Technical Note No. MT-60 at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/. For approximations of tree and

shrub salinity tolerance, see HortNote No. 6, *Selecting Plant Species for Salt-Affected Soils* at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/pmpubs/index.html#hortnotes.

This technical note provides basic guidelines for interpreting water quality tests and then making practical assessments of its suitability as irrigation water for tree and shrub plantings. The focus of this technical note is salt-affected water, since this condition frequently limits woody plant survival and growth in the northern Great Plains and Intermountain West. This document provides only simple guidelines and limited explanation. If the reader would like more detailed information, see *Determining the Suitability of Salt-Affected Water and Soil for Tree and Shrub Plantings*, Plant Materials Technical Note No. MT-62 at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/.

WHAT WATER QUALITY TESTS SHOULD A PERSON REQUEST? There are several tests that can be conducted on a sample of potentially salt-affected water to determine it's suitability for irrigating trees and shrubs. The more information that is available to the irrigator, the better the water quality interpretation that can be made. The following five tests are considered essential, and when evaluated together should provide a comprehensive overview of the suitability of a water source for irrigating tree and shrub plantings (see ANALYSIS REPORTS 1 and 2 at the end of this document for examples of comprehensive water quality tests and interpretations for salt-affected water).

WATER SALINITY TESTING

1. **Water Salinity** is an indicator of the total amount of dissolved salt in solution in a given water sample. A total salinity test indicates the saltiness level of the water, but does not identify which salts comprise that salinity, which may be important. In the western United States the most common ions of concern are calcium (Ca), magnesium, (Mg), and sodium (Na). Total salinity is measured indirectly by an **Electrical Conductivity** (EC_w) test or directly via a **Total Dissolved Solids** (TDS_w) test. Although results are provided in different units of measure, both tests provide the same type of information and each measure can be converted to the other (see APPENDIX 1 for units of measure and conversion values). **When comparing test results to restriction of use tables, always verify that units of measure are the same.**

2. **Water Salinity Standards and Interpretations.** TABLE 1 lists potential water use restrictions at different levels of irrigation water salinity. Simply compare your water test results with these values to determine if the water salt level is "good", "fair to questionable", or "poor". Keep in mind that the tolerable level of irrigation water salinity varies with soil texture, with plants growing on coarse textured or "light" soils (sands and loamy sands) tolerating more water salinity than plants growing on fine-textured or "heavy" soils (silty clay, sandy clay, clay). It is important to note that degrees of restriction severity are somewhat arbitrary as changes actually occur gradually. In TABLE 1, degree of restriction on use "none" indicates no need for special management practices relative to water salinity only. Although total salinity may be within acceptable limits, other tests may indicate water quality problems. "Slight to moderate" restrictions indicate that plant choice may be limited and/or specialized management will probably be necessary to achieve full production. "Severe" restriction on use indicates an increasing need for specialized management, although it does not necessarily indicate a complete lack of suitability for use. Keep in mind that using water with an EC_w as low as 1 dS/m can result in unacceptably high soil salinity levels with long-term, repeated use.

TABLE 1. Salinity Tests and Standards for Irrigation Water, Units, and Potential use restrictions[1]

Potential Irrigation Problem		Units	Degree of Restriction on Use		
			None	Slight to Moderate	Severe
SALINITY (affects crop water availability)	**EC_w** [2] or	dS/m	<0.7	0.7 - 3.0	>3.0
	TDS	mg/l	<450	450-2000	>2000

[1] Adapted from University of California Committee of Consultants 1974, and Ayers and Westcot, 1994 (modified).

[2] EC_w means electrical conductivity measured in deciSiemens per meter (dS/m) at 25°C or millimhos per centimeter (mmhos/cm). Units are equivalent.

