Drought Practices for Nurseries, Greenhouses and Growers Drought Practices for Landscape Management Drought Practices for Nurseries, Greenhouses and Growers Education of Employees Education of the Public Fertilizer Application Irrigation Efficiency (General Principles) Irrigation System Design Irriga igation System Maintenance I nstallation and Erosion and Se ntenance Lawn Aeration Law ting Mowing Mulching Park, Golf Course and Other Large Landscape Design and Management Pesticide and Herbicide Application Pesticide, Fertilizer and Other Chemical Storage, Handling and Disposal Plant Selection and Placement Production Practices

Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado

Prepared for
The Green Industries of Colorado (GreenCO)
5290 E. Yale Circle, Suite 204
Denver, CO 80222

Prepared by
Wright Water Engineers, Inc.
2490 West 26th Avenue, Suite 100A
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With support from:

The Colorado Water Conservation Board

Headwaters Consulting, LLC

Colorado Department of Public Health and Environment
Water Quality Control Division
(under a grant from the U.S. Environmental Protection Agency)

it's easy being green™ GreenCO

2ND RELEASE, MAY 2004

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May 2004

Dear GreenCO Member,

The following manual, "Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado" describes conservation practices for the Green Industry in Colorado. As a whole, GreenCO is dedicated to the conservation and preservation of all Colorado's precious resources which contribute to Colorado's natural environment and beauty. Since 1996, the Green Industries of Colorado (GreenCO) has been working with a diverse set of industry experts and partners to develop a water conservation and water quality protection program for its nine member associations. In May 2002, the first release of the BMP manual was developed and distributed to the green industry through the support of GreenCO, Wright Water Engineers, Inc., Colorado Water Conservation Board (CWCB), and Headwaters Consulting, LLC.

Coincidently, following the initial release of the manual, the Green Industry was hit-hard by drought restrictions during 2002 and 2003. The drought has been a wake-up call for Green Industry professionals and communities alike, emphasizing that water conservation must become a way of life in Colorado, all the time, not just during a drought. In order to promote this reality to the Green Industry professionals and to provide increased training regarding water conservation practices, GreenCO decided to take the BMPs to the next level by revising the manual. A training course was also developed to accompany the manual.

The revisions were based on lessons learned from the drought experiences during 2002 and 2003. Key practices which were added include herbaceous plant care and water budgeting. The manual will continue to be updated periodically to remain current with the state-of-the-art practices for water conservation and water quality protection. If periodic updates are necessary, the GreenCO website will reflect the latest updates.

Although the BMP manual is copyrighted by GreenCO, it is our intent that this information be distributed widely amongst Green Industry professionals, municipalities, water districts, and others concerned with wise water use landscapes. Green Industry professionals should use this manual as general guidance with the recognition that some environmentally sensitive or drought-stricken areas may require modification of some practices.

Whether you're a Green Industry professional, homeowner, commercial property manager, or homebuilder, we hope you find this manual useful. If you have any questions, please contact GreenCO's Project Manager, Brenda O'Brien (brenda.obrien@comcast.net).

Sincerely,
GreenCO Board Members

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Appendices

Acknowledgements

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Development of the manual and its initial release was made possible through the Colorado Water Conservation Board, which provided funding for the manual in keeping with its goals of conserving, developing, protecting and managing Colorado's water for present and future generations. The Colorado Department of Public Health and Environment Water Quality Control Division provided funding for the revision and second release of the manual.

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Kristen Sirovatka, ALCC
Paul Thomas, Wenk Associates
Keith Williamson, Little Valley Wholesale Nursery, CNA

In keeping with GreenCO's desire not to "reinvent the wheel" when high-quality information on relevant BMPs was already in existence, the following written materials were relied upon heavily and may have been partially reproduced or adapted into this manual:

- Colorado State University Cooperative Extension. 2004. Plant*talk* Colorado Web site: www.ext.colostate.edu/ptlk.

- Colorado State University Cooperative Extension. 2004. Gardening On-line Web site: www.coloradogardening.com.

- Denver Water. 2004. Denver Water Conservation and Xeriscape Web sites: http://www.denverwater.org/cons_xeriscape/cons_xeriscapeframe.html. Also Denver Water brochures. *(Particularly with regard to information related to Xeriscape, a term copyrighted by Denver Water in 1981.)*

- Irrigation Association Water Management Committee. 2001. *Turf and Landscape Irrigation Best Management Practices*. Falls Church, VA: Irrigation Association. Also see www.irrigation.org.

- Panter, K.L., S.E. Newman, and R.M. Waskom. 1998. *Pollution Prevention in Colorado Greenhouses*. XCM-206 (www.ext.colostate.edu/pubs/garden/xcm206.pdf). Ft. Collins, CO: Colorado State University Cooperative Extension.

- Urban Drainage and Flood Control District. 1999. *Urban Storm Drainage Criteria Manual, Volume 3, Stormwater Best Management Practices*. Denver, CO: UDFCD.

- Urban Drainage and Flood Control District. 2001. *Urban Storm Drainage Criteria Manual, Volume 2*. Denver, CO: UDFCD.

- Wright Water Engineers and Denver Regional Council of Governments. 1996. *Guidelines for Water Quality Enhancement at Golf Courses Through the Use of Best Management Practices*. Denver, CO: DRCOG.

Purpose and Limitations

The purpose of this manual is to consolidate and improve upon Green Industry Best Management Practices (BMPs) for the conservation of water resources and protection of water quality. These BMPs include a variety of design, installation, maintenance, grower and retail practices relevant to the Green Industry and the public that they serve. This document is an initial building block for the Green Industry to use in further developing common industry-wide standards.

This manual should be used to enhance the professional qualifications and judgement of the Green Industry—it is not a regulatory document. Green Industry professionals should use this manual as general guidance with the recognition that some environmentally sensitive or drought-stricken areas may require modification of these practices. This document is not a design manual; instead, it provides overviews of key BMPs and directs the user to relevant design and certification manuals, where appropriate.

As technological and horticultural advances occur, this manual will need to be updated periodically to remain current with the state-of-the-art practices for water conservation and water quality protection. For the most recent version of this manual, please refer to the GreenCO Web site (www.greenco.org) or the Colorado Water Conservation Board Web site (www.cwcb.state.co.us).

Background

The Green Industries of Colorado (GreenCO) is an umbrella trade organization representing the common interests of nine landscape-related trades:

- Associated Landscape Contractors of Colorado (ALCC)
- Colorado Chapter of the American Society of Landscape Architects (ASLA)
- Colorado Association of Lawn Care Professionals (CALCP)
- Colorado Greenhouse Growers Association (CGGA)
- Colorado Nursery Association (CNA)
- Garden Centers of Colorado (GCC)
- International Society of Arboriculture/Rocky Mountain Chapter (ISA/RMC)
- Rocky Mountain Sod Growers Association (RMSGA)
- Wholesale Florists of Colorado (WFC)

GreenCO members represent diverse interests including sod growers, landscape architects, greenhouse growers, nurseries, retailers, contractors, lawn care professionals, arborists and florists. Each of GreenCO's members has in common an economic dependence on built landscapes.

In 1996, GreenCO began working to help the Green Industry develop an understanding and strategy to respond to challenges posed to the industry by potential water shortages related to either population growth or drought. Representatives from GreenCO's nine trade associations worked with diverse partners including Colorado State University Cooperative Extension, the Colorado WaterWise Council, Denver Water and the Colorado Water Resources Research Institute. GreenCO worked proactively to support water conservation and quality goals without specific regulatory pressure.

