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NATURAL RESOURCES CONSERVATION SERVICE
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PLANT MATERIALS TECHNICAL NOTE

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

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INTRODUCTION

Conservation professionals and landowners alike will probably be involved in planting trees and shrubs at some point in time. The suitability of soil for growing trees and shrubs depends largely on the quality of that soil. One "quality" criteria is the amount and types of dissolved salts found in soil. Salts in soil and water frequently limit woody plant survival and growth in the northern Great Plains and Intermountain West. For tree and shrub plantings, determining soil suitability involves comparing test results to some standard indicating whether the salt level is low, average, or high. Unfortunately, soil tests typically provide only numbers, with little or no explanation of their meaning. As a result, it is difficult to make decisions regarding the quality of a soil without consulting a specialist. This document is designed to help readers interpret soil test results to determine if salts are likely to pose serious problems for tree and shrub plantings.

It is important to recognize that soil, water, and plant interactions are complex and unpredictable, varying with the specific crop, soil characteristics, local climate, and management practices. **In order to make meaningful soil quality interpretations when supplemental water is provided, it is necessary to consider both soil and water quality factors simultaneously.** For more information on interpreting water quality test results, see *Testing and Interpreting Salt-Affected Water for Tree and Shrub Plantings*, Plant Materials Technical Note No. MT-61 at: http://www.mt.nrcs.usda.gov/technical/ecs/plants/technotes/. If the reader would like detailed information on salts in soil and water, 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 SOIL QUALITY TESTS SHOULD A PERSON REQUEST? There are several tests that can be conducted on a sample of potentially salt-affected soil to determine it's suitability for growing trees and shrubs. The more information that is available to the landowner, the better the soil quality interpretation that can be made (see ANALYSIS REPORTS 1 and 2 at the end of this document for examples of comprehensive soil salinity tests and explanations of the results). Again, in order for soil quality interpretations to be meaningful for a given plant species and management strategy on an irrigated site, it will also be necessary to know the water quality characteristics of the irrigation water. Four characteristics that help define the suitability of salt-affected soil for growing trees and shrubs include salinity, sodicity, pH, and texture.

SOIL SALINITY TESTING

1. **Soil Salinity** indicates the total amount of soluble salts in solution in a given soil sample. A total salinity test indicates the saltiness level of the soil, but does not identify which salts or ions 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 by an **Electrical Conductivity (EC)** test. **When comparing test results to soil classifications or restriction of use tables, always make sure that the units of measure are the same** (see APPENDIX 1 for units of measure and conversion values).

It should be noted that Electrical Conductivity may be measured by the saturated paste extract or soil:water dilution methods. Although the two tests are expressed by the same units of measure, the values are <u>not</u> comparable. Soils are classified into five categories based on the concentration of ions present in a representative sample as measured by EC or Total Dissolved Solids (TDS), see TABLE 1.

TABLE 1. Soil Salinity Classes and EC Values Based on Saturated Paste vs. 1:2 Dilution Methods

Salinity Class	EC by Saturated Paste dS/m or mmhos/cm	~EC 1:2 Dilution Method For Clay Loam Soils	Potential Tree and Shrub Use Restrictions
Non-Saline	<2	0.15 – 0.25	**none**
Very Slightly Saline	2 to <4	> 0.25 – 0.30	**limited**
Slightly Saline	4 to <8	> 0.30 – 0.50	**moderate to severe**
Moderately Saline	8 to <16	> 0.50 – 1.00	**severe**
Strongly Saline	≥16	> 1.00	**extremely high**

2. **Soil Salinity Classifications and Interpretations.** TABLE 1 lists soils salinity classes and use restrictions based on two different methods of testing, the saturated paste and dilution methods, respectively. Salinity and use restriction classes are somewhat arbitrary as changes actually occur gradually. Once you know your soil-salt level, it will be necessary to determine which trees and shrubs grow well under those conditions. Most woody plants adapted to climatic conditions in the northern Great Plains and Intermountain West survive and grow well on Non-Saline to Very Slightly Saline soils. The number of woody species that will reach their full growth potential on soils with ECs ≥8 dS/m ("Moderately" or "Strongly Saline") is very limited. A number of species will survive but grow at a reduced rate and vigor on soils with ECs between 6 and 10 dS/m. For approximations of tree and shrub soil salinity tolerances, 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.

These values are only approximations of salinity tolerance; actual tolerance may be less depending on field conditions. Also, see Conservation Tree/Shrub Suitability Groups (CTSG) in Section II, Windbreak Interpretations in the Montana FOTG or eFOTG (see References) for a list of tree and shrub species adapted to salt-affected soils.

