

A SPECIAL REPORT FOR THE ELVENIA J. SLOSSON ENDOWMENT FUND

LANDSCAPE PLANT SALT TOLERANCE SELECTION GUIDE FOR
RECYCLED WATER IRRIGATION

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Currently in California more than one half million acre-feet of municipal wastewater is recycled per year and about 20% of that recycled water is used for landscape irrigation. California's population is expected to rise from 36 to 53 million by the year 2030. Urban wastewaters will need to be recycled to meet the anticipated shortfall of potable water. In order to use recycled waters effectively for landscape irrigation, there is an urgent need for information on how landscape plants respond to reclaimed waters and how they can be used safely for irrigation. Such information, however, is scant in the current literature.

Between 1995 and 2001 the Elvenia J. Slosson Endowment Fund, the Marin County Municipal Water District and the City of San Jose in northern California provided funding for research on the response of landscape plants to salt stress for reclaimed water irrigation. Research collaborators over the last six years included landscape specialist Jerry Brown of the City of San Jose, water recycling specialist Roger Waters of the Marin County Water District, and UC Cooperative Extension specialist Dr. Ali Harivandi. This team developed salt tolerance screening methods and tested a wide range of landscape plant species using those methods. Although through the course of research some interesting findings were published, sufficient data for assembling a practical landscape selection reference had not yet been accumulated.

Now, more information has been collected and salt tolerances of 86 tree and palm species, 65 shrub species, 58 groundcover and vine species, and 57 grass species have been summarized and compiled into several plant selection lists. These reference lists will be an important part of this education package and will serve as a plant selection guide for decision-making in landscape management. More landscape plant species will be added to the lists when additional data become available.

For landscape irrigation using recycled water, particularly in the urban environment, maintenance of environmental quality is an important condition that should be considered. The successful utilization of these reference lists requires additional information on water quality, irrigation management, soil physical and chemical properties, and unfavorable environmental conditions. Brief discussions of each of these aspects are presented in the following paragraphs. Successful management of reclaimed water irrigation in California landscapes also depends on appropriate selection of plant species that are adapted to local climate conditions. The climate of California is varied, ranging from subtropical, temperate, high mountains and desert to dry or humid coastal ranges. References of plant adaptation to California's local climate conditions can be found in existing landscape management publications and are not discussed here.

Quality of reclaimed water

Reclaimed water is water that has been previously used and, therefore, has suffered a loss in quality. This water is treated in separate facilities from potable water resources, but is subject to almost the same treatment processes. The chemical properties of reclaimed water vary among different water treatment facilities. After going through the water treatment process, sodium and chloride are the major chemical constituents remaining in waters that are potentially detrimental to plants. Other elements such as boron, selenium, magnesium, cadmium and other heavy metals are rarely found at levels that are damaging to landscape plants. California has a long history of water reuse and developed the first reuse regulations in 1918 which have been modified and expanded through the years (State of California, 1978).

Potential irrigation problems associated with reclaimed water can be classified according to salinity, permeability, specific ion toxicity, and miscellaneous effects. The potential restrictions in use of reclaimed water are divided into three categories of management skill requirements. Category 1 requires no special management, category 2 requires slight to moderate management skill and category 3 requires substantial water and soil management input to avoid severe soil and plant damage. The divisions are somewhat arbitrary, but they do provide applicable guidelines for evaluating the quality of reclaimed waters (Westcot and Ayers, 1984). The recommended limits of inorganic constituents for irrigation water have also been established and published by the National Academy of Engineering (1973) and they have been used as criteria standards ever since.

Most recycled municipal wastewater in California falls into the second category of the water quality divisions. In order to relate the common constituents of a recycled water to the subsequent interpretation of how the tolerances of landscape plants are defined, an example of the chemical constituents of reclaimed water as well as potable water are presented in Table 1. The water quality values in the table were adapted from the 2001 Recycled Water Quality Report published by the South Bay Water Recycling agency of the City of San Jose, California in the summer of 2002 (<http://www.sanjoseca.gov/sbwr/water-quality.htm>). Generally, recycled waters have greater varieties of chemical constituents than potable waters, but the concentrations of these chemical constituents are very low and are not expected to have any significant negative effects on plants. The levels of sodium and chloride, however, as shown in the table are not only considerably higher than those in potable water, but also could cause detrimental effects on plants. The chemical constituents of the recycled water generated by the South Bay Water Recycling facility represent a general characteristic of most recycled waters. Its highest sodium concentration was close to 200 mg L^{-1} (parts per million) and its maximum chloride concentration was close to 300 mg L^{-1} . The salinity of the recycled water generated from the water treatment facility is relatively consistent. For example, the yearly average salinity of the recycled water generated by the South Bay Water Recycling facility between 1996 and 2003 was within a range of $1 \text{ dS}\cdot\text{m}^{-1}$ to $1.4 \text{ dS}\cdot\text{m}^{-1}$ (Figure 1).

Salt tolerance of landscape plants

From the above brief overview of the quality of reclaimed water, it is clear that sodium and chloride concentrations are the major concerns in landscape irrigation. Salt stress response is usually measured by dry weight accumulation, elongation of plant parts, or relative growth rate. For agricultural crops, salt stress damage is usually measured as yield of specific plant parts such as seeds, roots, fruits, or leaves. In addition, management of salinity problems in crop plants is possible by selecting a single crop species and variety whose yield is only slightly affected by a specific level of salinity.

Landscape plants, however, are judged by their aesthetic value rather than growth rate or production, and the salt concentration in reclaimed water must be acceptable for a wide range of plant species in a single landscape setting. In addition, plants are more susceptible to salt damage from direct contact of sprayed irrigation water on leaves than when it is applied to the soil and roots. In order to develop a salt tolerance screening method to be able to differentiate salt tolerance among landscape plant species based on their aesthetic quality, field trials were conducted using sprinkler and drip irrigation systems and water containing salt at concentrations near the upper level found in most recycled waters (Wu *et al.*, 2001). The salt stress response of landscape plants could be evaluated visually or measured using image analysis technology (Lumis *et al.*, 1973; Wu *et al.*, 2001; Wu and Guo, 2005).

The relationship between salt tolerance of foliar-applied water and tolerance of water applied to roots has rarely been reported. Nevertheless, these two characteristics were found to have evolved independently between different ecotypes within a species of creeping bentgrass (*Agrostis stolonifera* L.) under prevailing selection pressure in a sea coast environment (Ashraf, *et al.*, 1986). In addition, the characteristics of leaf wettability were found to be responsible for tolerance to salt spray in salt tolerant creeping fescue cultivars (*Festuca rubra* L.) (Humphreys, 1986).

At the species level, however, there is a positive relationship for different landscape plant species between the salt tolerance revealed by salt spray and by root supply (Wu *et al.*, 2001). The salt tolerance levels in roots were found to be three to four times higher than in leaves (Wu *et al.*, 2001). Exceptions exist for trees of fruit crops used in landscapes that are grafted on rootstocks of different species. Their tolerance to salt spray and to soil salinity may be unrelated.

Based on the results of the landscape plant salt tolerance screening tests conducted at U.C. Davis in conjunction with the information gathered from the literature, lists of the salt tolerance of 266 landscape plant species were developed and are presented in this plant selection guide. In the plant selection tables, the plants are placed into four relative salt tolerance categories: Highly tolerant, Tolerant, Moderately tolerant, and Sensitive. Five or 6 salt tolerance divisions have been used to separate salt tolerance of crop plant species (Maas and Grattan, 1999), but for landscape plants fine separations of salt

tolerance among plant species is not necessary because, in a single landscape setting, the reclaimed water irrigation should be able to accommodate plants having a wide range of salt tolerance. In reality, there are no clear cut borderlines between the tolerance categories. In addition, the amount of stress that can be tolerated by an ornamental landscape plant represents a highly subjective cutoff level. Nevertheless, a separation based on the visual quality of the plants is a practical approach. Brief definitions of the salt tolerance categories for the plant species listed in the tables are presented below. All the plant salt tolerance screening tests were conducted under field conditions and during the summer months (Wu *et al.*, 2001).