Looking to the future, GreenCO recognizes that the economic health of the industry and the health of the state's water resources are inextricably linked. Its water-related goals are to:

- Realize significant, measurable improvements in water quality and conservation statewide through improved and efficient landscape practices.
- Ensure the future health and competitiveness of the Green Industry in Colorado in the face of new standards and regulations.
- Provide improved water management tools and resources for GreenCO member businesses and their customers.

To realize these goals, GreenCO identified the development of industry-wide BMPs as a first step toward getting its “house in order” by compiling and improving industry-wide standards for tools and technologies that support water conservation and quality.

Definition of Best Management Practices (BMPs) and Principles

The simplest way to define a BMP for purposes of this manual is a voluntary activity undertaken to reduce water consumption and protect water quality. Appropriateness of the BMPs may vary depending on site-specific and regional conditions. The term BMP has been selected for use in this manual primarily for consistency with other national and international efforts to protect water quality. For example, the U.S. Environmental Protection Agency (EPA), the state of Colorado (including the Nonpoint Source Council and the Water Quality Control Division), regional organizations such as the Denver Regional Council of Governments, local governments, as well as many others, have retained the term BMP in ordinances, regulations and guidance manuals.

Most of the BMPs in this manual are relevant to both water quality and water conservation and are based on these basic principles:

1. Healthy landscapes enhance water quality and the environment. Inclusion of green areas in urban settings helps minimize pollutant-laden runoff to waterbodies and allows precipitation in urban areas to infiltrate into the soil, rather than overload natural drainageways. Landscape features such as grass swales, vegetated buffer strips along waterways, constructed wetlands and other well-vegetated areas are key components of good stormwater management. Well-vegetated areas are particularly important in reducing sediment loading to streams and lakes.

2. Over-irrigation is the leading source of water waste in landscaping. Landscapes (including their irrigation systems) are water-efficient when they are properly designed, installed and maintained according to sound landscaping and water conservation principles. The term "Xeriscape" was copyrighted by Denver Water in 1981 to help make water-conserving landscaping an easily recognized concept based on these seven principles: comprehensively designed landscapes, healthy soil, practical turf areas, proper plant selection and placement, efficient irrigation, mulching and good maintenance.

3. Water budgeting is an effective tool for designing and maintaining water-efficient landscapes during both normal and drought conditions. An outdoor water budget identifies the amount of water needed for healthy landscapes. Comparison of actual water used to the water budget provides a basis for adjusting water usage to reduce water waste.

4. It is easier to prevent or reduce pollution by controlling it at its source, rather than correcting its impacts. For the Green Industry, this means minimizing runoff from landscapes, properly applying and/or minimizing pesticide and fertilizer usage, and minimizing erosion and sediment-laden runoff at landscaping sites.

5. Both improved water quality and water conservation are dependent on behavior changes. Education of both the end user (homeowner/landscape owner) and Green Industry professionals (growers, retail owners, landscape designers, installation and maintenance professionals) is necessary for behavior change to occur. It takes more than a nice manual on a shelf for improved water quality and conservation to happen. BMPs must be integrated into a variety of Green Industry professional training and certification programs and actually put into practice in the field. Both Green Industry businesses and the public must recognize the value of water quality and water conservation, and the consequences of failing to implement these BMPs, in order for behavioral change to occur.

List of BMPs

Hundreds of individual practices have been consolidated into 31 general BMPs described in this document and summarized by industry in Table 1 including:

1. Drought and General Water Conservation Practices for Landscape Management
2. Drought and General Water Conservation Practices for Nurseries, Greenhouses and Growers
3. Education of Employees
4. Education of the Public
5. Herbaceous Plant Care
6. Fertilizer Application
7. Irrigation Efficiency (General Principles)
8. Irrigation System Design
9. Irrigation System Installation
10. Irrigation System Maintenance
11. Landscape Design
12. Landscape Installation and Erosion and Sediment Control
13. Landscape Maintenance
14. Lawn Aeration
15. Lawn Waste Disposal/Composting
16. Mowing

17. Mulching
18. Park, Golf Course and Other Large Landscape Design and Management
19. Pesticide and Herbicide Application
20. Pesticide, Fertilizer and Other Chemical Storage, Handling and Disposal
21. Plant Selection and Placement
22. Production Practices for Nurseries, Greenhouses and Growers
23. Regulatory Awareness and Compliance
24. Retail Practices for Nurseries, Greenhouses and Garden Centers
25. Revegetation of Drainageways
26. Riparian Buffer Preservation
27. Soil Amendment/Ground Preparation
28. Turf Management
29. Water Budgeting
30. Woody Plant Care
31. Xeriscape

Table 1
Summary of GreenCO BMPs by Industry

BMP	BMP Description	Member Industries								
		ASLA	ALCC	CALCP	CGGA	CNA	GCC	ISA	RMSGA	WFC
Drought and General Water Conservation Practices for Landscapes	Manage landscapes using the most water-efficient techniques during drought conditions.	X	X	X	X	X	X	X	X	
Drought and General Water Conservation Practices for Nurseries, Greenhouses and Growers	Properly irrigate nursery and greenhouse crops with the minimum amount of water waste during drought conditions.				X	X	X	X	X	
Education of Employees	Educate industry employees on water quality and water conservation practices.	X	X	X	X	X	X	X	X	X
Education of the Public	Model and teach water conservation and water pollution prevention to the general public and consumers of green industry products.	X	X	X	X	X	X	X	X	X
Fertilizer Application	Properly apply fertilizers, based on the specific needs of plants, particularly as identified by appropriate soil or plant tissue tests.		X	X	X	X	X	X	X	
Herbaceous Plant Care	Properly plant and maintain herbaceous plants to maximize plant health and conserve water.	X	X	X	X	X	X	X		
Irrigation Efficiency	Properly design, install and maintain irrigation systems to ensure uniform and efficient distribution of water, thereby conserving water and protecting water resources.	X	X	X	X	X	X	X	X	
Irrigation System Design	Design the irrigation system for the efficient and uniform distribution of water.	X	X	X	X	X	X	X	X	
Irrigation System Installation	Install the irrigation system according to the irrigation design specifications, which should be in accordance with manufacturer's specifications, local code requirements and sound principles of efficient and uniform water distribution.		X	X	X	X	X	X	X	
Irrigation System Maintenance	Maintain the irrigation system for optimum performance, ensuring efficient and uniform distribution of water Modify the irrigation system as needed to provide supplemental water for maintaining healthy plants withou wasting water.		X	X	X	X	X	X	X	
Landscape Design	Plan and design landscaping comprehensively to conserve water and protect water quality.	X	X	X	X	X	X	X	X	
Landscape Installation/Erosion and Sediment Control	Minimize erosion and control sediment leaving the construction site during landscape installation.	X	X	X		X		X	X	
Landscape Maintenance	Practice landscape maintenance appropriate for the site including practices such as pruning, weeding, mulching, fertilization and attention to the irrigation system.		X	X				X	X	
Lawn Aeration	Aerate lawns to reduce thatch, thereby improving nutrient and water uptake, reducing runoff and reducing compaction.		X	X					X	
Lawn Waste Disposal/Composting	Dispose of yard waste to minimize adverse impacts to the environment by keeping waste out of storm drains. Recycle and compost organic materials whenever possible.		X	X	X	X	X	X	X	
Mowing	Mow lawns to the proper height and at the proper frequency to maintain turfgrass health, thereby minimizing the need for pesticide and fertilizer application and reducing water usage.		X	X					X	
Mulching	Use organic mulches to reduce water loss through evaporation, to reduce soil loss due to exposure to wind and runoff, to suppress weeds, and to provide a more uniform soil temperature.		X	X	X	X	X	X		
Park, Golf Course and Other Large Landscape Design and Management	Large landscaped areas such as parks and golf courses should be well designed and properly managed to be an environmental amenity and to minimize runoff to waterbodies.	X	X	X				X	X	
Pesticide and Herbicide Application	Apply pesticides and herbicides at minimal levels in accordance with the label and targeted to specific disease and weed problems.		X	X	X	X	X	X	X	
Pesticide, Fertilizer and Other Chemical Storage, Handling and Disposal	Pesticides, herbicides, fertilizers, fuel and other maintenance chemicals must be properly applied, stored, handled and disposed of to prevent contamination of surface water and groundwater.		X	X	X	X	X	X	X	
Plant Selection and Placement	Select appropriate plants for the site, place plants in appropriate locations and group plants according to similar water needs (i.e., "hydrozoning").	X	X	X	X	X	X	X	X	
Production Practices for Nurseries, Greenhouses and Growers	Nurseries, greenhouses and other growers should implement a variety of source, structural, cultural and managerial controls to minimize pollution of water resources. Irrigation practices that minimize off-site transport of pollutants also typically conserve water.				X	X		X	X	
Regulatory Awareness	A variety of local, state and federal environmental regulations impact landscaping and nursery operations. Green industry professional should be aware of these regulations and comply with their requirements.	X	X	X	X	X	X	X	X	X
Retail Practices for Nurseries, Greenhouses and Garden Centers	Retail businesses should operate in a manner to maintain the health of plants, to conserve water and to promote water conservation and water resource protection to the general public.				X	X	X	X	X	
Revegetation of Drainageways	Establishment of a robust cover of vegetation is critical to the proper functioning of engineered drainage structures such as grass-lined channels, detention basins, retention ponds, and wetlands.	X	X	X				X	X	
Riparian Buffer Zone Preservation	Preserve wide, undisturbed natural riparian areas along streams.	X	X	X				X		
Soil Amendment/Ground Preparation	Evaluate soil and improve, if necessary, to promote efficient water usage and healthy plants.	X	X	X	X	X	X	X	X	
Turf Management	Plan, properly install and maintain practical turf areas.	X	X	X					X	
Water Budgeting	Calculate the water needs of irrigated landscapes based on plant types, land area and irrigation system efficiency. Use the calculated water budget to apply water according to the needs of the plants and manage irrigation.	X	X	X	X	X	X	X	X	
Woody Plant Care	Properly plant and maintain prune or trim trees, shrubs and other woody plants to maximize the plants' health.	X	X	X	X	X	X	X		
Xeriscape	Implement the seven basic landscape principles of Xeriscape: planning and design, soil improvement, zoning of plants, practical turf areas, efficient irrigation, mulching and appropriate maintenance.	X	X	X	X	X	X	X	X	