3. **Water Salinity Management Options.** What corrective actions, if any, can be taken if the water salinity level indicates that there is likely to be a problem growing trees and shrubs? This depends on the water salinity level, expense that the landowner is willing to incur, type of planting (conservation planting versus ornamental landscape), other environmental factors (soil, climate), cultural treatments (management) the landowner is willing to practice, and more. The most common water-specific treatment is to install a filtration system to reduce the amount of salt being applied to plants and soil. Another option is to dilute high salinity water with lower salinity water, or to periodically use lower salinity water (EC_w <2 dS/m; TDS <1,280 ppm) to flush or leach salts from the soil profile that accumulate as a result of irrigating with high salt water. For leaching to be successful, the soil must be well-drained enough that irrigation water readily infiltrates and percolates through the soil profile. The installation of soil drains and/or deep ripping of the soil to fracture impervious soil layers (pans) may be necessary. The selection and use of salt-tolerant trees and shrubs is another management option. The type of water delivery system can have a substantial affect on plant salinity tolerance, with drip, soaker, bubbler and flood irrigation preferred to sprinkler irrigation, especially if the sprinklers apply water to the foliage. Increasing irrigation frequency on well-drained soils can help prevent salt accumulation in the upper soil profile, but this practice can be complicated by the need to periodically deep flush the salts through the soil, and may contribute to shallow rooting of some plants. Other water salinity management options are addressed with soil treatment, and are described in *Testing and Interpreting Salt-Affected Soil for Tree and Shrub Plantings*, Plant Materials Technical Note, MT-60 at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/. It is recommended that landowners consult water treatment specialists, their local county extension agent, or their local USDA Natural Resources Conservation Service office for specific recommendations.

WATER SODIUM TESTING

1. The **sodium (Na)** level in water is another important measure of irrigation water quality. High irrigation water sodium tends to reduce soil aeration, a critical tree and shrub survival parameter. Although we can use the level of sodium alone to give us a basic idea of potential water quality problems, it is the **Sodium Adsorption Ratio (SAR_w)** that provides the best indication of the likelihood of plant growth problems resulting from the presence of this element. Most trees and shrubs can tolerate limited levels of sodium, although tolerance to sodium decreases when it is applied to the foliage (i.e., with sprinklers) versus the soil surface.

2. **Water Sodium Standards and Interpretations.** TABLE 2 lists potential water use restrictions as a function of the irrigation water sodium level. **When interpreting results, it is necessary to consider SAR_w in conjunction with EC_w because the two factors together influence water infiltration, soil aeration, and plant growth.** The best scenario occurs when the SAR_w is <3 and the EC_w is equal to or slightly greater than 0.7 dS/m. Keep in mind that a soil salinity buildup is likely over time whenever the EC_w is >0.7 dS/m, even if higher water salinity values (EC_w) are needed to prevent an infiltration and aeration problem at a given SAR_w.

TABLE 2. Sodium Tests and Standards for Irrigation Water, Units, and Potential use restrictions[1]

Water Infiltration/Soil Aeration Problem		
Water SAR_w	**Unlikely when ECw (dS/m) is more than**	**Likely when ECw (dS/m) is less than**
0-3	0.6	0.3
3-6	1.0	0.4
6-12	2.0	0.5
12-20	3.0	1.0
20-40	5.0	2.0

[1] Adapted from Ayers and Westcot, 1994 (modified).

For more information on the interaction between SAR_w and EC_w and their potential impacts on irrigation water suitability, see CHART 1 in *Determining the Suitability of Salt-Affected Water and Soil for Tree and Shrub Plantings*, Plant Materials Technical Note, MT-62 at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/.

3. **Water Sodium Management Options.** The same water treatment and management options that were described for managing other salts generally apply to sodium. Additionally, applying gypsum to irrigation water, as well as selecting sodium tolerant plant species, helps ameliorate the effects of sodium in water. Managing soil sodium is described in *Testing and Interpreting Salt-Affected Soil for Tree and Shrub Plantings*, Plant Materials Technical Note, MT-60 at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/.

TESTING FOR SPECIFIC IONS IN IRRIGATON WATER

In addition to sodium, certain ions alone, either because of their direct toxicity to plants or through their effect on water and soil chemistry, can be indicators of irrigation water quality. Dissolved ions sometimes found in the western United States in concentrations in water that are toxic to trees and shrubs include chlorides (Cl) and boron (B). Although little information is available on the tolerance of conservation tree and shrub species to these ions, use the values in TABLE 3 as guidelines for determining potential use limitations.