(1): Tolerances to salt spray are defined by the degree of salt stress symptoms (relative to plants irrigated with potable water) on leaves of the plants and the salt concentrations in the applied irrigation water. Highly tolerant (H): No apparent salt stress symptoms were observed when the plants were irrigated with water having 600 mg L⁻¹ sodium and 900 mg L⁻¹ chloride (salt concentrations rarely reach these levels in recycled water). Tolerant (T): No apparent salt stress symptoms were observed when the plants were irrigated with water having 200 mg L⁻¹ sodium and 400 mg L⁻¹ chloride. Moderately tolerant (M): salt stress symptoms were observed in 10% or less of leaves when the plants were irrigated with water having 200 mg L⁻¹ sodium and 400 mg L⁻¹ chloride under dry and warm weather conditions. Sensitive (S): salt stress symptoms were seen in 20% or more of leaves when the plants were irrigated with water having 200 mg L⁻¹ sodium and 400 mg L⁻¹ chloride.

(2): Tolerances to soil salinity were defined as the limit of soil salinity that does not induce significant salt stress symptoms on plants. The soil salinity tolerance values were either determined in the field trials conducted at UC Davis or estimated based on information found in the literature. The definitions of soil salinity tolerance are: Highly tolerant (H): Acceptable soil electrical conductivity (EC) greater than 6 dS m⁻¹ and plants may not develop any salt stress symptoms even if the soil salinity exceeds this permissible level. Tolerant (T): Acceptable EC greater than 4 and less than 6 dS m⁻¹ and the plants in this category are adaptable to most reclaimed water irrigation without extra management input if restricted to soil application. Moderately tolerant (M): Acceptable EC greater than 2 and less than 4 dS m⁻¹, plants in this category require extra irrigation and soil management input. Sensitive (S): Acceptable EC less than 2 dS m⁻¹ and plants in this category are very sensitive to soil salinity. Serious foliar damage may occur if soil salinity exceeds the permissible level and/or plants are exposed to dry and warm weather conditions.

Tolerance of popular landscape species to salt spray and soil salinity are presented for trees (Table 2), shrubs (Table 3), groundcovers and vines (Table 4) and ornamental grasses (Table 5).

Salt stress symptoms and management precautions

The typical salt stress injury visually observable is leaf chlorosis (scorch-like symptom). It is detrimental physically and aesthetically to plants. Under severe salt stress, the whole leaf blade may become chlorotic and die. Under moderate salt stress, symptoms are similar among salt sensitive plant species. Nevertheless, there are differences in terms of the distribution of symptoms on the leaves and color of the symptoms.

Highly tolerant species are unlikely to develop any salt stress symptoms under recycled water irrigation even during the dry and warm summer season. Examples include Mexican Pinon Pine (*Pinus cembriodes*) (tree), Oleander (*Nerium oleander*) (Figure 2) (shrub), Red Apple Iceplant (*Aptenia cordifolia*) (Figure 3) (groundcover), and Alkali Sacaton (*Sporobolus airoides*) (grass). These species can tolerate salt spray with over 1000 mg L^{-1} NaCl in the water and are tolerant to soil salinity beyond 10 dS m^{-1} and require only routine management practices.

Tolerant plants are able to tolerate spray with water having salt levels found in most recycled waters and, generally, no apparent salt stress symptoms will develop on the plants if the soil salinity remains below 6 dS m^{-1} . However when their foliage is exposed to salt concentrations beyond 200 mg L^{-1} sodium and 300 mg L^{-1} chloride, leaves may develop salt damage symptoms such as those shown in the photo of Indian Hawthorn (*Rhaphiolepis indica*) (Figure 4).

Moderately tolerant species can tolerate recycled water spray having salt concentrations at levels found in most recycled waters. However, they may develop salt stress symptoms toward the end of the growing season when salt accumulation in the leaves becomes high and/or the soil salinity goes beyond the permissive level, but generally, their aesthetic quality is acceptable. Examples include Cork Oak (*Quercus suber*) (Figure 5). When there are dry season and wet season cycles, irrigation may be discontinued during wet seasons and the moderately tolerant plants may do very well through most of the year.

Sensitive plants may develop salt stress symptoms under salt spray if the water sodium concentration reaches 200 mg L^{-1} and chloride concentration reaches 400 mg L^{-1} , especially under warm and dry weather conditions. Examples of salt sensitive species include Liquidambar (*Liquidambar styraciflua*) (Figure 6), Heavenly Bamboo (*Nandina domestica*) (Figure 7), Silk Tree (*Albizia julibrissin*) (Figure 8), Cornelian Cherry (*Cornus mas*) (Figure 9), Ginkgo (*Ginkgo biloba*) (Figure 10), and Rose (*Rosa* spp.) (Figure 11). Plants sensitive to salt spray are also sensitive to soil salinity. For example, roses may develop severe salt stress symptoms if the soil salinity reaches 3 dS m^{-1} .

It should be noted that salt tolerance of any given plant species depends on factors such as climate, weather, irrigation management, soil texture, soil structure, soil fertility and interactions between the plants and these various environmental and soil factors. Most landscape plants can tolerate greater salt stress under cool and humid weather conditions. Therefore, plants may look perfect over the winter and spring, but when the dry and warm summer comes or they encounter a windy day, the plants may suddenly develop serious salt stress symptoms due to increased transpiration rates and salt accumulation in

their leaves, especially for the salt sensitive species. The moderately tolerant plants often show increased symptoms in the fall after the extended dry summer season (such as in the Sacramento Valley, California) when salt accumulation in their leaves becomes high as in Rockspray Cotoneaster (*Cotoneaster microphyllus*) (Figure 12). Temperature, radiation, humidity, and wind speed are factors affecting transpiration rate, salt accumulation, and salt tolerance of plants. Therefore, for moderately tolerant and salt sensitive plants, close monitoring of soil salinity and irrigation practices is necessary.

Landscape plants respond differently to salt concentrations in irrigation water depending on the method of irrigation used such as drip, ground surface application, or sprinkler irrigation. In California, for most landscape plantings, sprinkler irrigation is preferred because it requires less maintenance and is less vulnerable to damage than drip irrigation. Plants irrigated with a sprinkler system are subject to injury not only from salts in the soil but also from salts absorbed directly through wetted leaves. In addition, management of sprinkler irrigation can affect the degree of leaf injury caused by salt deposition. Infrequent heavy irrigation should be applied rather than frequent light irrigation. Slowly rotating sprinklers that allow drying between cycles should be avoided. Sprinkler irrigation should be done at night or early morning and should be avoided on hot, dry, windy days.

Soil with a poor structure or impermeable layers can restrict the growth of roots and distribution of water and salt in the soil. Flooded or poorly drained soils can cause poor aeration of the soil and inadequate drainage results in a shallow water table. Such poor soil conditions inevitably reduce the overall health of plants and they can become more vulnerable to salt stress. In addition, low soil fertility and nutrient deficiency can reduce salt tolerance of plants. Soil salinity in the field is seldom constant. It may be highly variable. The salt concentrations near the soil surface may be equal to approximately that of the irrigation water, but at the bottom of the root zone concentrations may be many times greater. If a saline water table exists within a meter of the surface, salts may be transported upward by capillary flow. Under such conditions, soil salinity may be inverted, with the highest salt concentrations at the surface. Soil salinity also increases between irrigations with the evaporation of soil water. Plant growth closely responds to the change of salt concentrations in the root zone. Therefore, the tolerance of plants to soil salinity is related to salinity integrated over time and is affected by the salt concentration in the root zone where roots absorb most of the water. Modification of soil physical properties and improvement of management practices can reduce salt accumulation in the root zone and, therefore, improve growth of plants.