ASLA = American Society of Landscape Architects
ALCC = Associated Landscape Contractors of Colorado, Inc.
CALCP = Colorado Association of Lawn Care Professionals
CGGA = Colorado Greenhouse Growers Association
CNA = Colorado Nursery Association
GCC = Garden Centers of Colorado
ISA = International Society of Arboriculture
RMSGA = Rocky Mountain Sod Growers Association
WFC = Wholesale Florists of Colorado

Organization of BMP Descriptions

The BMPs in this manual are listed alphabetically. Each of the BMP descriptions is in the form of a fact sheet including the following information:

- Brief description of the BMP.
- Identification of the BMP's applicability to design, installation, maintenance, grower or operation activities.
- Identification of the BMP's relevance to various GreenCO member industries.
- Basic practice guidelines to follow when implementing the BMP.
- Regional or industry considerations/adaptations.
- Key references for more detailed information.

The discussion of each BMP is limited to several pages with the intention that the BMP sheets can be taken out of this notebook for easy reference and distribution. Because it is expected that users of this manual may focus on individual BMPs rather than the manual in its entirety, there may be redundancy among some BMP descriptions. Efforts have been made to minimize this redundancy by cross-referencing the user to related BMPs.

One important aspect of the BMP descriptions focuses on regional considerations for implementation of the BMP. Because climate and topographic conditions along the Front Range vary considerably from the western slope of Colorado, some practices that work well in one location may not work well in others, or may require special adaptations. Where appropriate, these types of considerations have been identified in the BMP descriptions.

This BMP manual is <u>not</u> intended to serve as a design and specification manual; instead, it compiles and summarizes into one document the key BMPs spread across the nine trades within the Green Industry. For many of the BMPs, entire workbooks and certification manuals are already in place, providing detailed guidance on the practice. In these cases, the "key references" identified in the BMP fact sheets can be obtained for more detailed guidance. A comprehensive list of these references is also provided at the end of this document.

Literature Review

A key component of this project was to identify to the degree to which the Green Industry BMPs have been developed. As a companion to this manual, a notebook of existing publications has been compiled. As a credit to the environmental awareness already present in the Green Industry, the majority of the BMPs included in this manual already have high quality publications, brochures and other materials available from multiple sources. Most of the industry certification manuals also cover many of these BMPs. The challenge to the Green Industry is ensuring that BMPs are implemented more broadly among its individual members. This manual will serve as a key step towards achieving this goal.

In general, the written information on Green Industry water conservation and water quality BMPs was consistent among sources, at least in principle, even if the details of the practice varied somewhat. Given the broad scope of this manual, primary emphasis has been given to communicating the basic principles. Where differing recommendations exist with regard to supporting details for the BMP, the source of the recommendation has been provided with an acknowledgement that recommendations may vary among industry professionals. An example relates to fertilizer application. Most key sources agree on the basic principles that fertilizer application should be timed to the needs of the plants and that fertilizer should not be over-applied. However, significant variation in recommended fertilizer application rates exists among references and member industries. In the case of lawn fertilizer application, a table of recommendations prepared by CSU Cooperative Extension experts was included as reasonable guidance for the industry with an acknowledgement that best professional judgement and site conditions should be taken into consideration.

Some of the key information sources that industry professionals may be interested in obtaining that have been important resources in developing this manual include industry certification manuals, industry web sites, local government ordinances, CSU Cooperative Extension resources, publications developed in other states experiencing water shortages and several other key resources. A few of the most relevant resources from over 200 documents used in development of this manual are listed below.

Industry Certification Manuals

Associated Landscape Contractors of America

- Associated Landscape Contractors of America. 2003. *Landscape Installation Training*. Herndon, VA: ALCA.

- Associated Landscape Contractors of America. 2003. *Landscape Irrigation Training.* Herndon, VA: ALCA.

- Associated Landscape Contractors of America. 2003. *Landscape Maintenance Training.* Herndon, VA: ALCA.

Colorado Nursery Association

- Colorado Nursery Association. 2001. *Colorado Certified Nursery Professionals Manual*. Denver, CO: CNA.

Colorado Greenhouse Growers

- Colorado Greenhouse Growers. 2003. *Colorado Certified Greenhouse Professional Manual*. Denver, CO: CGGA.

International Society of Arboriculture

- International Society of Arboriculture. 1992. *Arborists Certification Study Guide*. Champaign, IL: ISA.

- Britton, John. 1994. *Tree–Pruning Guidelines*. Champaign, IL: ISA.

Industry Web Sites

American Nursery and Landscape Association (ANLA). 2002. Web site: www.anla.org.

American Society of Landscape Architects (ASLA). 2002. Web site: www.asla.org.

Associated Landscape Contractors of Colorado (ALCC). 2002. Web site: www.alcc.com.