NEEDLE NECROSIS IN PONDEROSA PINE CAUSED BY HIGH SOIL SALINITY

3. **Soil Salinity Management Options.** If your soil test indicates that salts are likely to be a problem, some corrective action will be necessary. What steps to take depends on the soil salinity level, expense that you are 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. If supplemental water is available, reducing soil salinity typically involves using less salty irrigation water to leach salts from the soil profile. If the irrigation water is also high in salts, it will be necessary to filter the water or dilute it with lower salinity water before applying it to the soil. The periodic use of lower salinity water (EC_w <2 dS/m; TDS <1,280 ppm) to flush or leach salts from the soil profile is another option. For leaching to be successful, the irrigation water must readily infiltrate and percolate through the soil profile. Caution must be taken to avoid creating additional salinity problems downstream resulting from the improper deposition of drainage water. The type of water delivery system influences leaching of salts from the soil profile, with properly placed drip, soaker, bubbler and flood irrigation preferred to sprinkler irrigation. Increasing irrigation frequency on well-drained soils helps prevent salt accumulation in the upper soil profile, but this practice can be complicated by the need to periodically deep flush salts through the soil, and may contribute to shallow rooting of some plants. The installation of soil drains and/or deep ripping of the soil to fracture impervious soil layers (pans) may be necessary for effective leaching. The use of salt tolerant trees and shrubs, particularly on dryland plantings, is another management option as previously described. It is recommended that landowners consult their local county extension agent or USDA Natural Resources Conservation Service office for specific recommendations.

SOIL SODIUM TESTING

1. The amount of **sodium (Na)** in the soil is another important factor in determining its suitability for supporting trees and shrubs because sodium strongly influences water infiltration and soil aeration.

a. **Soil Sodium Adsorption Ratio** - Soil sodium hazard is best described by the **Sodium Adsorption Ratio (SAR)**, an indication of the likelihood of reduced soil permeability (water infiltration) and aeration, especially on heavy-textured (clay) soils. A soil SAR >13 suggests a likelihood of reduced soil permeability and decreased plant survival and growth.

b. **Exchangeable Sodium Percentage** - Another useful indicator of potential soil sodium hazards is **Exchangeable Sodium Percentage (ESP)**. ESP measures the amount of soil exchange capacity occupied by sodium and expressed as a percentage. As the ESP goes up, more exchangeable sodium is available, and the greater the potential for negative plant and soil impacts. An ESP >15% indicates that soil sodium will probably limit permeability.

2. **Soil Sodium Management Options.** What corrective actions, if any, can be taken if your soil sodium level indicates that there is likely to be a problem growing trees and shrubs? Attempting to use leaching to remove excess sodium can actually result in higher exchangeable sodium and soil pH, two undesirable side-effects. To prevent this, sodium must first be displaced from soil exchange sites by adding calcium to the soil in the form of gypsum. After application of the gypsum, the profile can then be leached of sodium salt by-products to prevent an increase in overall soil salinity. It is recommended that landowners consult agriculturists, their local county extension agent, or their local USDA Natural Resources Conservation Service office for specific recommendations on gypsum application.

SOIL PH TESTING AND MANAGEMENT

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Listed in TABLE 2 are soil **pH** classes. Since soluble salts affect soil pH and vice versa, pH is often included in evaluations and discussions of soil saltiness. Changing the soil pH often results in a corresponding change in plant nutrient availability. The availability of certain nutrients in soil solution begins to decrease above pH ~5.5 (iron [Fe], manganese [Mn], zinc [Zn], copper [Cu], cobalt [Co]), above ~7.0 (phosphorus [P], boron [B]), and above 8.5 (calcium [Ca], magnesium [Mg]). The soil pH scale ranges from 0 to 14, with <7 considered acidic, 7 neutral, and >7 alkaline or basic. Most arable soils in our region have a pH in the range of

7 to 9. Soil pH measuring 6.1 to 7.0 is considered ideal for most trees and shrubs, although various species will grow in a range from 5.5 to 8.0+. It is more likely that a naturally salt-affected soil will have a high, rather than low, soil pH. Reducing high soil pH is typically accomplished by applying acidifying fertilizers (such as ammonium sulfate, ammonium phosphate-sulfate, etc.,) to the soil, often in conjunction with soil applied chelated iron and manganese if inter-veinal chlorosis is noted.