Additional remarks

Plant species considered salt sensitive or moderately salt tolerant require extra management if salt concentrations in the recycled water exceed their tolerance levels. Young leaves of trees in this category and bud sprouts of deciduous trees are more vulnerable to salt spray than mature leaves. Once the trees grow above spray height less management is necessary. However, tree branches at lower levels may be exposed to

water spray and develop salt stress symptoms such as in Chinese Pistache (*Pistachia chinensis*) (Figure 13). Using drip irrigation to prevent contact of recycled water with the foliage of salt sensitive shrub and groundcover species is recommended. However, the soil salinity needs to be monitored. For new landscape plantings, plants in similar salt tolerance categories can be planted in the same area and irrigated accordingly.

Coast redwood (*Sequoia sempervirens*) is one of the most popular evergreen tree species used in landscapes in northern California. In the years of 2000 and 2001, chlorosis symptoms and death of coast redwood occurred in landscapes and on golf courses in several counties near the San Francisco Bay. Although incidences were found on sites with and without recycled water irrigation, public concern increased regarding utilization of recycled water. The situation was further complicated by the fact that coast redwood has been established as a host for Sudden Oak Death disease (*Phytophthora ramorum*). It was not possible to attribute the damage seen on redwoods in the landscape to disease or salt injury without further research.

At the University of California, Davis the tolerance of coast redwood to salt and boron spray was tested (Wu and Guo, 2005). The information generated by the study revealed several management guidelines. (1) Coast redwood is considered to be salt sensitive, but varietal differences were observed (Figure 14). It is possible to select varieties with greater salt tolerance for reclaimed water irrigation. (2) Coast redwood should not be planted in landscapes in close proximity to the seacoast. Salt concentrations in the straight airborne seawater are too high for the coast redwood. However, in locations near the coast, where the humidity is high and temperature is mild the coast redwood may not develop any salt stress symptoms. (3) For existing coast redwood plantings, irrigation with recycled water should be restricted to ground level and should be closely monitored to ensure that soil salinity does not exceed 2 dS m^{-1} .

Generally, most grass species are within the **Tolerant** category for recycled water irrigation and no extra management is necessary. In addition, the amount of chlorosis that can be tolerated in an ornamental landscape, especially for ornamental grasses, is highly subjective. Many perennial grass species naturally retain mature brown leaves and this is often considered a desirable characteristic such as in Deergrass (Figure 15). When turfgrass is routinely mowed, salt is removed with the clippings making the grass more tolerant to salt stress than non-mowed grass. For example, for tall fescue turf irrigated with recycled water, no fertilizer application was needed over several years and a healthy and dense turf surface was maintained (Figure 16). In addition, single species of turfgrass are usually planted in large areas such as for sports turf, parks, golf courses and utility turf. In these instances, the specific level of salt tolerated in recycled water can be considered for the particular turfgrass species.

Boron (B) is an essential element for plants but it can become toxic when soil-water concentrations exceed the level for optimum plant growth. Toxic concentrations of boron are often found in soil and water in arid regions. Most surface irrigation waters contain boron concentrations below levels considered toxic to plants. There are some areas, however, where well waters contain toxic levels of boron such as in some locations of the

California Central Valley. In most recycled waters, boron concentrations do not exceed levels toxic to landscape plants, but in rare cases where the boron level exceeds 1 mg L^{-1} damage to boron sensitive plant species can occur. Limited information on boron tolerance of landscape plants can currently be found in the literature. Boron tolerance of 9 tree, 24 shrub, and 8 grass species are presented in Table 6.

Summary

A total of 209 tree, shrub and groundcover species are listed in this salt tolerance selection guide. Generally, the species that tolerate salt spray also tolerate soil salinity. Among the 86 tree species, 31% are salt sensitive and 11% are highly tolerant. Among the 65 shrub species, 22% are salt sensitive and 19% are highly tolerant. Among the 58 groundcover species, 19% are salt sensitive and 30% are highly tolerant. Overall, 27% of species are salt sensitive and 20% are highly tolerant. For the highly tolerant species, no extra management input is required for recycled water irrigation. Salt sensitive species are not recommended for recycled water irrigation. Approximately 50% of landscape plant species are either tolerant or moderately tolerant to salt. If recycled water irrigation is considered, both plant selection and soil salinity management are recommended to ensure successful use of recycled water. Among the 57 grass species, only 7 species are salt sensitive. Over 90% of the grass species are tolerant to recycled water irrigation. In addition, a single species of turfgrass is usually planted in large areas for sports turf, parks, golf courses and utility turf. The specific salt level in recycled water can be considered for each particular turfgrass species.

Acknowledgements

The authors wish to acknowledge the Slosson Endowment Fund, the City of San Jose, and the Marin County Water District for providing funding for this project. The author also wishes to thank Dr. Ali Harivandi of UC Cooperative Extension, Mr. Jerry Brown of the City of San Jose, and Mr. Roger Waters of the Marin County Municipal Water District for their generous input into this research.

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Table1. Comparison of chemical constituents found in recycled water from South Bay Water Recycling and in the municipal drinking water of the City of San Jose, California in the year 2001. (Data adapted from the 2001 South Bay Recycled Water Quality Report).

| Chemical constituents | Recycled water | | | | San Jose Municipal drinking water |
|---|---------------------|---------------|---------------|----------------|-----------------------------------|
| | Unit of measurement | Minimum level | Maximum level | Yearly average | |
| Alkalinity – Total CaCO ₃ | ppm | 140 | 220 | 184 | 15 - 234 |
| Sodium Adsorption Ratio - SAR | mg/L | 4.3 | 4.8 | 4.5 | - |
| Electrical Conductivity - EC _w | dS/m | 1.1 | 1.5 | 1.3 | - |
| Hydrogen Ion Activity - pH | Units | 6.68 | 7.40 | 6.98 | 7.2 – 9.8 |
| Nitrate (as Nitrogen) | ppm | 5.8 | 15.9 | 9.2 | ND -12 |
| Total Dissolved Solids (TDS) | ppm | 680 | 840 | 748 | 21 -390 |
| | | | | | |
| Arsenic | ppb | 0.7 | 1.9 | 1.2 | - |
| Boron | ppm | 0.49 | 0.59 | 0.52 | - |
| Cadmium | ppb | 0.5 | 0.5 | 0.5 | - |
| Calcium | ppm | 47.2 | 51.8 | 48.8 | 4 - 39 |
| Chloride | ppm | 173 | 244 | 208 | 3 -86 |
| Copper | ppb | 1.9 | 6.7 | 3.5 | 0.114 – 0.260 |
| Chromium | ppb | 0.7 | 0.7 | 0.7 | 15 -17 |
| Iron | ppm | 0.14 | 0.14 | 0.14 | - |
| Lead | ppb | <1.0 | <1.0 | <1.0 | 2.2 – 5.8 |
| Magnesium | ppm | 26.6 | 32.1 | 29.0 | 0.5 – 4.5 |
| Mercury | ppb | 0.0020 | 0.0035 | 0.0026 | |
| Nickel | ppb | 4.0 | 10 | 6.5 | - |
| Sodium | ppm | 139 | 185 | 162 | 3 - 58 |
| Silver | ppb | <0.2 | <1.0 | <1.0 | - |
| Phosphate | ppm | 1.0 | 9.50 | 4.46 | - |
| Potassium | ppm | 12.6 | 16.4 | 15.0 | 0.5 – 2.9 |
| Sulfate | ppm | 94 | 124 | 107 | 0.5 – 56.3 |
| Zinc | ppb | 27 | 86 | 52 | 0.28 – 0.56 |
| Nitrate | ppm | 5.8 | 15.9 | 9.2 | ND - 12 |
| Nitrite | ppm | 0.1 | 0.9 | 0.3 | - |
| Ammonia | ppm | 0.1 | 1.2 | 0.3 | - |

Table 2. Tolerance of landscape tree species to salt spray (overhead irrigation with recycled water) and soil salinity.