TABLE 3. Specific Ion Tests and Standards for Irrigation Water, Units, and Potential Use restrictions[1]

Potential Irrigation Problem			Units	Degree of Restriction on Use		
				None	**Slight to Moderate**	**Severe**
SPECIFIC ION TOXICITY (affects sensitive crops)	**Sodium (Na)** [2]	surface irrigation (SAR)		<3	3 - 9	>9
		sprinkler irrigation	meq/l	<3	>3	
		sprinkler irrigation	mg/l	<69	>69	
	Chloride (Cl) [2]	surface irrigation	meq/l	<4	4 - 10	>10
		sprinkler irrigation	meq/l	<3	>3	
		sprinkler irrigation	mg/l	<106	>106	
	Boron (B)		mg/l	<0.7	0.7 - 2.0[4]	>2.0 [4]
MISCELLANEOUS EFFECTS (affects susceptible crops)	**Nitrogen ($N0_3$-N)** [3]		mg/l	<5	5 - 30	>30
	Carbonates ($HC0_3$ and CO_3)	(overhead sprinkling only)	meq/l	<1.5	1.5 - 8.5	>8.5
		(overhead sprinkling only)	mg/l	<92	92 - 519	>519
	Residual Sodium Carbonate (RSC) (affects infiltration rate of water)		meq/l	<1.25	1.25 - 2.5	>2.5
	pH			**Normal Range 6.5 - 8.4**		

[1] Adapted from University of California Committee of Consultants 1974, and Ayers and Westcot, 1994 (modified).
[2] Most woody plants are sensitive to sodium and chloride applied via surface irrigation. With overhead sprinklers and low humidity (<30%), sodium and chloride may be absorbed through the leaves of sensitive crops.
[3] NO_3 - N means nitrate nitrogen reported in terms of elemental nitrogen (NH_4-N and Organic-N should be included when wastewater is being tested.
[4] Value amended, based on Montana Irrigation Manual values.

Sprinkler Applied Irrigation Water. It is important to note that water quality use restrictions may be more limiting when irrigation water is applied by sprinkler systems. Acceptable concentrations of specific ions in surface-applied irrigation water may cause plant injury if applied directly to foliage. In addition, frequent, low volume applications of salty irrigation water can result in rapid salt accumulation in the root zone, especially on heavy-textured (clay) soils. Potentially damaging ions include sodium, chlorides, and bicarbonates. Water quality characteristics may also affect the function and maintenance of drip irrigation systems. Salts may precipitate on emitters causing clogging and poor operation of drip systems. Check with sprinkler suppliers for water quality guidelines or see *Assessing Water Quality for Agriculture and Aquatic Life Uses*, Environment Technical Note, MT-1 at: http://www.mt.nrcs.usda.gov/technical/ecs/environment/technotes/.

WATER pH TESTING AND MANAGEMENT

Although not a salinity test per se, pH is an important indicator of the chemical status of water and should be included as part of a comprehensive set of water tests. Irrigation water pH, in conjunction with soil pH, has its primary affect on plant survival and growth via the availability of essential plant nutrients, although it also influences many physical and biological properties of soil. As alkaline (pH >7) irrigation water raises the soil pH, the availability of certain micronutrients, particularly iron (Fe) and manganese (Mn), is reduced. Inter-veinal chlorosis (yellowing) is a common symptom of iron deficiency and many species of woody plants are susceptible to low plant-available iron including Amur maple (*Acer ginnala*), members of the mountain ash genus (*Sorbus* sp.), quaking aspen (*Populus tremuloides*), members of the spirea genus (*Spiraea*), and other species found growing naturally on low pH (acidic) soils. Irrigation water pH within the 6.5 to 8.4 range is considered acceptable for most plants. Reducing high soil pH caused by application of high pH water is typically accomplished by applying acidifying fertilizers (such as ammonium sulfate, ammonium phosphate-sulfate, etc.,) to the soil or water, often in conjunction with soil applied chelated iron and manganese if inter-veinal chlorosis is noted.

WATER CARBONATE TESTING

Although considered of secondary importance to salinity, sodicity, and specific ion tests, bicarbonates (HCO_3) and carbonates (CO_3) in high pH irrigation water can worsen the soil sodium hazard. Irrigation water "carbonates" (both HCO_3 and CO_3) is measured by two methods (see TABLE 3). The first method directly measures the total carbonate level, and is used when irrigation water calcium and magnesium are low. Problems with calcium carbonate ($CaCO_3$) precipitation begin at approximately 1.5 meq/l and are considered severe above 8.5 meq/l. When water concentrations of calcium and magnesium are high, the second method, Residual Sodium Carbonate equation (RSC), is used. Over time, the repeated use of irrigation water with a high RSC value can lead to soil alkalinity or create a sodic soil if the water contains an appreciable amount of sodium (SAR > ~4). If RSC values are high (> ~2) while SAR_w values are low (< ~4), it is unlikely that infiltration problems will occur, although soil pH is still likely to rise to a detrimental level. As a general rule, RSC values less than or equal to 1.25 meq/l are safe for irrigation; 1.25 to 2.5 are marginal; and greater than 2.5 are unsuitable.