TABLE 2. Soil pH Classes

pH Class	pH
Ultra Acid	<3.5
Extremely Acid	3.5-4.4
Very Strongly Acid	4.5-5.0
Strongly Acid	5.1-5.5
Moderately Acid	5.6-6.0
Slightly Acid	6.1-6.5
Neutral	6.6-7.3
Slightly Alkaline	7.4-7.8
Moderately Alkaline	7.9-8.4
Strongly Alkaline	8.5-9.0
Very Strongly Alkaline	>9.0

SOIL TEXTURE CLASSIFICATION

Although soil texture is not a salinity measure, it is often included with salt tests because texture greatly influences how salty soil can be managed. Soil texture indicates the relative amount of sand, silt, and clay particles in a soil sample. The proportions of these three particle sizes influences several soil properties, including water infiltration, percolation, soil aeration, moisture holding capacity, and others. Soils with a high percentage of small clay particles are called "heavy-textured" and are characterized by slow water infiltration into the soil, slow water percolation through the soil, low soil aeration, and a tendency for the soil to hold moisture with great tension. Soils with a high percentage of large sand particles are called "light-textured" and are characterized by rapid water infiltration and percolation, high soil aeration, but low water holding capacity. Light soils (sands and loamy sands) lend themselves to management practices designed to reduce soil salinity by leaching salts from the soil with applications of excess, low-salt irrigation water. Heavy soils (silty clay, sandy clay, clay) are generally more difficult to manage for salinity than soils classified as sandy or loamy. Medium-textured soils (sandy loams, loams, sandy clay loam, clay loam, silt, silt loam, silty clay loam) fall somewhere between light- and heavy-textured soils in terms of their properties and management.

WHERE CAN A PERSON HAVE THEIR SOIL SAMPLE TESTED? For a list of soil testing laboratories 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.montana.edu/wwwpb/pubs/eb150.pdf.

WHEN SHOULD A PERSON SAMPLE THEIR SOIL? Soil should be sampled well before planting to determine its suitability for trees and shrubs. Additionally, soil quality may vary over time, and should be tested at intervals, especially during the growing season. 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.

Again, these guidelines are provided in an attempt to help identify potential soil salts problems when planting trees and shrubs. For detailed information, or further assistance, contact your local NRCS, county extension, or conservation district office.

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.clemson.edu/turfornamental/tmi/Irrigation/Irrigation%20Water%20Quality.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://agnews.tamu.edu/drought/DRGHTPAK/SALINITY.HTM

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.extension.umn.edu/distribution/horticulture/components/1731-03.html

APPENDIX

APPENDIX 1. Soil Quality Tests, Units of Measure, and Conversions[(1)]

Test	Units of Measurement	Symbol	Multiply by	To Convert to	Symbol	Conversion Examples
Soil Salinity						
a. electrical conductivity (EC)	millimhos per centimeter	mmhos/cm	1	deciSiemens per meter	dS/m	see B
	millimhos per centimeter	mmhos/cm	1000	micromhos per centimeter	µmhos/cm	see C
	Siemens per meter	S/m	10	deciSiemens per meter	dS/m	see D
	microSiemens per centimeter	µS/cm	1	micromhos per centimeter	µmhos/cm	see E
Specific Ion Toxicity	milliequivalents per liter	meq/l	see A.			

[(1)]Soil salinity unit conversions 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 1. Soil Quality Tests, Units of Measure, and Conversions[1] -- continued

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 atomic weights and charges in *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/ 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.

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

ANALYSIS EXAMPLE 1 – RESULTS

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

LABORATORY ANALYTICAL REPORT

Client:	Ms. Judy Landowner	**Report Date:**	02/01/2007
Project:	Riparian Forest Buffer	**Collection Date:**	12/01/2006
Lab ID:	SRFB	**Date Received:**	12/05/2006
Client Sample ID:	JDS	**Matrix:**	Soil

Analyses	Results	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date/By
PHYSICAL PROPERTIES							
Soil Texture	Clay					USDA	1/15/07 / jaa
Conductivity (EC)*	4860	umhos/cm		1		A2510 B	1/15/07 / jaa
INORGANICS							
Sodium Adsorption Ratio (SAR)	2.19	unitless		0.01		Calculation	1/17/07 / lab
METALS, DISSOLVED							
Calcium	355	mg/l		1		E200.7	1/21/07 / nxs
Magnesium	121	mg/l		1		E200.7	1/21/07 / nxs
Sodium	188	mg/l	D	2		E200.7	1/21/07 / nxs
pH	8.10	s.u.		0.01		E150.1	1/21/07 / nxs

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^{o}C.

ANALYSIS EXAMPLE 1 – INTERPRETATION

<u>TEXTURE</u>. A soil texture classification of “Clay” suggests water infiltration into the soil, percolation of water through the soil profile, as well as soil aeration may be compromised. It will be difficult to use leaching as a soil salts management technique on soils with this texture. Incorporation of large volumes of sand and/or organic matter, in conjunction with the installation of drainage systems may be necessary. Select tree and shrub species tolerant of heavy-textured soils.