| Botanical name | Common name | Tolerance to salt spray ⁽¹⁾ | Tolerance to soil salinity ⁽²⁾ |
|--|--------------------------------------|--|---|
| <i>Acer pseudoplatanus</i> L. | Sycamore Maple | S | S |
| <i>Acer rubrum</i> L. | Red Maple | S | S |
| <i>Albizia julibrissin</i> Durazz. | Silk Tree | S | S |
| <i>Araucaria heterophylla</i> (Salisb.) | Norfolk Island Pine | H | T |
| <i>Averrhoa carambola</i> L. | Carambola, Starfruit | M | M |
| <i>Bauhinia purpurea</i> L. | Orchid Tree | S | M |
| <i>Callistemon citrinus</i> Curtis. | Lemon Bottlebrush | T | M |
| <i>Carya illinoensis</i> Koch. | Pecan | M | M |
| <i>Cedrus deodara</i> D. Don | Deodar Cedar | M | M |
| <i>Celtis sinensis</i> Pers. | Chinese Hackberry | S | S |
| <i>Citrus limon</i> L. | Lemon | S | S |
| <i>Citrus paradisi</i> Macf. | Grapefruit | S | S |
| <i>Citrus reticulata</i> Blanco. | Tangerine | S | S |
| <i>Citrus sinensis</i> Osbeck. | Orange | S | S |
| <i>Coccoloba uvifera</i> L. | Sea Grape | H | T |
| <i>Cornus mas</i> L. | Cornelian Cherry | S | S |
| <i>Cotoneaster microphyllus</i> Lindl. | Rockspray or Little-leaf Cotoneaster | M | M |
| <i>Cupressus sempervirens</i> L. | Italian Cypress | M | M |
| <i>Diospyros digyna</i> L. | Black Sapote | M | M |
| <i>Diospyros virginiana</i> L. | American Persimmon | S | S |
| <i>Eriobotrya japonica</i> Lindl. | Loquat | M | M |
| <i>Euryops pectinatus</i> | Golden Marguerite | S | S |
| <i>Ficus carica</i> L. | Edible Fig | T | T |
| <i>Forsythia x intermedia</i> Zabel | Forsythia | T | T |
| <i>Fraxinus oxycarpa</i> Bieb. Ex Willd. | Raywood Ash | M | M |
| <i>Ginkgo biloba</i> L. | Ginkgo | S | S |
| <i>Grevillea robusta</i> Cunn. | Silk Oak | H | T |
| <i>Jacaranda mimosifolia</i> D. Don. | Jacaranda | S | S |
| <i>Juniperus silicicola</i> Bail. | Southern Red Cedar | H | T |
| <i>Juniperus virginiana</i> L. | Skyrocket Juniper | H | T |
| <i>Koelreuteria paniculata</i> Laxm. | Goldenrain Tree | M | M |
| <i>Lagerstoemia indica</i> L. | Crape Myrtle | S | S |
| <i>Ligustrum japonicum</i> Thunb. | Japanese Privet | M | M |
| <i>Liquidambar styraciflua</i> L. | Sweet Gum | S | S |

| | | | |
|--------------------------------------|----------------------------------|---|---|
| <i>Litchi chinensis</i> Sonn. | Lychee | S | S |
| <i>Magnolia grandiflora</i> L. | Southern Magnolia | S | S |
| <i>Malus sylvestris</i> Mill. | Crab Apple | S | S |
| <i>Mangifera indica</i> L. | Mango | S | S |
| <i>Manilkara zapota</i> | Sapodilla | T | T |
| <i>Musa acuminata</i> Colla. | Banana | S | S |
| <i>Olea europaea</i> L. | Olive | S | S |
| <i>Parthenium argentatum</i> Gray. | Guayule | H | H |
| <i>Persea americana</i> Mill. | Avacado | M | M |
| <i>Pinus cembroides</i> Zucc. | Mexican Pinon Pine | H | T |
| <i>Pinus clausa</i> Vasey | Sand Pine | H | T |
| <i>Pinus elliottii</i> Engelm. | Florida Slash Pine | M | M |
| <i>Pinus halepensis</i> Mill. | Aleppo Pine | M | M |
| <i>Pinus thunbergii</i> Parl. | Japanese Black Pine | M | M |
| <i>Pistachia chinensis</i> Bunge. | Chinese Pistache | S | S |
| <i>Platycladus orientalis</i> Franco | Oriental Arbor-Vitae | M | M |
| <i>Plumbago auriculata</i> Lam. | Cape Plumbago | T | M |
| <i>Plumeria</i> spp. L. | Frangipani | T | T |
| <i>Prunus armeniaca</i> L. | Apricot | S | S |
| <i>Prunus caroliniana</i> Ait. | Carolina Laurel Cherry | M | S |
| <i>Prunus dulcis</i> D.A. Webb. | Almond | S | S |
| <i>Prunus persica</i> Batsch | Peach | S | S |
| <i>Prunus spinosa</i> L. | Blackthorn | T | M |
| <i>Psidium guajava</i> L. | Guava | S | S |
| <i>Punica granatum</i> L. | Pomegranate | M | M |
| <i>Pyrus communis</i> L. | Pear | L | L |
| <i>Pyrus spinosa</i> Forssk. | Almond-leaved Pear | M | M |
| <i>Quercus agrifolia</i> Nee | Coast Live Oak | T | T |
| <i>Quercus laurifolia</i> Michux | Laurel Oak | S | S |
| <i>Quercus suber</i> L. | Cork Oak | M | M |
| <i>Quercus virginiana</i> Mill. | Live Oak | H | T |
| <i>Sapium sebiferum</i> Roxb. | Chinese Tallow Tree | H | T |
| <i>Schefflera actinophylla</i> Harms | Schefflera, Umbrella Tree | M | M |
| <i>Sequoia sempervirens</i> Endl. | Coast Redwood Var. Aptos Blue | S | S |
| <i>Sequoia sempervirens</i> Endl. | Coast Redwood Var. Los Altos | M | M |
| <i>Syzygium jambos</i> Alston | Rose Apple | S | S |
| <i>Ulmus parvifolia</i> 'Drake' | Chinese Elm cv. Drake | M | M |
| <i>Ulmus parvifolia</i> Jacq. | Chinese Elm | M | M |
| Palms | | | |
| <i>Acoelorrhaphe wrightii</i> Becc. | Paurotis Palm | M | M |
| <i>Butia capitata</i> Becc. | Pindo Palm | T | T |
| <i>Caryota mitis</i> Lour. | Fishtail Palm | M | M |

| | | | |
|--|------------------------------------|---|---|
| <i>Chamaerops humilis</i> L. | Mediterranean Fan Palm | T | T |
| <i>Chrysalidocarpus lutescens</i> Wendl. | Areca Palm | M | M |
| <i>Nolina recurvata</i> Hemsle | Ponytail Palm (not a true palm) | M | M |
| <i>Phoenix canariensis</i> Chabaud. | Canary Island Date Palm | M | M |
| <i>Phoenix dactylifera</i> L. | Date Palm | T | T |
| <i>Phoenix reclinata</i> Jacq. | Senegal Date Palm | M | M |
| <i>Phoenix roebelinii</i> O'Brien. | Pygmy Date Palm | M | M |
| <i>Rhapis excelsa</i> Henry | Lady Palm | M | M |
| <i>Sabal palmetto</i> Lodd. | Cabbage Palm | T | T |
| <i>Serenoa repens</i> Small | Saw Palmetto | T | T |
| <i>Syagrus romanzoffiana</i> L. | Queen Palm | M | M |
| <i>Washingtonia robusta</i> Wendl. | Mexican Fan Palm | T | T |

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(2): The definitions of soil salinity tolerance are: Highly tolerant (H): acceptable soil EC greater than 6 dS m⁻¹, Tolerant (T): acceptable soil EC greater then 4 and less than 6 dS m⁻¹, Moderately tolerant (M): acceptable soil EC greater than 2 and less than 4 dS m⁻¹, Sensitive (low tolerance) (S): acceptable soil EC less than 2 dS m⁻¹.