WHERE CAN A PERSON HAVE THEIR WATER SAMPLE TESTED? For a list of analytical services near you, reference your local phone book, conduct an Internet search, or access *Soil, Plant and Water Analytical Laboratories for Montana Agriculture* at: http://www.msuextension.org/store/Products/Soil--Plant-and-Water-Analytical-Laboratories-for-Montana-Agriculture__EB0150.aspx.

WHEN SHOULD A PERSON SAMPLE THEIR WATER? Ground and surface water to be used for irrigation should be sampled before application to determine its suitability for trees and shrubs. Additionally, water quality should be tested over the course of the irrigation season. Since most tree and shrub irrigation occurs in late spring through mid-summer, initial testing in late spring to early summer of the year prior to planting is an ideal time to begin. Analytical laboratories usually list test costs, sampling, and preservation procedures on their web page.

REFERENCES

Ayers, R.S. and D.W. Westcot. 1994. Water Quality for Agriculture, revised. FAO Irrigation and Drainage paper 29 Rev. 1. Food and Agriculture Organization of the United Nations, Rome, Italy. URL: http://www.fao.org/DOCREP/003/T0234E/T0234E00.HTM.

Brady, N.C. and R.R. Weil. 1999. The Nature and Properties of Soils, Twelfth Edition. Prentice Hall, Upper Saddle River, New Jersey. 881 p.

Camberato, J. 2001. Irrigation Water Quality. Update from the 2001 Carolinas GCSA Annual Meeting, Clemson University Turfgrass Program. URL: http://www.scnla.com/Irrigation_Water_Quality.pdf.

eFOTG (electronic Field Office Technical Guide). 2006. Species List and Associated Conservation Tree/Shrub Suitability Groups. Accessed at http://www.mt.nrcs.usda.gov. (click on eFOTG, select county, click on A. Soils Information, click on Species List and Associated Conservation Tree/Shrub Suitability Groups).

Fipps, G. accessed 2006. Irrigation Water Quality Standards and Salinity Management Strategies B-1667, 4-03. Texas Cooperative Extension, Texas A&M University. URL: http://lubbock.tamu.edu/irrigate/documents/2074410-B1667.pdf.

Pick, T. 2002. Assessing Water Quality for Agriculture and Aquatic Life Uses. USDA, Natural Resources Conservation Service, Environment Technical Note, MT-1. URL: http://www.mt.nrcs.usda.gov/technical/ecs/environment/technotes/envtechnoteMT1.html .

Schafer, W.M. 1982. Saline and Sodic Soils in Montana. Bulletin Number 1272. Cooperative Extension Service, Montana State University, Bozeman, Montana. 56 p.

Montana Irrigation Manual. USDA, Soil Conservation Service, Bozeman, Montana.

_____1983. Irrigation Water Quality in Montana (publication MT 198373AG)

_____2004. Soil pH Modification. University of Minnesota Extension Service, BU-01731. URL http://www.sustland.umn.edu/implement/soil_ph.html

APPENDIX

APPENDIX 1 lists unit conversion factors that may be useful when interpreting water quality tests that are based on the following relationships:

[1 dS/m = 0.1 S/m = 1000 µS/cm =1 mmhos/cm = 1000 µmhos/cm] (Camberato 2001)