Colorado Association of Lawn Care Professionals (CALCP). 2002. Web site: www.gardeningcolorado.com/calcp.

Colorado Nursery Association (CNA). 2002. Web site: www.coloradonurseries.org.

Garden Centers of Colorado (GCC). 2002. Web site: www.gardencentersofcolorado.org.

International Society of Arboriculture, Rocky Mountain Chapter (ISA/RMC). 2002. Web site: www.isarmc.org.

Rocky Mountain Sod Growers Association (RMSGA). 2002. Web site: www.rockymountainsodgrowers.com.

Local Government/Agency Ordinances and Guidance

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GreenCO BMPs for the Protection and Conservation of Water Resources in Colorado

Second Release, May 2004

Drought and General Water Conservation Practices for Landscape Management

BMP Type			
Design			X
Installation			X
Maintenance/Operations			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Manage landscapes using the most water-efficient techniques during drought conditions.

This BMP has been adapted with only minor modifications from "Coping with Drought: Water Restrictions and the Landscape" by Patrick McCarty, Colorado State University Cooperative Extension Agent, Garfield County, and Dr. Curtis E. Swift, Area Extension Horticulture Agent, Grand Junction, as posted on www.colostate.edu/Depts/CoopExt/TRA/PLANTS/drought.html. This guidance will continue to be updated as conditions change.

Note: At the time of publication of this BMP Manual, Colorado was experiencing a drought. Many web sites and publications are available with specific guidance for drought. The information selected from McCarty and Swift (2002) has been reproduced in this manual because it provides a good overview of practices appropriate for drought consistent with the BMPs included in this manual.

Basic Practice Guidelines

Turfgrass Irrigation Practices

1. Base the first watering on soil moisture content. Spring is the time of maximum nutrient uptake. Watering too early in the spring cools the soil and reduces nutrient uptake. This stresses the grass and makes it more susceptible to insect and disease problems. Early spring watering can also saturate the soil, reducing the oxygen available to deeper roots, which results in the death of these deep roots. The loss of deep roots increases the grass's susceptibility to drought stress, and increases the need for more frequent waterings.

2. Check the moisture content of the soil with a trowel, shovel or soil probe to a depth of 4 to 6 inches for turf areas and 6-8 inches for trees and shrubs. If the soil is dry, water. If the soil is moist, delay watering.

3. Irrigate according to the requirements of the plants, not on a fixed schedule. Apply only enough irrigation to replace water loss by evapotranspiration (ET). Match irrigation application rate to the soil type and root depth. Avoid applying more water than can be contained in the root zone. Daily observation is necessary to determine the appropriate changes to make to the irrigation system. ET controller technology is also available that can be added to irrigation controllers to more easily water according to ET requirements.

4. When turfgrass requires water, it will:

   - Turn darker than normal (it appears as if a shadow is cast on the lawn).
   - Turn blue-gray.
   - Not spring back when walked on (depressions left by footprints do not bounce back).
   - Prevent the blade of a screwdriver or other such implement from easily penetrating into the soil any deeper than 2 inches.

5. Drought symptoms can appear in patches or over the complete turf area. When only small areas exhibit drought stress, water only those areas that need to be irrigated. Watering the complete lawn when only a small area requires water, or watering too frequently, results in shallow roots, increased susceptibility to drought (especially during the hot and dry days of July and August), and increased susceptibility to Melting-out Disease (Leaf-spot Disease).

6. Water deeply but only as needed; avoid shallow frequent waterings. Watering a lawn on a frequent, shallow basis results in death of deep roots, increasing the need to water.

7. In some instances, it may be necessary to water daily or every other day. This is especially true if the soil is very sandy as this soil texture dries out quickly. Turf on a shallow soil will likewise require more frequent irrigation. Soils should always be amended with a good quality organic matter such as compost. This will help hold the soil moisture and reduce the need for frequent irrigation.

8. Water at night to reduce water loss from evaporation. Watering during the heat of the day can result in excessive levels of evaporation. Watering during the night (particularly after midnight) reduces problems with turf diseases and reduces the amount of water lost from evaporation, making the irrigation more efficient.

9. The most efficient and ideal time to irrigate turfgrass is between midnight and 6 A.M. Such timing, however, is difficult for all but those gardeners with an automatic sprinkler system. Gardeners not wishing to spend their night hours watering should consider watering during the day after the night moisture has been burned off by the morning sun, but prior to 10:00 A.M. Lawns should not be watered between the hours of 10:00 A.M. and 6:00 P.M. For further information on watering lawns, go to: www.coopext.colostate.edu/TRA/PLANTS/lawnwat.html.

10. To reduce water loss from evaporation, do not water during windy times. Wind will also divert the water, resulting in some areas getting much more water than others, and leaving dry spots. Areas of the turf that do not receive adequate moisture will require more water to stay alive.

Irrigation System Maintenance

11. Check, adjust and repair irrigation equipment on a regular basis, weekly and within 24 hours of mowing, whenever possible. Identify irrigation system leaks and repair them promptly.

12. Spring is a great time to check the irrigation system for consistency, uneven water coverage, and leaks. Place straight-sided cans or glasses in the area to be irrigated. Turn the sprinkler system on for a set length of time and measure the amount of water collected in the containers during that time. Using containers to measure the amount of water applied will pinpoint any variation in water distribution in the irrigated area. Plugged heads, improper spacing of sprinkler heads, etc., can be identified and subsequently corrected using this method. For information on self-auditing irrigation systems, see http://www.ext.colostate.edu/pubs/garden/07239.html.

13. The amount of water applied and the depth of water penetration should be rechecked occasionally during the summer months to avoid problems that develop from clogged or twisted heads. Reset or clean heads as necessary.

14. Immediately shut off irrigation systems and adjust whenever irrigation water falls or runs onto hard surfaces such as sidewalks, streets or driveways. Signs of leakage include overgrown or particularly green turf areas, soggy areas around spray heads and above-ground hoses, jammed spray heads and torn hoses. In drip systems, leakage problems may be due to damaged tubing from foot traffic or gnawing by animals.

15. Whenever possible, update and retrofit existing irrigation systems to take advantage of new water-saving technology (e.g., rain shut-off devices, ET controllers, soil moisture sensors, drip irrigation).

16. Manage the irrigation system to respond to the changing/seasonal requirements for water in the landscape. The most efficient systems match irrigation application to landscape water requirements through effective irrigation scheduling. Whenever possible, irrigation scheduling should incorporate the use of evapotranspiration (ET) and precipitation data.

17. Reset automatic controllers according to the seasonal needs of plants. Controllers should be inspected at least bi-monthly to correct run times.

18. *See the Irrigation Efficiency, Design, Installation and Maintenance BMPs of this Manual for more detailed guidance.*

Lawn Aeration

19. Aerate the lawn in the spring and again in the fall to obtain these benefits:

    - Improving water penetration into compacted soils and through thatch and mat layers.

    - Improving fertilizer movement to the turf roots.

- Allowing greater levels of oxygen to reach the soil in exchange for carbon dioxide and other gases.
- Enhancing turfgrass shoot and root development.
- Reducing water runoff (runoff from turf areas may carry pesticide residues and fertilizers into neighboring storm drains and streams causing pollution problems).

20. Use core-type aerators to loosen the soil, rather than spike-type aerators, which compact it.

Turfgrass Maintenance

21. Kentucky bluegrass can be allowed to go dormant without permanent and excessive injury if healthy. This is a worst-case scenario option if drought conditions persist. Watering properly when restrictions are lifted will allow Kentucky bluegrass to recover. Kentucky bluegrass can recover even after nine months without water.