Table 3. Tolerance of landscape shrub species to salt spray (overhead irrigation with recycled water) and soil salinity.

| Botanical name | Common name | Tolerance to salt spray ⁽¹⁾ | Tolerance to soil salinity ⁽²⁾ |
|--|-----------------------------------|--|---|
| <i>Abelia grandiflora</i> Rehd. | 'Edward Goucher' Abelia | S | S |
| <i>Acacia redolens</i> Maslin. | Prostrate Acacia | T | T |
| <i>Acalypha wilkesiana</i> Muell. | Copper Leaf | S | S |
| <i>Agave americana</i> L. | Century Plant | H | T |
| <i>Arctostaphylos densiflora</i> M.S.Bac | Vine Hill Manzanita | T | T |
| <i>Bambusa sp.</i> Schreb. | Bamboo | M | M |
| <i>Buddleja davidii</i> Franch. | Butterfly Bush | S | S |
| <i>Buxus microphylla</i> Mull. Arg. | Japanese Boxwood | T | M |
| <i>Calliandra haematocephala</i> Hassk. | Powder Puff Tree | S | S |
| <i>Callistemon rigidus</i> R. Br. | Bottle Brush | M | M |
| <i>Camellia japonica</i> L. | Camellia | S | S |
| <i>Canna x generalis</i> Bailey. | Canna Lily | M | M |
| <i>Carica papaya</i> L. | Papaya | M | M |
| <i>Carissa macrocarpa</i> A. DC. | Natal Plum | H | T |
| <i>Ceanothus thyrsiflorus</i> Esch. | Blue Blossom | T | M |
| <i>Cestrum aurantiacum</i> Lindl. | Orange Cestrum | M | M |
| <i>Codiaeum variegatum</i> Blume. | Croton | S | S |
| <i>Cornus mas</i> L. | Cornelian Cherry | S | S |
| <i>Cotoneaster congestus</i> Baker | Pyrenees Cotoneaster | S | S |
| <i>Cotoneaster microphylla</i> Lindl. | Rockspray Cotoneaster | M | S |
| <i>Dracaena deremensis</i> Engler. | Dracaena | M | M |
| <i>Elaeagnus pungens</i> Thunb. | Silverthorn, Silverberry | H | T |
| <i>Escallonia rubra</i> Pers. | Escallonia | T | M |
| <i>Eugenia uniflora</i> L. | Surinam Cherry | S | S |
| <i>Euphorbia milii</i> Ch. Des Moulins | Crown of thorns | H | H |
| <i>Euphorbia pulcherrima</i> Willd. | Poinsettia | S | S |
| <i>Euryops pectinatus</i> L. | Golden Shrub Daisy | T | M |
| <i>Forsythia x intermedia</i> Zabel | Hybrid Forsythia | M | M |
| <i>Gamolepis chrysanthemoides</i> DC. | African Bush Daisy | H | T |
| <i>Gardenia augusta</i> Merrill | Cape Jasmine, Gardenia | M | M |
| <i>Heliconia sp.</i> | Heliconia | M | M |
| <i>Hibiscus rosa-sinensis</i> L. | Rose of China, Garden Hibiscus | M | M |
| <i>Hydrangea macrophylla</i> Ser. | Hydrangea | T | M |
| <i>Ilex cornuta</i> Burford | Chinese Holly | M | M |
| <i>Ilex vomitoria</i> 'Nana ' | Dwarf Yaupon Holly | H | T |
| <i>Ilex vomitoria</i> Ait. | Yaupon Holly | T | T |

| | | | |
|---|-------------------------------|---|---|
| <i>Ixora coccinea</i> L. | Ixora | S | S |
| <i>Jasminum polyanthum</i> Franch. | Jasmine | M | M |
| <i>Jatropha multifida</i> L. | Coral Plant | S | M |
| <i>Justicia brandegeana</i> Wassh. | Shrimp Plant | S | S |
| <i>Lantana camara</i> L. | Lantana | H | T |
| <i>Mahonia aquifolium</i> Nutt. | Oregon Grape | S | S |
| <i>Mahonia pinnata</i> Fedde | California Holly Grape | S | S |
| <i>Murraya paniculata</i> L. | Orange Jessamine | S | S |
| <i>Myrica cerifera</i> L. | Wax Myrtle | H | T |
| <i>Myrtus communis</i> L. | True Myrtle | T | T |
| <i>Nandina domestica</i> Thunb. | Heavenly Bamboo | S | S |
| <i>Nerium oleander</i> L. | Oleander | H | T |
| <i>Opuntia</i> sp. Miller | Opuntia Cactus | M | T |
| <i>Parthenium argentatum</i> Gray. | Guayule | H | H |
| <i>Pentas lanceolata</i> Deflers | Pentas, Egyptian star-cluster | S | S |
| <i>Photinia fraseri</i> Dress | Photinia | S | S |
| <i>Photinia glabra</i> Maxim. | Japanese Photinia | S | S |
| <i>Pittosporum tobira</i> Aiton | Mock Orange | H | T |
| <i>Plumbago auriculata</i> Lam. | Cape Plumbago | T | T |
| <i>Podocarpus macrophyllus</i> D. Don | Yew Pine | S | S |
| <i>Pyracantha coccinea</i> Roem. | Red Firethorn | M | M |
| <i>Raphiolepis indica</i> Lindl. | Indian Hawthorn | H | T |
| <i>Rosa</i> sp. L. | Rose | S | S |
| <i>Russelia equisetiformis</i> Schlecht & Cham. | Firecracker Plant | M | M |
| <i>Sambucus callicarpa</i> Greene | Coast Red Elderberry | T | M |
| <i>Schefflera arboricola</i> L. | Dwarf Schefflera | M | M |
| <i>Strelitzia reginae</i> Bankses Dryander | Bird of Paradise | M | M |
| <i>Viburnum odoratissimum</i> Ker. | Sweet Viburnum | M | M |
| <i>Viburnum suspensum</i> Lindl. | Sandankwa Viburnum | M | M |
| <i>Yucca aloifolia</i> L. | Spanish Bayonet | H | H |

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(2): The definitions of soil salinity tolerance are: Highly tolerant (H): acceptable soil EC greater than 6 dS m⁻¹, Tolerant (T): acceptable soil EC greater then 4 and less than 6 dS m⁻¹, Moderately tolerant (M): acceptable soil EC greater than 2 and less than 4 dS m⁻¹, Sensitive (low tolerance) (S): acceptable soil EC less than 2 dS m⁻¹.

Table 4. Tolerance of landscape groundcover and vine species to salt spray (overhead irrigation with recycled water) and soil salinity.

| Botanical name | Common name | Tolerance to salt spray ⁽¹⁾ | Tolerance to soil salinity ⁽²⁾ |
|--|-------------------------|--|---|
| Ground Covers | | | |
| <i>Adiantum sp.</i> L. | Maidenhair Fern | M | M |
| <i>Ajuga reptans</i> | Carpet Bugle | S | S |
| <i>Aloe vera</i> Burm. f. | Aloe | H | T |
| <i>Alternanthera ficoidea</i> R. Br. | Joyweed | M | M |
| <i>Aptenia cordifolia</i> N. E. Br. | Red Apple Iceplant | T | T |
| <i>Arctostaphylos densiflora</i> | Lynne's Vine Hill | M | M |
| 'Lynne' M.S.Bak. | Manzanita | | |
| <i>Athyrium filix-femina</i> Rith. | Lady Fern | S | S |
| <i>Bromeliaceae sp.</i> L. | Bromeliads | M | M |
| <i>Caladium sp.</i> Vent. | Caladium | S | S |
| <i>Carissa macrocarpa</i> A. DC. | Natal Plum | H | T |
| <i>Carpobrotus edulis</i> L. Bolus. | Hottentot Fig | H | T |
| <i>Catharanthus roseus</i> G. Donf. | Periwinkle | T | M |
| <i>Chlorophytum comosum</i> Jacq. | Spider Plant | M | M |
| <i>Cuphea hyssopifolia</i> Kunth. | False Heather | M | T |
| <i>Cyperus alternifolius</i> L. | Umbrella Sedge | M | M |
| <i>Delosperma 'Alba'</i> N. E. | White Iceplant | H | H |
| <i>Dietes spp.</i> Salisb. ex Klatt. | African Iris | M | M |
| <i>Drosanthemum hispidum</i> | Rosea Iceplant | H | H |
| Schwantes. | | | |
| <i>Ficus pumila</i> L. | Creeping Fig | H | T |
| <i>Hemerocallis sp.</i> L. | Daylily | M | M |
| <i>Iris hexagona</i> Walter | Iris | M | M |
| <i>Juniperus chinensis</i> L. | Chinese Juniper | M | M |
| <i>Juniperus conferta</i> Parl. | Shore Juniper | T | T |
| <i>Juniperus horizontalis</i> | Creeping Juniper | H | T |
| Moench. | | | |
| <i>Juniperus procumbens</i> Siebild ex Endl. | Japanese Garden Juniper | M | M |
| <i>Kalanchoe sp.</i> Adans. | Kalanchoe | M | M |
| <i>Lampranthus productus</i> N. E. Br. | Purple Iceplant | H | H |
| <i>Liriope muscari</i> L. H. Bail. | Lilyturf (Liriope) | M | M |
| <i>Malephora crocea</i> Schwantes. | Iceplant | H | H |
| <i>Nephrolepis exaltata</i> Schott. | Sword Fern | H | T |
| <i>Peperomia obtusifolia</i> Dietr. | Peperomia | S | S |
| <i>Portulaca grandiflora</i> Hook. | Purslane (Rose Moss) | M | S |
| <i>Rosmarinus officinalis</i> L. | Rosemary | M | M |
| <i>Salvia farinacea</i> Benth. | Mealycup Sage | S | S |