<u>CONDUCTIVITY</u>. Based on standards in TABLE 1, soil with a conductivity reading of 4860 umhos/cm (4.86 dS/m) would have a soil salinity classification of “Slightly Saline”. Only non-sensitive trees and shrubs would grow to full performance at this salinity level without additional management. As noted earlier, the high clay content of this soil would make leaching of salts difficult. Other salinity tests should be evaluated to determine if additional management will be needed. Similarly, if soil salt leaching or other management is being considered, water quality tests should be conducted.

ANALYSIS EXAMPLE 1 – INTERPRETATION -- continued

SODIUM ADSORPTION RATIO. A soil with an SAR of 2.19 would not suggest any plant growth limitations based on the sodium level relative to other ions. A soil with an SAR of 2.19 and an EC of 4860 umhos/cm would result in a soil classification of “Saline”.

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

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

SODIUM. A soil sodium level of 188 mg/l (ppm) does not indicate a soil quality problem. Sodium level alone is not typically an important soil quality parameter, but is used to calculate SAR.

pH. Based on classifications in TABLE 2, a soil pH of 8.1 is considered “Moderately Alkaline”, but is still considered within the acceptable pH range for the growth of many trees and shrubs, with the exception of woody species that specifically prefer acidic soils. Acidifying fertilizers, as well as amendment with stable (chelated) forms of insoluble nutrients may be necessary for adequate growth of certain trees and shrubs.

SUMMARY INTERPRETATION. The total salinity level of this soil sample, although not exceptionally high, will limit its use to non-salt-sensitive tree and shrub species, unless additional management is provided. Only the soil texture and pH results suggest other potential limitations. If nutrient availability to plants is determined to be an issue because of the high soil pH, acidifying products should be added to the soil and/or irrigation water. Water filtration, such as reverse osmosis, may be helpful if irrigation water is the source of the soil salts, or if leaching will be attempted. A complete water analysis is recommended before proceeding with any corrective measures if there is a likelihood of high irrigation water salts.

ANALYSIS EXAMPLE 2 – RESULTS

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

LABORATORY ANALYTICAL REPORT

Client:	Mr. John Landowner	**Report Date:**	02/01/2007
Project:	Living Snowfence	**Collection Date:**	12/01/2006
Lab ID:	WLSF	**Date Received:**	12/05/2006
Client Sample ID:	MKS	**Matrix:**	Soil

Analyses	Results	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date/By
PHYSICAL PROPERTIES							
Texture	Loamy Sand					USDA	1/15/07 /mkd
Conductivity*	855	umhos/cm		1		A2510 B	1/15/07 / mkd
INORGANICS							
Sodium Adsorption Ratio (SAR)	12.24	unitless		0.01		Calculation	1/17/07 / 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	8.80	s.u.		0.01		E150.1	1/21/07 / jds

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^{o}C.

ANALYSIS EXAMPLE 2 – INTERPRETATION

TEXTURE. A soil texture classification of “Loamy Sand” suggests that water infiltration, percolation, and soil aeration should not be limiting. Leaching of salts from the soil profile with excess irrigation water should be possible, given other favorable conditions.

CONDUCTIVITY. Based on the standards in TABLE 1, soil with a conductivity reading of 855 umhos/cm (0.855 dS/m) would have a salinity classification of “Non-Saline”. Leaching or other management practices are not currently needed. Water quality tests should also be conducted if salts in irrigation water are a concern.

SODIUM ADSORPTION RATIO. A soil with an SAR of 12.24 would not indicate plant growth limitations based on the sodium level relative to other ions. This is, however, close to the SAR level (~>13) at which water infiltration and soil aeration can become limiting. An SAR value of 12.24 in conjunction with an EC of 855 umhos/cm (0.855 dS/m) would result in a soil classification of “Normal”.

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

ANALYSIS EXAMPLE 2 – INTERPRETATION -- continued

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

SODIUM. A soil sodium level of 355 mg/l (ppm) does not indicate a soil quality problem. Sodium level alone is not typically an important soil quality parameter, but is used to calculate SAR.

pH. Based on standards in TABLE 2, a soil pH of 8.8 is classified as "Strongly Alkaline" and would not be suitable for most trees and shrubs, with the exception of alkaline tolerant species. Regular applications of acidifying fertilizers, as well as amendment with stable (chelated) forms of insoluble nutrients will be necessary for adequate growth of most trees and shrubs. The 8.8 pH is only characteristic of soils classified as "Sodic" (see CHART 3 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/).

SUMMARY INTERPRETATION. The SAR of this soil is close to a level that may impact tree and shrub survival and growth. Water filtration, such as reverse osmosis, may be necessary if additional sodium is added to the soil via irrigation water. Only the soil pH results suggest additional potential problems. If nutrient availability to plants is determined to be an issue because of the high soil pH, acidifying products should be added to the soil and/or water. A complete water analysis is recommended before proceeding with any corrective measures if there is a likelihood of high irrigation water salts.

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