22. If unsure what grass is in the lawn, take a sample to the local Colorado State University Cooperative Extension office or local garden center for identification.

23. Weeds always seem to thrive regardless of the conditions and use water intended for other plants. Do not allow uncontrolled weeds to overtake the lawn or garden. Apply the proper methods necessary to prevent weed growth such as hand-pulling or careful herbicide application.

24. Carefully inspect the lawn at least weekly for disease and pests, correcting problems as they occur. During a year of potential high stress from drought, this becomes even more important. Early detection and control of problems is essential.

Fertilizer Application

25. Conduct a soil test to determine the nutrient needs by sending a soil sample to a reputable soil-testing laboratory. (For more information on soil testing go to: www.coopext.colostate.edu/TRA/PLANTS/soiltest.html.)

26. A properly fertilized lawn requires less water. Applying more fertilizer than is needed can deplete other nutrients and cause deficiencies. Excessive quantities of nutrients are often as detrimental as deficiencies. Adding excess may adversely affect the availability of other nutrients that were previously in sufficient supply. For example, adding too much phosphorus may result in a deficiency of available iron both within the soil and within plants grown in the soil. Nutrient-stressed plants with deficiencies are more susceptible to insect and disease problems, as well as drought stress.

27. Generally, for low-maintenance bluegrass lawns (common throughout Colorado), apply one pound of nitrogen fertilizer per 1,000 sq. ft. in the fall and fertilize lightly (one-half pound/1,000 sq. ft.) in the spring and again in early summer. *(See the Fertilizer Application BMP of this Manual for more detailed guidance.)*

28. Avoid the use of manure as top-dressing on lawns; applying manure can increase the need to water. Gardeners applying manure as a top dressing assume (incorrectly) that this meets the nutrient needs of the turf. Manures are very low in nitrogen with several inches of manure being necessary for each pound of nitrogen needed by the turf. Manures are typically high in salt. Adding salt to a lawn increases the need to apply more water.

Mowing

29. Mow the lawn at a height of 2 ½ to 3 inches, removing no more than one-third of the grass blade at each mowing. The higher the lawn is mown, the deeper the roots (as long as the soil was prepared deeply).

Landscape Installation

30. If establishing a new lawn, prepare the soil properly; this will increase rooting depth and spread and increase drought tolerance of the grass. Proper soil preparation means the addition of organic matter and tilling the soil as deep as possible. Add 3 to 5 cubic yards of a decomposed organic matter per 1,000 square feet of lawn. Use a coarse, not a fine material. Cultivate the soil to a depth of 4 to 6 inches or more. While root depth is controlled in part by genetics, the depth of soil preparation determines the ultimate rooting depth. Shallow soil preparation causes shallow roots.

31. Because of limited water supplies, delay expanding the lawn or garden space. Small grass areas (turf islands) that are difficult to water, and the parts of the lawn that are not doing well may be candidates for change. Consider transforming these areas into drought-tolerant gardens. Always consider the use of xeric trees and shrubs (plants that are drought resistant or require less water) when planning new garden areas. Make sure to change the irrigation system accordingly.

32. For a great selection of xeric plants compiled by the Colorado State University/Denver Botanic Gardens Plant Select® program, go to: www.plantselect.org.

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Drought and General Water Conservation Practices for Nurseries, Greenhouses and Growers

BMP Type			
Design			X
Installation			X
Maintenance/Operations			X
Green Industry Relevance			
ASLA		GCC	X
ALCC		ISA	X
CALCP		RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Properly irrigate nursery and greenhouse crops with the minimum amount of water waste during drought conditions.

This BMP has been adapted primarily from "Coping with Drought: Water Conservation Methods for the Greenhouse by Laura Pottorff, Regional Commercial Greenhouse Specialist, Colorado State University Cooperative Extension, Adams County, May 2002.

Basic Practice Guidelines

The guidelines below are divided into three steps for ease of implementation. Step 1 should be implemented wherever feasible by all greenhouses, nurseries and growers. Step 2 is strongly recommended for implementation whenever physically and financially possible. Step 3 illustrates the ideal.

Step 1: Reduce Wasted Water/Runoff

1. Group plants with similar water needs together (i.e., hydrozones) to improve irrigation efficiency. Adjust individual sections of the irrigation system to avoid excessive watering.

2. Space containers under fixed overhead irrigation to maximize plant irrigation and reduce waste between containers.

3. Use drip tubes for each individual container, when reasonably practical. This ensures that the water is available for the plant's use, not wasted on the ground.

4. When using programmable irrigation booms, adjust travel rate and flow rates to crop needs.

5. Choose sub-irrigation systems where appropriate using ebb and flood or capillary mat irrigation technologies with a water capture and reuse system. Fertility rates for most sub-irrigation systems can be reduced 50 percent.

6. Minimize leaching from containers or pulse-irrigate containers. Many textbooks recommend leaching greenhouse and nursery crops to 10 percent excess. This rate can be reduced to close to zero by reducing fertilizer rates and closely monitoring the electrical conductivity of the root substrate. The rate of irrigation must be low to allow the water to percolate through the growing media without the water overflowing the top of the container.

7. Check growing media. The condition of the growing media is very important in determining irrigation efficiency. Many of the organic constituents used in growing media, such as peat moss, have hydrophobic or water repelling characteristics. These media tend to be difficult to

"wet" after becoming excessively dry, and therefore require excess water. Wetting agents may be added to avoid these problems; however, a wise management strategy is to avoid potting plants in excessively dry media or preventing media from drying out between irrigation periods. Make sure media has adequate porosity (well drained) as well as good water-holding capacity. This will help minimize irrigation frequency.

Step 2: Examine and Improve Efficiency of Irrigation System

8. Work towards adapting new irrigation technologies to production systems to help lower costs and reduce water waste or runoff. A well-designed, efficient irrigation system is a large part of the water use reduction equation.

9. There are several means by which to supply a crop with irrigation water: overhead sprinkler, hand-watering, drip or trickle irrigation systems and sub-irrigation. Overhead irrigation and hand watering are typically more wasteful delivery systems. These systems also wet the foliage, increasing the potential for disease. Drip or trickle systems are more efficient and provide the greatest control over the amount of water applied.

10. Sub-irrigation (ebb and flow, flood floors, troughs or capillary mats) systems are extremely effective at reducing water waste. These systems also require half the fertilizer of overhead irrigation and lead to less disease because the foliage remains dry. However, they can be expensive to install and water may need to be treated before reuse can occur.

11. Plug sprinkler heads that are not watering plants, keep sprinkler heads as low as possible to the plants and use larger water droplet size to reduce irrigation time.

12. Install rain sensors for outdoor nursery crops to ensure irrigation does not occur during rain. Also consider other water conserving devices such as check valves, pressure regulators, soil moisture sensors, ET controllers, wind sensors and other such devices.

13. Irrigate plants when needed based on media moisture levels, which can be assessed by these methods:

    - Appearance or Feel—water when the media will crumble easily when compressed in the hand. Examine the media at several depths.

    - Tensiometers—these devices are made of a porous ceramic tip attached to a vacuum gauge filled with water. The tip is inserted in the soil and the reservoir is filled with water. As the rooting media dries, water moves through the tip and the resulting tension is recorded.

    - Weight of Media Moisture—one potted plant on a bench is used as a control. It rests on a scale that is adjusted to trip a switch when the moisture level drops below a certain level. As the plant grows, the setting must be adjusted to account for added plant weight.