APPENDIX -- continued

APPENDIX 1. Water Quality Tests, Units of Measure, and Conversions

Test	Units of Measurement	Symbol	Multiply	To Convert to	Symbol
Water Salinity					
a. electrical conductivity (EC_w)	millimhos per centimeter	mmhos/cm	1	deciSiemens per meter	dS/m
	millimhos per centimeter	mmhos/cm	1000	micromhos per centimeter	µmhos/cm
	Siemens per meter	S/m	10	deciSiemens per meter	dS/m
	microSiemens per centimeter	µS/cm	1	micromhos per centimeter	µmhos/cm
b. total dissolved salts (TDS)	milligrams per liter	mg/l	1	parts per million	ppm
	percent	%	10,000	parts per million	ppm
	percent	%	10,000	milligrams per liter	mg/l
To approximate TDS, multiply EC_w X 640 if the EC value <5 dS/m					
To approximate TDS, multiply EC_w X 800 if the EC value >5 dS/m					
Water Sodium Hazard					
a. sodium adsorption ratio (SAR) (1)	NA	NA			
b. percentage	NA	NA			
Specific Ion Toxicity	milliequivalents per liter	meq/l	see A.		
meq/l equals mg/l divided by the equivalent weight were equivalent weight equals atomic weight divided by atomic charge.					

(1) The SAR value for water with significant amounts of bicarbonate needs to be adjusted.

A. Meq/l equals mg/l divided by the equivalent weight where equivalent weight equals atomic weight divided by atomic charge. You will need to reference the atomic weights and charges in *Determining the Suitability of Salt-Affected Water and Soil for Tree and Shrub Plantings*, Plant Materials Technical Note, MT-62 at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/ to make this calculation.

$$\text{meq/l} = \frac{\text{mg/l}}{(\text{atomic weight} \div \text{atomic charge})}$$

If we have 325 mg/l calcium and want to know the value in meq/l, we use the formula:

$$\frac{325}{(40.1 \div 2)} = 16.21 \text{ meq/l}$$

B. You have an electrical conductivity reading of 855 mmhos/cm and want to compare this value to standards given in dS/m. Since mmhos/cm is equivalent to dS/m, the value stays the same (855 mmhos/cm x 1 = 855 dS/m).

C. You have an electrical conductivity reading of 637 mmhos/cm and want to compare this value to standards given in µmhos/cm. To convert, multiply 637 mmhos/cm x 1,000 = 637,000 µmhos/cm. Conversely, if you have 637,000 µmhos/cm, divide 637,000 µmhos/cm by 1,000 to convert to 637 mmhos/cm.

D. You have an electrical conductivity reading of 769 S/m and want to compare this value to standards given in dS/m. To convert, multiply 769 S/m x 10 = 7,690 dS/m. Conversely, if you have 7,690 dS/m, divide 7,690 dS/m by 10 to convert to 769 S/m.

APPENDIX 1. Water Quality Tests, Units of Measure, and Conversions -- continued

E. All readings in µS/cm are equal to readings in µmhos/cm, so 325 µS/cm equals 325 µmhos/cm.

APPENDIX 2. Classification of Irrigation Waters, USDA, Agriculture Handbook 60

Low Salinity Water (C1) can be used for irrigation of most crops with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

Medium Salinity Water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High Salinity Water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required, and plants with good salt tolerance should be selected.

Very High Salinity Water (C4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

Low Sodium Water (S1) can be used for irrigation on most soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stonefruit trees and avocados may accumulate injurious concentrations of sodium.

Medium Sodium Water (S2) will present an appreciable sodium hazard in fine-textured soils having high cation exchange capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured soils or organic soils with good permeability.

High Sodium Water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management – good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.

Very High Sodium Water (S4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may take the use of these waters feasible.

Sometimes the irrigation water may dissolve sufficient calcium from the calcareous soils to decrease the sodium hazard appreciably, and this should be taken into account in the use of C1-S3 and C1-S4 waters. For calcareous soils with high pH values or non-calcareous soils, the sodium status of water in classes C1-S3, C1-S4, and C2-S4 may be improved by the addition of gypsum to the water. Similarly, it may be beneficial to add gypsum to the soil periodically when C2-S3 and C3-S2 waters are used.

Source: Agriculture Handbook 60, U.S. Department of Agriculture.

ANALYSIS EXAMPLE 1 – RESULTS

XYZ ***XYZ LABORATORIES, INC.*** *P.O. Box 12345, 0000 Water Testing Road,*
LABORATORIES *Anywhere, USA, 00000-0000, phone 1-800-000-0000, xyzlabs.com.*

LABORATORY ANALYTICAL REPORT

Client:	Ms. Jane Q. Landowner	**Report Date:**	01/01/2007
Project:	Windbreak Installation	**Collection Date:**	11/05/2006
Lab ID:	WQST	**Date Received:**	11/05/2006
Client Sample ID:	JDS	**Matrix:**	Aqueous (water)