| | | | |
|---|-----------------------|---|---|
| <i>Tigridia pavonia</i> Ker Gawler | Tiger Flower | T | M |
| <i>Tradescantia pallida</i> Hunt. | Purple Queen | H | T |
| <i>Tulbaghia violacea</i> Harvey | Society Garlic | M | M |
| <i>Verbena sp.</i> L. | Verbena | S | S |
| <i>Zamia integrifolia</i> L. f. | Coontie | H | T |
| Vines | | | |
| <i>Allamanda blanchetii</i> A. DC. | Purple Allamanda | M | M |
| <i>Allamanda cathartica</i> L. | Allamanda | T | T |
| <i>Antigonon leptopus</i> Hookery | Coral Vine | S | M |
| <i>Bougainvillea glabra</i> Choisy | Bougainvillea | H | T |
| <i>Campsis radicans</i> Seem. | Trumpet Creeper | S | S |
| <i>Clerodendrum thomsoniae</i> Balf. f. | Bleeding Heart Vine | S | S |
| <i>Clytostoma callistegioides</i> Miers ex Bur. | Violet Trumplt Vine | S | S |
| <i>Epipremnum sp.</i> Schott. | Pothos | M | M |
| <i>Ficus pumila</i> L. | Creeping Fig | H | T |
| <i>Hedera canariensis</i> Willd. | Algerian Ivy | H | T |
| <i>Hedera helix</i> L. | English Ivy | M | M |
| <i>Hylocereus undatus</i> Britton & Rose | Night Blooming Cereus | M | M |
| <i>Ipomoea pescaprae</i> R. Br. | Railroad Vine | H | T |
| <i>Ipomoea stolonifera</i> Gmel. | Seafoam Morning Glory | H | T |
| <i>Passiflora incarnata</i> L. | Passion Flower | S | S |
| <i>Philodendron williamsii</i> Hook. | Philodendron | M | M |
| <i>Tecomaria capensis</i> Spach. | Cape Honeysuckle | H | T |
| <i>Trachelospermum jasminoides</i> Lem. | Star Jasmine | T | T |

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Table 5. Tolerance of landscape grass species to salt spray (overhead irrigation with recycled water) and soil salinity

| Botanical name | Common name | Tolerance to salt spray ⁽¹⁾ | Tolerance to soil salinity ⁽²⁾ |
|--|---------------------------------------|--|---|
| <i>Agropyron cristatum</i> (L.) Gaertn. | Fairway Wheatgrass | M | M |
| <i>Agropyron elongatum</i> (host) Beauv. | Tall Wheatgrass | M | T |
| <i>Agropyron intermedium</i> (Host) Beauv. | Intermediate Wheatgrass | M | M |
| <i>Agropyron sibiricum</i> Willd. | Siberian Wheatgrass | M | M |
| <i>Agropyron smithii</i> Rydb. | Western Wheatgrass | M | M |
| <i>Agropyron trachycaulum</i> (Link) Malte | Slender Wheatgrass | M | M |
| <i>Agrostis palustris</i> Hunds. | Creeping Bentgrass | M | M |
| <i>Agrostis palustris</i> Hunds. | Creeping Bentgrass, (Seaside variety) | T | M |
| <i>Agrostis tenuis</i> Sibth. | Colonial Bentgrass | M | M |
| <i>Allopecurus pratensis</i> L. | Meadow Foxtail | S | S |
| <i>Arrhenatherum elatius</i> Beauv. | Oat Grass | M | S |
| <i>Bouteloua gracilis</i> (H.B.K.) Lag. Ex Steud. | Blue grama | M | M |
| <i>Bromus carinatus</i> Hook. et Arm. | California Brome | M | M |
| <i>Bromus inermis</i> Leyss. | Bromegrass, smooth | T | M |
| <i>Bromus marginatus</i> Nees | Bromegrass, mountain | T | M |
| <i>Bromus unioloides</i> Willd. | Rescue Grass | T | M |
| <i>Buchloe dactyloides</i> (Nutt.) Engelm. | Buffalograss | M | M |
| <i>Chloris gayana</i> Kunth | Rhodes Grass | T | M |
| <i>Cynodon dactylon</i> (L.) Pers. | Bermudagrass | T | T |
| <i>Dactylis glomerata</i> L. | Orchard Grass | S | S |
| <i>Deschampsia caespitosa</i> (L.) Beauv. | California Hairgrass | M | S |
| <i>Deschampsia elongata</i> (Hook) Munro ex Benth. | Slender Hairgrass | T | M |
| <i>Distichlis spicata</i> L. Greene. | Saltgrass | H | H |
| <i>Elymus angustus</i> Trin. | Altai Wildrye | T | T |
| <i>Elymus canadensis</i> L. | Canadian Wildrye | T | T |
| <i>Elymus glaucus</i> Buckl. | Blue Wildrye | T | M |
| <i>Elymus junceus</i> L. | Russian Wildrye | T | T |
| <i>Elymus triticoides</i> Buckl. | Beardless Wildrye | T | T |

| | | | |
|---|---------------------|---|---|
| <i>Eragrostis sp.</i> Beauv. | Love Grass | M | S |
| <i>Eremochloa ophiuroides</i> (Munro) Hack. | Centipede grass | M | M |
| <i>Festuca arundinacea</i> Schreb. | Tall Fescue | T | M |
| <i>Festuca californica</i> Vasey. | California Fescue | T | M |
| <i>Festuca elatior</i> L. | Meadow Fescue | M | M |
| <i>Festuca longifolia</i> Thuill. | Hard Fescue | M | M |
| <i>Festuca rubra</i> L. | Creeping Fescue | M | M |
| <i>Leptochloa fusca</i> (L.) Kunth [syn. <i>Diplachne fusca</i> Beauv.] | Kallar grass | T | T |
| <i>Lolium multiflorum</i> Lam. | Annual Ryegrass | S | S |
| <i>Lolium perenne</i> L. | Perennial Ryegrass | M | M |
| <i>Melica californica</i> Scribn. | California Melic | M | M |
| <i>Muhlenbergia rigens</i> Benth. | Deer grass | T | T |
| <i>Panicum antidotale</i> Retz. | Panic grass | T | M |
| <i>Paspalum dilatatum</i> Vasey | Dallis grass | S | S |
| <i>Paspalum notatum</i> Flugge. | Bahi grass | M | M |
| <i>Paspalum vaginatum</i> L. (Seashore ecotype) | Seashore Paspalum | H | T |
| <i>Phalaris arundinacea</i> L. | Canary grass | T | M |
| <i>Phalaris tuberosa</i> L. | Harding Grass | M | M |
| <i>Phleum pratense</i> L. | Timothy | S | S |
| <i>Poa annua</i> L. | Annual Blue grass | S | S |
| <i>Poa pratensis</i> L. | Kentucky Blue grass | S | S |
| <i>Poa scabrella</i> (Thurb.) Benth. | Pine Blue grass | T | M |
| <i>Poa trivialis</i> L. | Rough Blue grass | S | S |
| <i>Puccinellia airoides</i> Parl. | Alkali grass | H | H |
| <i>Sorghum sudanense</i> (Piper) Stapf. | Sundangrass | M | M |
| <i>Sporobolus airoides</i> Torr. | Alkali Sacaton | H | H |
| <i>Stenotaphrum secundatum</i> (Walt.) Kuntze. | St. Augustine grass | T | M |
| <i>Zea mays</i> L. | Corn | M | S |
| <i>Zoysia japonica</i> Steud. | Zoysiagrass | M | M |