    - Light Accumulators—based on the idea that increased light causes increased evaporation. A photoelectric cell and counter activate a solenoid valve when a predetermined level of

light is received.

- Soil Moisture Conductivity—several devices relate soil moisture to electrical conductivity. When the soil dries to a pre-set level, the electronic circuit activates the solenoid valve.

14. Properly maintain existing irrigation systems to maximize efficiency. This includes both manual inspection of equipment and attention to irrigation controllers. Some representative practices include:

    - Replace washers to reduce leaks.

    - Replace leaking hoses, pipes and sprinklers.

    - Regularly monitor and adjust irrigation controllers to meet the seasonal needs of the plants. (Know how to use existing technology, including water budgeting features.)

    - Clean spray heads to ensure uniform distribution and proper application of water.

Step 3: Collect and Reuse/Recycle Irrigation Water

15. Many greenhouse operations across the country have already adopted capture and recycling systems. Whether voluntary or mandated, these capture systems have environmental *and* monetary benefits. While some greenhouses have made the switch due to irrigation cost savings, others have adopted these systems to ensure adequate supply of sufficiently high quality water during production. In Colorado, it is important to consider water rights constraints when adopting these systems.

16. Implementation of a new system means there will be an inevitable learning curve. Potential problems that may occur with recycled water systems can be easily avoided with careful planning and some monetary investment.

17. A common method of collection and reuse of water is the installation of retention basins, storage ponds, storage tanks and additional pumping capacity. Concerns related to these systems include build-up of salts, chemicals and nutrients, and changes in pH that can adversely impact crop quality. To mitigate these concerns, it is important to monitor and test irrigation water at least three times per year for salts, chemicals, nutrients and pH. Fertilizer application should be based on the results of these tests. If buildup of salts in recycled water becomes a problem, the water should be diluted with fresh water. Many growers use water treated through a process known as reverse osmosis (RO) to remove potentially harmful salts. The systems are relatively expensive but work well as a source of water for back blending.

18. Other concerns with recycled water systems include waterborne pathogens such as *Pythium sp.* that may be present in recycled water at relatively high concentrations and that ultimately cause root rot. Unfortunately, there are no scientifically derived thresholds for levels of pathogens in irrigation water. Growers can proactively address waterborne pathogens such as *Pythium* by implementing these practices:

- Increase the frequency of scouting for signs of disease.
- Remove diseased plants from the system quickly.
- Monitor pathogen levels in irrigation water. Water can be sampled at different points to determine pathogen presence and levels.
- Treat water for disease organisms by retention and dilution, filtration, chlorination, ozonation, and/or UV light.

19. Costs associated with installation of holding ponds, tanks, pumps, and possible treatment systems eventually pay for themselves. Phasing installation of these capture systems helps spread capital outlay over a number of years.

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Employee Education

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	X
CNA	X		

Description

Educate Green Industry employees on water quality and water conservation practices.

Basic Practice Guidelines

1. Educate employees on turf, plant and water management practices that conserve water and protect water quality. Explain the environmental benefits provided by properly designed, installed and maintained landscapes.

2. Provide bilingual educational materials, as needed.

3. Provide easy-to-read guidance sheets for field use that include water conservation and water quality topics.

4. Encourage employees to obtain and maintain professional certifications and licenses appropriate to each industry. Representative examples include: certified pesticide applicator; certified nursery professional; certified irrigation designer, contractor, or manager; certified landscape irrigation auditor, etc. Ensure that employees know when licenses and certifications are mandatory by law for certain activities (e.g., applying restricted-use pesticides).

5. Encourage employees to take continuing education courses to stay up-to-date with the state-of-the-practice and to obtain region-specific practice guidelines and information.

6. Encourage active participation in local, state, regional and national Green Industry organizations to keep up with current water efficiency technology and trends.

7. Make water conservation a priority for employees. This is particularly important for irrigation maintenance crews. A water conservation awareness campaign and incentive program can be helpful in changing attitudes and actions.

8. Emphasize the importance of always reading labels on fertilizers, pesticides and other chemicals and following the directions. Employees must be properly trained and educated on chemical usage. Employees should know where Material Data Safety Sheets (MSDSs) are and be familiar with commonly used chemicals as required under the Community Right-to-Know laws.

9. Emphasize proper installation of and regular maintenance of irrigation systems—proactive maintenance is more cost-effective than repair or treatments required due to poor irrigation systems.

10. Mandate that employees follow the requirements of relevant permits, local ordinances and health and safety regulations (e.g., Occupational Safety and Health Administration).

Regional or Industry Considerations/Adaptations

1. Region-specific considerations should be incorporated in the local certification courses.

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Public Education

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	X
CNA	X		

Description

Model and teach water conservation and water pollution prevention to all consumers of green industry products.

Basic Practice Guidelines

Green Industry professionals have the opportunity to model water conservation and water quality protection practices to the public through their actions and through distribution of educational materials. Following these basic public education guidelines is a list of references that are readily accessible and already in a form appropriate for the general public.

1. Provide leadership to the public by demonstrating practical and attractive water-efficient devices and landscapes.

2. Distribute water conservation and water quality protection information through a wide range of media including the Internet, nurseries and garden centers.

3. Educate the public on the many environmental and aesthetic benefits of landscaping.

4. Emphasize the value of conservation-oriented watering practices and the benefits of Xeriscape to clients and customers. For example, clearly communicate the basic principle that proper irrigation saves water, money and promotes healthier plants. Also let clients know that Xeriscape "doesn't have to be ugly" or grass-less. Turf has its place in Xeriscaped landscapes and provides water quality benefits when properly maintained.

5. Provide technical assistance to the public in converting existing landscapes into those that incorporate Xeriscape principles.

6. Provide education to customers and the public regarding the benefits of establishing a water budget and adjusting irrigation practices to fit the water budget (and therefore the needs of the plants.)

7. Actively participate in educational programs focused on water conservation and water quality protection. Examples may include speaking in schools, distributing videos and brochures, hosting Xeriscape demonstration projects, etc. Nurseries and garden centers can provide displays featuring Xeriscape demonstration gardens or hands-on demonstrations on creating Xeriscape landscapes.

8. For lawn care professionals, offer clients a water audit service to improve efficiency of water use. This would include evaluating sprinkler systems for proper coverage, replacing damaged heads, realigning heads, teaching owners how to program their controllers, preparing watering schedules based on weather conditions, etc.

9. Cooperate with other agencies on local ordinance development, public workshops, garden tours, videos, newsletters, events, etc.

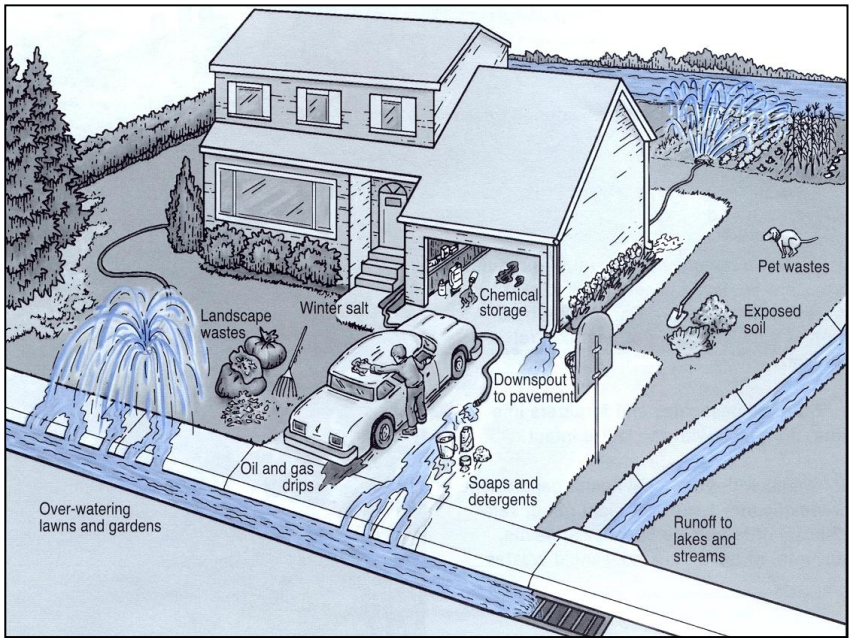
10. Educate new owners of irrigation systems on how to operate them. At a minimum, owners should know how to run the controller and change watering times and duration (minutes) based on weather and seasonal conditions. Irrigation contractors should provide owners with proper scheduling guidelines and techniques and an "as-built" drawing of the irrigation design that specifies the location and specifications of all application devices, pipelines, wiring, control valves, back-flow prevention devices and rain shut-off equipment.