Analyses	Results	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date/By
PHYSICAL PROPERTIES							
Conductivity*	2860	umhos/cm		1		A2510 B	12/15/06 / jaa
INORGANICS							
Sodium Adsorption Ratio (SAR)	2.19	unitless		0.01		Calculation	12/17/06 / lab
METALS, DISSOLVED							
Calcium	355	mg/l		1		E200.7	12/21/06 / fxs
Magnesium	121	mg/l		1		E200.7	12/21/06 / fxs
Sodium	188	mg/l	D	2		E200.7	12/21/06 / fxs
pH	7.46	s.u.		0.01		E150.1	12/21/06 / fxs

Irrigation Classification: C4-S1

Report Definitions: RL - Analyte reporting limit. MCL - Maximum contaminant level.
QCL - Quality control limit. ND - Not detected at reporting limit.
D - RL increased due to sample matrix interference.

*Conductivity is sometimes reported as Specific Conductance (SP) which is the electrical conductivity measured at 25^{o}C.

ANALYSIS EXAMPLE 1 - INTERPRETATION

CONDUCTIVITY. Based on standards in TABLE 1, water with a conductivity reading of 2,860 umhos/cm (2.86 dS/m) would have a degree of restriction on use classification on the high (saltier) end of "slight to moderate", requiring filtration and/or other management practices to be usable. At this level of salinity, this water source would not be considered suitable for most trees and shrubs, regardless of other test results. If filtration or other water and soil management treatments are being considered, the other water quality tests should be evaluated to determine if additional management will be needed. Similarly, if water filtration or other management is being considered, soil quality tests should be conducted.

SODIUM ADSORPTION RATIO. Water with an SAR of 2.19 would have a degree of restriction on use classification of "none" if applied to the soil surface (versus sprinkler applied) (see CHART 1 in *Determining the Suitability of Salt-Affected Water and Soil for Tree and Shrub Plantings*, Plant Materials Technical Note, MT-62 at:

http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/.) Similarly, an SAR value of 2.19 in conjunction with an EC of 2,860 umhos/cm would not result in a water infiltration problem based

ANALYSIS EXAMPLE 1 – INTERPRETATION -- continued

on our standards in TABLE 2. However, the high total salt level indicated by the EC would result in a soil-salinity buildup and plant toxicity in a short period of time.

CALCIUM. A water calcium level of 355 mg/l (ppm) does not indicate a water quality problem. Calcium level alone is not typically an important water quality parameter, but is used to calculate SAR.

MAGNESIUM. A water magnesium level of 121 mg/l (ppm) does not indicate a water quality problem. Magnesium level alone is not typically an important water quality parameter, but is used to calculate SAR.

SODIUM. Based on standards in TABLE 3, a water sodium level of 188 mg/l would create a "moderate" to "severe" degree of restriction on use if applied with a sprinkler. SAR is a more appropriate test when evaluating water quality for surface-applied water sources.

pH. Based on standards in TABLE 3, a water pH of 7.46 is considered within the normal range (this soil pH would classify as "slightly alkaline") and would be suitable for irrigating most trees and shrubs, with the exception of woody species that specifically prefer acid soils.

IRRIGATION CLASSIFICATION. The irrigation classification system considers total saltiness ("C" for conductivity or electrical conductivity) and the amount of sodium relative to calcium and magnesium ("S" for SAR). Based on the definitions in APPENDIX 2, an irrigation classification of C4-S1 indicates an unacceptable level of total saltiness (EC or TDS) and an acceptable Sodium Adsorption Ratio (SAR). This system does not take into account the interaction of salinity and SAR as they affect water infiltration. It is recommended that landowners consult professionals if total salinity or SAR levels individually exceed the accepted limits for tree and shrub survival and growth.

SUMMARY INTERPRETATION. The high total salinity of this water source would limit its use for tree and shrub plantings, regardless of acceptable water infiltration into the soil. None of the other tests alone suggest potential problems. If nutrient availability to plants was determined to be an issue because of the water pH, acidifying products could be added to the water and/or soil. Water filtration, such as reverse osmosis, would be necessary. A complete soil analysis would be necessary before proceeding with any corrective measures if there is a likelihood of high soil salts or other limiting soil characteristics.