(1): Tolerances to salt spray are defined by the degree of salt stress symptoms developed in plant leaves and the salt concentrations in the irrigation water. Highly tolerant (H): No apparent salt stress symptoms observed when plants are irrigated with water containing 600 mg L⁻¹ sodium and 900 mg L⁻¹ chloride. Tolerant (T): No apparent salt stress symptoms observed when plants are irrigated with water containing 200 mg L⁻¹ sodium and 400 mg L⁻¹ chloride. Moderately tolerant (M): Symptoms observed on less than 10% of leaves when plants are irrigated with water containing 200 mg L⁻¹ sodium and 400 mg

L⁻¹ chloride. Sensitive (S): More than 20% of leaves develop symptoms when plants are irrigated with water containing 200 mg L⁻¹ sodium and 400 mg L⁻¹ chloride.

(2): The definitions of soil salinity tolerance are: Highly tolerant (H): acceptable soil EC greater than 6 dS m⁻¹, Tolerant (T): acceptable soil EC greater then 4 and less than 6 dS m⁻¹, Moderately tolerant (M): acceptable soil EC greater than 2 and less than 4 dS m⁻¹, Sensitive (low tolerance) (S): acceptable soil EC less than 2 dS m⁻¹.

Table 6. Boron tolerance of landscape plant species.

| Botanical name | Common name | Boron tolerance based on: | Tolerance rating |
|--|----------------------|---------------------------|------------------|
| Trees | | | |
| <i>Citrus limon</i> (L.) Burm. f. | Lemon | Leaf injury | S |
| <i>Citrus paradisi</i> Macf. | Grapefruit | Leaf injury | S |
| <i>Citrus sinensis</i> (L.) Osbeck | Orange | Leaf injury | S |
| <i>Ficus carica</i> L. | Fig kadota | Whole plant | S |
| <i>Juglans regia</i> L. | Walnut | Leaf injury | S |
| <i>Persea americana</i> Mill. | Avacado | Leaf injury | S |
| <i>Prunus armeniaca</i> L. | Apricot | Leaf injury | S |
| <i>Prunus domestica</i> L. | Plum | Leaf injury | S |
| <i>Sequoia sempervirens</i> Endl. | Coast redwood | Leaf injury | S ⁽¹⁾ |
| Shrubs | | | |
| <i>Abelia grandiflora</i> (Andre) Rehd. | Glossy Abelia | Leaf injury | S |
| <i>Buxus microphylla</i> Siebold and Zucc. | Japanese Boxwood | Leaf injury | T |
| <i>Callistemon citrinus</i> (Curits) Stapf | Bottlebrush | Leaf injury | T |
| <i>Carissa grandiflora</i> (E.H. Mey) | Natal Plum | Leaf injury | H |
| <i>Cordyline indivisa</i> (G. Forest) Steud | Blue Dracaena | Leaf injury | M |
| <i>Elaeagnus pungens</i> Thunb. | Thorny Elaeagnus | Leaf injury | M |
| <i>Euonymus japonica</i> Thunb. | Spindle Tree | Leaf injury | M |
| <i>Feijoa sellowiana</i> O. Berg. | Pineapple Guava | Leaf injury | M |
| <i>Ilex cornuta</i> Lindl. and Paxt. | Chinese Holly | Leaf injury | S |
| <i>Juniperus chinensis</i> L. | Juniper | Leaf injury | S |
| <i>Lantana camara</i> L. | Yellow Sage | Leaf injury | S |
| <i>Leucophyllum frutescens</i> (Brtland) I.M. Johnst | Texas Ranger, Ceniza | Leaf injury | T |
| <i>Ligustrum japonicum</i> Thunb. | Wax-leaf privet | Leaf injury | T |
| <i>Mahonia aquifolium</i> (Pursh) Nutt | Oregon Grape | Leaf injury | S |
| <i>Nerium oleander</i> L. | Oleander | Leaf injury | T |
| <i>Photinia x fraseri</i> Dress | Photinia | Leaf injury | M |
| <i>Pittosporum tobira</i> (Thunb.) Ait. | Japanese Pittosporum | Leaf injury | S |
| <i>Platycladus orientalis</i> (L.) Franco | Oriental Arbovitae | Leaf injury | M |
| <i>Podocarpus macrophyllus</i> (Thunb.) D. Don. | Southern Yew | Leaf injury | T |

| | | | |
|--|-----------------------|------------------------|---|
| <i>Raphiolepis indica</i> (L.) Lindl. | Indian Hawthorn | Leaf injury | T |
| <i>Rosmarinus officinalis</i> L. | Rosemary | Leaf injury | M |
| <i>Syzygium paniculatum</i> Gaertn. | Brush Cherry | Leaf injury | T |
| <i>Viburnum tinus</i> L. | Laurustinus | Leaf injury | M |
| <i>Xylosma congestum</i> (Lour.) Merrill | Xylosma | Leaf injury | S |
| Grasses | | | |
| <i>Agrostis palustris</i> Huds. | Creeping Bentgrass | Growth and leaf injury | T |
| <i>Agrostis tenuis</i> Sibth. | Highland Bentgrass | Growth and leaf injury | T |
| <i>Cynodon dactylon</i> L. | Bermudagrass | Growth and leaf injury | T |
| <i>Festuca arundinacea</i> Schreb. | Tall Fescue | Growth and leaf injury | T |
| <i>Lolium perenne</i> L. | Perennial Ryegrass | Growth and leaf injury | T |
| <i>Poa pratensis</i> L. | Kentucky bluegrass L. | Growth and leaf injury | S |
| <i>Puccinellia distans</i> L. | Puccinellia | Growth and leaf injury | H |
| <i>Zoysia japonica</i> Steud. | Japanese Lawngrass | Growth and leaf injury | T |

Plant tolerance ratings are based on the critical concentrations of boron in irrigation water applied to the root zone that may cause growth reduction or leaf injury. Sensitive (**S**): Plants may develop severe leaf burn (especially at the leaf tip) by irrigation with water containing 1 to 2 mg B L⁻¹. Moderately tolerant (**M**): Irrigation with water containing 2 mg B L⁻¹ may not cause leaf injury, but plants may be severely injured by 4 to 6 mg B L⁻¹ in irrigation water. Tolerant (**T**): Irrigation with water containing 4 to 6 mg B L⁻¹ may not cause leaf injury, but plants may be severely injured by 6 to 10 mg B L⁻¹ in irrigation water. Highly tolerant (**H**): Plants will not be injured by irrigation with water containing 6 to 10 mg B L⁻¹.

⁽¹⁾ The boron tolerance of coast redwood (*Sequoia sempervirens*) was tested by overhead irrigation involving contact of water with the foliage.