11. When communicating with the public, be properly educated about the water requirements of plants and recommend plants with lower water requirements. Don't be fooled by marketing campaigns touting low-water usage or native plants without the data to back up their claims.

12. Emphasize the fact that reading the label when applying pesticides, herbicides and fertilizers is critical—over-application and misuse of these chemicals can harm plants and often damages the water quality in streams and lakes.

13. Emphasize the critical importance of proper ground preparation prior to planting and laying sod. Many new homeowners have "basement topsoil" left to work with and may not understand how important it is to properly amend this soil to facilitate efficient water usage and healthy lawns.

14. Consider establishing displays, signage, information brochure distribution shelves, or pilot-demonstration test sites for the purposes of effective public education.



Green Industry professionals can help to educate the public on measures to conserve water and minimize pollution.

Source: Colorado Nonpoint Source Council/U.S. Environmental Protection Agency.

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Fertilizer Application

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Properly apply fertilizers based on the specific needs of plants, particularly as identified by appropriate soil or plant tissue tests.

Basic Practice Guidelines

1. Apply fertilizer when needed to achieve a clearly defined objective such as increasing shoot growth, root growth, flowering or fruiting; establishing newly planted trees and shrubs; enhancing foliage color and plant appearance; or correcting or preventing nutrient deficiencies.
2. Because manufactured fertilizers can be relatively high in nutrient content, it is critical to follow the manufacturer's directions, using the minimum amount recommended. Over-application "burns" leaves, may lead to water pollution, thatch buildup and excessive mowing.
3. Only apply nutrients the plants can use. Fertilizer labels identify product contents in terms of ratios that indicate percentage of ingredients by product weight.
4. When practical and appropriate, base fertilizer application on soil analysis. Be aware that at many new home sites, "basement" topsoil may make obtaining representative soil samples challenging.
5. Prior to fertilizing, modify soil as needed to improve nutrient uptake.
6. Utilize split applications of slow-release (controlled-release) fertilizer forms such as IBDU, sulfur-coated urea and natural organic-based fertilizers (not to be confused with raw manure) to minimize the risk of nutrients leaching into groundwater or running off in surface water. When properly applied, other forms of fertilizer can also be safely used, provided that over-watering and over-fertilization do not occur.
7. When applying fertilizer, broadcast it uniformly over the targeted area of the landscape.
8. If possible, properly irrigate turf following fertilization to help grass utilize applied nutrients and to minimize the potential for fertilizer burn. Care should be taken to avoid excessive irrigation that would result in fertilizer being washed away. Similarly, avoid application of fertilizer immediately prior to heavy rainfall.
9. Fall is the best time of year to fertilize bluegrass lawns to promote a healthier turf before winter, a healthier root system, and turf that greens up earlier in the spring without excessive top growth. Fertilize with nitrogen sometime during late September to early November along the Front Range, and earlier in the mountains to ensure nitrogen is applied two to three weeks before the ground freezes.

10. Over-application of nitrogen fertilizer in April may cause grass to grow too fast before roots can support the growth, resulting in less heat tolerance.

11. Recommendations for fertilizer application vary among industry professionals. CSU Cooperative Extension's fertilizer recommendations for established Colorado lawns are provided in the table below. Site-specific conditions should also be considered when determining the need for fertilizer.

	CSU Cooperative Extension Recommendations for Nitrogen Application Rate in Pounds/1,000 sq. ft.				
Turfgrass Species	Mid-March to April[A,B]	May to Mid-June [B]	July to Early August [B]	Mid-August to Mid-September[B, C]	Early October to Early November[B, D]
High Maintenance Bluegrass Ryegrass	0.5-1	1	Not Required	1	1-2 (optional)
Low Maintenance Bluegrass	0.5	0.5-1	Not Required	1	1 (optional)
Tall Fescue,	0.5	0.5-1	Not Required	1	1 (optional)
Fine Fescue	0.5	0.5-1	Not Required	0.5-1	None
Buffalograss, Blue Grama, Bermudagrass	None	0.5-1	0.5-1	None	None

Notes:

[A]The March-April nitrogen application may not be needed if prior fall fertilization was completed. If spring green-up and growth is satisfactory, delay fertilizing to May or June.

[B]Application rates may be reduced by 1/4 to 1/3 when grass clippings are left on the lawn.

[C]On very sandy soils, do not fertilize turf after late September to prevent nitrogen from leaching into groundwater during the winter months.

[D]Apply when the grass is still green and at least 2-3 weeks prior to the ground freezing. Optional nitrogen applications are indicated for use where higher quality or heavily-used turf is present.

Source: T. Koski and V. Skinner, CSU Cooperative Extension, 2003.

12. As a general rule, the Colorado Nursery Association recommends waiting until the second growing season to fertilize ornamental (woody) plants. Commercial fertilizer should not be used in the backfill where it comes in direct contact with the roots. After the plant becomes established, the proper use of fertilizer is beneficial to the health, vigor, and vitality of the plant.

13. Correcting iron deficiencies in soils is difficult. For best results, choose plants adapted to alkaline soils.

14. Keep fertilizer off of streets, sidewalks and driveways to prevent water pollution. Fertilizer that inadvertently falls on impervious surfaces should be swept back onto the lawn.

15. Maintain a buffer zone around wells or surface waterbodies where fertilizers are not applied to minimize pollution. Consult the fertilizer product label and local regulations and landscape ordinances for appropriate distances. Research in this area is limited; however, CSU Cooperative Extension recommends a buffer of 6 to 10 feet for mowed turf areas.

Special Regional or Industry Considerations/Adaptations

1. Phosphorus can be beneficial to soils along the Front Range and mountains of Colorado, particularly in sandy soils. Phosphorous does not move out of the soil like nitrogen, so constant additions are unnecessary. Phosphorus is commonly overused and application should always be based on soil tests. Phosphorus washing into surface waterbodies leads to excessive algae growth in state waterbodies.

2. Soils along the Front Range and in many mountainous areas contain abundant potash, so it's unnecessary to add more.

3. In areas with sandy soils, it is particularly important to avoid over-application of fertilizer that could leach into groundwater. These areas may be particularly well suited to slow-release fertilizer forms and conservative application rates.

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Herbaceous Plant Care

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	
CGGA	X	WFC	
CNA	X		

Description

Properly plant and maintain herbaceous plants to maximize plant health and conserve water.

This BMP is directly adapted from *Flower Management Before, During and Following Drought* by J.E. Klett, J L.Vickerman, and C. Wilson, as posted on the GreenCO web site (http://www.greenco.org/downloadables/Drought%20Flower%20Management.pdf).