ANALYSIS EXAMPLE 2 – RESULTS

XYZ ***XYZ LABORATORIES, INC.*** *P.O. Box 12345, 0000 Water Testing Road,*
LABORATORIES *Anywhere, USA, 00000-0000, phone 1-800-000-0000, xyzlabs.com.*

LABORATORY ANALYTICAL REPORT

Client:	Ms. Jane Q. Landowner	**Report Date:**	02/01/2007
Project:	Living Snowfence	**Collection Date:**	12/05/2006
Lab ID:	WLSF	**Date Received:**	12/05/2006
Client Sample ID:	JDS	**Matrix:**	Aqueous (water)

Analyses	Results	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date/By
PHYSICAL PROPERTIES							
Conductivity*	855	umhos/cm		1		A2510 B	12/30/06 / mkd
INORGANICS							
Sodium Adsorption Ratio (SAR)	12.24	unitless		0.01		Calculation	12/30/06 / lab
METALS, DISSOLVED							
Calcium	29	mg/l		1		E200.7	1/21/07 / jds
Magnesium	20	mg/l		1		E200.7	1/21/07 / jds
Sodium	355	mg/l	D	2		E200.7	1/21/07 / jds
pH	7.88	s.u.		0.01		E150.1	1/21/07 / jds
Irrigation Classification: C3-S3							

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix interference.
MCL - Maximum contaminant level.
ND - Not detected at reporting limit.

*Conductivity is sometimes reported as Specific Conductance (SP) which is the electrical conductivity measured at 25°C.

ANALYSIS EXAMPLE 2 – INTERPRETATION

CONDUCTIVITY. Based on standards in TABLE 1, water with a conductivity reading of 855 umhos/cm (0.855 dS/m) would have a degree of restriction on use classification on the low side (less salty) of "slight to moderate". Filtration and/or other management practices would only be needed for long-term use on sensitive plants. This level of salinity is considered generally suitable for irrigation of trees and shrubs, depending on other test results. Soil quality tests should also be conducted.

SODIUM ADSORPTION RATIO. Water with an SAR of 12.24 would have a degree of restriction on use classification of "severe" if applied to the soil surface (versus sprinkler applied) see CHART 1 in *Determining the Suitability of Salt-Affected Water and Soil for Tree and Shrub Plantings*, Plant Materials Technical Note, MT-62 at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/. Similarly, an SAR value of 12.24

in conjunction with an EC of 855 umhos/cm (0.855 dS/m) would result in a “severe” water infiltration problem based on our standards in TABLE 2.

ANALYSIS EXAMPLE 2 – INTERPRETATION -- continued

CALCIUM. A water calcium level of 29 mg/l (ppm) does not indicate a water quality problem. Calcium level is not typically an important water quality parameter alone, but is used to calculate SAR.

MAGNESIUM. A water magnesium level of 20 mg/l (ppm) does not indicate a water quality problem. Magnesium level is not typically an important water quality parameter alone, but is used to calculate SAR.

SODIUM. Based on standards in TABLE 3, a water sodium level of 355 mg/l would create a “moderate” to “severe” degree of restriction on use if applied with a sprinkler. SAR is a more appropriate test when evaluating water quality for surface-applied water sources.

pH. Based on standards in TABLE 3, a water pH of 7.88 is within the normal range (this soil pH would classify as “slightly” to “moderately” alkaline and would be suitable for most trees and shrubs, with the exception of acid-loving species.

IRRIGATION CLASSIFICATION. The irrigation classification system considers total saltiness (“C” for conductivity or electrical conductivity) and the amount of sodium relative to calcium and magnesium (“S” for SAR). Based on the definitions in APPENDIX 2, an irrigation classification of C3-S3 indicates a high salinity and high sodium irrigation water that would be unacceptable. This system does not take into account the interaction of salinity and SAR as they affect water infiltration. It is recommended that landowners consult professionals if total salinity or SAR levels individually exceed the accepted limits for tree and shrub survival and growth.

SUMMARY INTERPRETATION. The SAR of this water source would severely limit its use for tree and shrub plantings, regardless of acceptable water infiltration into the soil. Water filtration, such as reverse osmosis, would be necessary. None of the other tests alone suggest potential problems. If nutrient availability to plants was determined to be an issue because of the water pH, acidifying products could be added to the water and/or soil. A complete soil analysis would be necessary before proceeding with any corrective measures if there is a likelihood of high soil salts or other limiting soil characteristics.