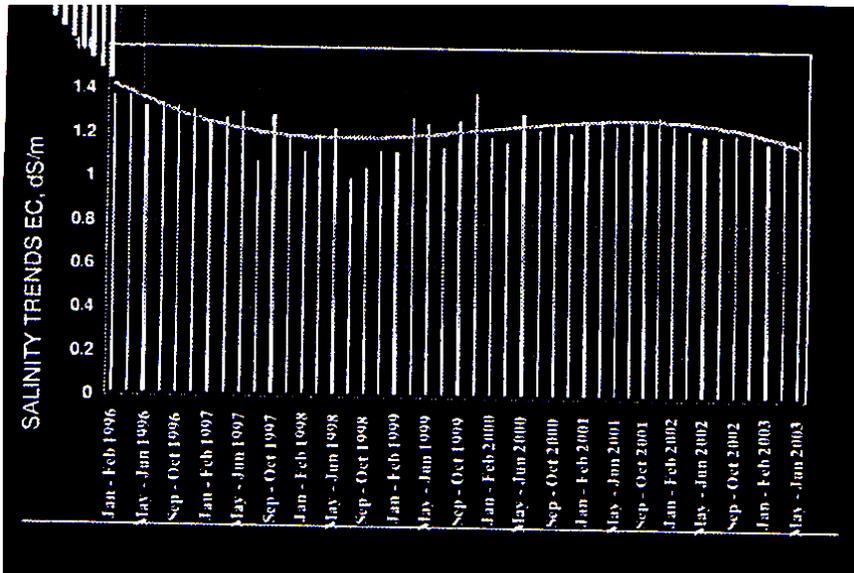


Figure 1. Yearly average salinity values (EC) of reclaimed water generated by the South Bay Water Recycling facility, City of San Jose, California. The EC values are relatively consistent over the time period from February 1996 to January 2003.



Figure 2. The popular shrub Oleander (*Nerium oleander*) is considered very salt tolerant. When sprinkler-irrigated with recycled water containing 600 mg L^{-1} sodium and 900 mg L^{-1} chloride, oleander shows no symptoms of salt stress. This species does well under recycled water irrigation with no extra management required unless other environmental stress factors are involved such as poor drainage leading to waterlogged soil.



Figure 3. Red Apple Iceplant (*Drosanthemum hispidum*) is one of several groundcover species used in California landscapes that are considered very salt tolerant. These plants were sprinkler-irrigated with recycled water containing 200 mg L^{-1} sodium and 200 mg L^{-1} chloride. The plants show no salt stress symptoms and may even benefit from nutrients in the recycled water.



Figure 4. Indian Hawthorn (*Raphiolepis indica*) is tolerant to salt spray and soil salinity. This species does not require extra management input when irrigated with recycled water. Even after several years in a landscape sprinkler-irrigated with recycled water containing 200 mg L^{-1} sodium and 300 mg L^{-1} chloride, Indian Hawthorn plants show no signs of salt stress (upper left). If the salt concentration in the irrigation water increases to 600 mg L^{-1} sodium and 900 mg L^{-1} chloride Indian Hawthorn leaves can show scorch-like symptoms at the tips of the leaves (below left).



Figure 5. Cork Oak is moderately tolerant to salt spray. With appropriate management of recycled irrigation water containing less than 200 mg L^{-1} sodium and less than 300 mg L^{-1} chloride, cork oak may not show any signs of salt stress. In California's Central Valley, however, cork oak may exhibit some foliar chlorosis by the end of the dry season in the fall (left). Overhead irrigation during these hot dry days may contribute to these symptoms but they are usually not serious.



Figure 6. Liquidambar (*Liquidambar styraciflua*) is considered a salt sensitive species. When sprinkler-irrigated with recycled water containing 200 mg L^{-1} sodium and 300 mg L^{-1} chloride, liquidambar leaves become chlorotic and develop scorch-like symptoms along the margins (left). These sodium and chloride levels are in the upper range of concentrations found in most recycled waters. Drip irrigation with recycled water containing the identical sodium and chloride concentrations may not induce salt stress symptoms on liquidambar leaves if the soil salinity remains below $2 \text{ dS}\cdot\text{m}^{-1}$. Other stress factors such as drought, heat or poor drainage can, however, make these plants more susceptible to salt stress.



Figure 7. Heavenly Bamboo (*Nandina domestica*) is considered a salt sensitive species. Overhead irrigation with recycled water containing 200 mg L^{-1} sodium and 300 mg L^{-1} chloride results in foliar chlorosis that progresses to a reddish color along leaf margins (left). To prevent such damage, recycled water irrigation should be restricted to ground level and soil salinity should be monitored and maintained below 2 dS m^{-1} .



Figure 8. Silk tree (*Albizia julibrissin*) is considered a salt sensitive species. Overhead irrigation with recycled water containing 200 mg L^{-1} sodium and 300 mg L^{-1} chloride results in chlorosis and light brown necrosis on the tips of leaflets of the compound pinnate leaves (left).



Figure 9. Cornelian Cherry (*Cornus mas*) is considered a salt sensitive species. Overhead irrigation with recycled water containing 200 mg L^{-1} sodium and 300 mg L^{-1} chloride results in foliar necrosis that progresses from the tips and margins of the leaves (left) and may extend to entire leaf blades. To prevent such damage, recycled water irrigation should be restricted to ground level and soil salinity levels should be maintained below 2 dS m^{-1} .



Figure 10. Ginkgo tree (*Ginkgo biloba*) is considered a salt sensitive species. Overhead irrigation with water containing 200 mg L^{-1} sodium and 300 mg L^{-1} chloride results in chlorosis of leaf blades and necrosis of leaf margins.



Figure 11. In general, roses are very sensitive to salt damage. Overhead irrigation with water containing 200 mg L^{-1} sodium and 300 mg L^{-1} chloride results in leaf symptoms such as those shown at left. Scorch-like symptoms on rose leaves begin at the tips of the leaves and may expand to involve entire leaflets. Salt sensitive landscape plants like roses are not recommended for recycled water irrigation. If irrigation with recycled water cannot be avoided, water should be applied on the soil surface or with a drip irrigation system. In addition, soil salinity levels should be monitored and maintained below 2 dS m^{-1} .



Figure 12. Rockspray Cotoneaster (*Cotoneaster microphylla*) is moderately salt tolerant and often does well under recycled water irrigation in the spring and over the summer months. When sprinkler-irrigated with water containing 200 mg L^{-1} sodium and 300 mg L^{-1} chloride, this species may start to show symptoms of chlorosis in the fall when salt accumulation in leaves becomes high (left).



Figure 13. Sprinkler irrigation of salt sensitive landscape plants should be kept below the plant canopy to avoid or reduce wetting of the foliage. Severe damage occurred to the lower leaves of this Chinese Pistache (*Pistacia chinensis*) irrigated with recycled water due to direct contact of salt on the leaves (upper left). Close-up view of lower leaves on Chinese Pistache irrigated with recycled water containing approximately 150 mg L^{-1} sodium and 300 mg L^{-1} chloride. Necrotic areas developed where the recycled water came in direct contact with the leaves (lower left).



Figure 14. Cultivars of the coast redwood (*Sequoia sempervirens*) show different levels of tolerance to irrigation with recycled water in the landscape. The variety 'Aptos Blue' shows leaf chlorosis and limited new growth on young branches (left). The variety 'Los Altos' shows only slight chlorosis and young branches are actively growing (right).



Figure 15. Most native grass species used in California landscapes are perennial and naturally retain mature brown leaves and flower stalks such as those shown at left for salt tolerant deergrass (*Muhlenbergia rigens*). This is often considered a desirable characteristic for ornamental grasses. Grass species in the salt tolerant and very tolerant categories can do well under recycled water irrigation with no extra management input provided no other unfavorable environmental stress factors are involved.



Figure 16. Most turfgrass species are salt tolerant or moderately salt tolerant. Mowing periodically removes salt with the clippings thereby making the turfgrass more tolerant to continued irrigation with recycled water. The tall fescue (*Festuca arundinacea*) turf pictured above has been irrigated with recycled water containing approximately 200 mg L^{-1} sodium, 300 mg L^{-1} chloride, 30 mg L^{-1} nitrogen, and 4 mg L^{-1} phosphorus for two years. In the time since the turf was established from sod, no fertilizer application was needed and the turf was healthy and provided a dense turf surface. Turfgrass species in the salt sensitive category such as annual ryegrass (*Lolium multiflorum*), annual bluegrass (*Poa annua*) and Kentucky bluegrass (*Poa pratensis*) are not recommended for recycled water irrigation.