Basic Practice Guidelines

1. Prepare soil before planting by loosening it to 12 inches. If a heavy clay or sandy soil, add 2 to three inches of compost on the soil surface and then till in to a 12-inch depth.

2. Apply one to two inches of organic mulch between flowers to reduce evaporation and control water-using weeds. This practice is particularly critical during drought conditions, but helps to conserve water under all conditions.

3. Fertilizing perennials is generally not needed if proper soil preparation is done prior to planting. Fertilizer causes lush growth that requires more water. If fertilization is needed, a slow release fertilizer can be applied in the spring.

4. Moderate fertilization for bedding plants (annuals) is recommended either in liquid or granular form or a combination of both.

5. Annual and perennial flowers under water stress will have drooping leaves and a lack of blooms. Foliage often appears gray-green in color. Water when signs of stress become obvious. Apply irrigation in the evening or early morning to minimize evaporation. Avoid watering between the hours of 10 A.M. and 6 P.M.

6. Overhead spray irrigation is the least water-wise method because much water is lost to evaporation and wind drift. Soaker hoses or drip irrigation are more efficient because they deliver water to the ground level near roots. Hand watering is another alternative that maximizes delivery of water to the soil and roots.

7. When selecting plants, be aware that some perennials are more efficient at utilizing water than others. Choose plants to match the site conditions and consider plants with lower water needs.

8. Group plants with similar water needs together and water accordingly. *(See the Plant Selection and Placement BMP for more information.)* See Appendix E for water requirements of various plants in different portions of Colorado.

9. Gray-leaved annuals and perennials are often more drought tolerant. Spring bulbs are drought avoiders as they complete their life cycle prior to the onset of hot weather.

Regional or Industry Considerations/Adaptations

1. When water restrictions are expected or mild restrictions are in place, annuals can be watered two to three times per week if approximately one inch of water is applied during each irrigation cycle. Water perennials deeply (one inch of water or more) two times per week during hot, dry periods.

2. During drought restrictions when no watering is allowed, annuals and perennials should not be planted.

3. Following removal of drought restrictions, it is important to resume watering. Water perennials well in the fall and monthly during dry winters with no snow cover to ensure survival during the dormant season. Mulching the crowns of dormant perennials will prevent frost heaving and conserve moisture in the plant through the winter.

4. Some drought-tolerant annuals include:

   Annual Fountain Grass – (*Pennisetum setaceum*)
   Bachelor Button – (*Centaurea cyanus*)
   Coreopsis – (*Coreopsis tinctoria*)
   Cosmos – (*Cosmos sulphureus*)
   Creeping Zinnia – (*Sanvitalia procumbens*)
   Cup Flower – (*Nierembergia hippomanica* var. *violacea*)
   Dusty Miller – (*Senecio cineraria*)
   Gazania – (*Gazania rigens*)
   Globe Amaranth – (*Gomphrena globosa*)
   Johnny-Jump-Up – (*Viola tricolor*)
   Mealy Cup Sage – (*Salvia farinacea*)
   Mexican Sunflower – (*Tithonia rotundifolia*)
   Moss Rose – (*Portulaca grandiflora*)
   Periwinkle – (*Catharanthus roseus*)
   Rocket Larkspur – (*Conslida ambigua*)
   Rudbeckia – (*Rudbeckia hirta* var. *pulcherrima*)
   Spider Flower – (*Cleome hassleriana*)
   Sweet Alyssum – (*Lobularia maritima*)

5. Some drought tolerant perennials include:

   Artemisia – (*Artemisia* species)
   Blanket Flower – (*Gaillardia* x *grandiflora*)
   Blue Fescue – (*Festuca cinerea*)
   Creeping Phlox – (*Phlox subulata*)
   Creeping Potentilla – (*Potentilla neumanniana*)

German Statice – (*Goniolimon tataricum*)
Globe Thistle – (*Echinops ritro*)
Hens and Chicks – (*Sempervivum tectorum*)
Ice Plant – (*Delosperma* species)
Lambs Ear – (*Stachys bysantina*)
Lavender Cotton – (*Santolina chamaecyparissus*)
Little Bluestem – (*Schizachyrium scoparium*)
Oriental Poppy – (*Papaver orientale*)
Ozark Primrose – (*Oenothera missouriensis*)
Penstemon – (*Penstemon* species)
Plumbago – (*Ceratostigma plumbaginoides*)
Poppy Mallow – (*Callirhoe involucrata*)
Prairie Coneflower – (*Ratibida columnifera*)
Prairie Dropseed – (*Sporobolus heterolepsis*)
Purple Coneflower – (*Echinacea purpurea*)
Russian Sage – (*Perovskia atriplicifolia*)
Snow-in-Summer – (*Cerastium tomentosum*)
Stonecrop – (*Sedum* species)
Yarrow – (*Achillea* species)

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Irrigation Efficiency (General Principles)

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Properly design, install and maintain irrigation systems to ensure uniform and efficient distribution of water, thereby conserving water and protecting water resources.

Basic Practice Guidelines

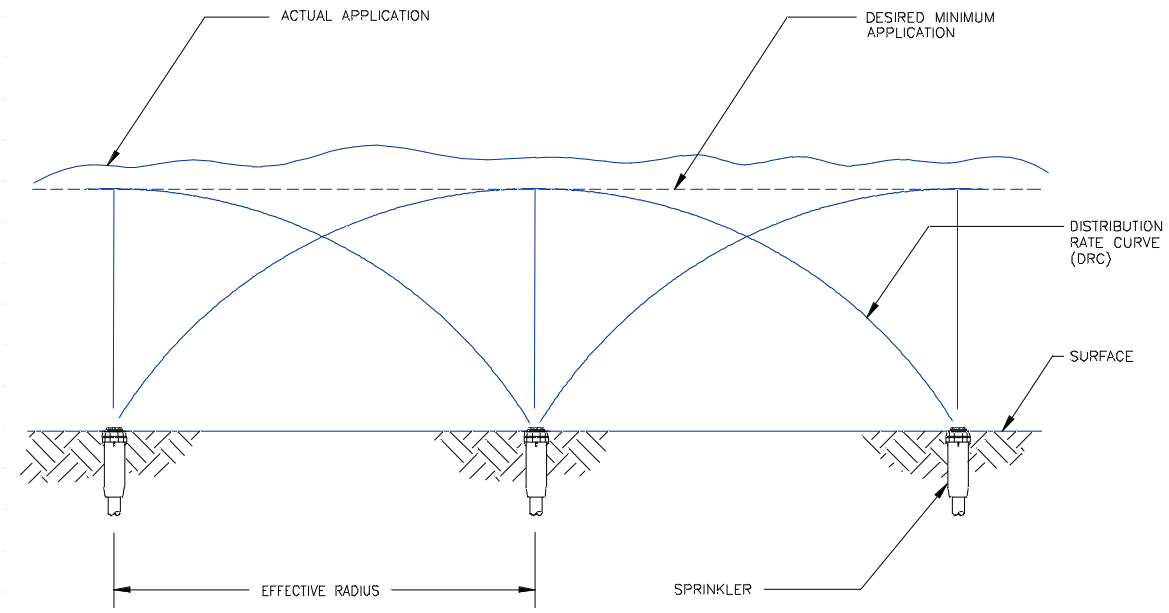
The Irrigation Association has established five overall BMPs for irrigation systems:

1. Assure the overall quality of the irrigation system.
2. Design the irrigation system for the efficient and uniform distribution of water.
3. Install the irrigation system to meet the design criteria.
4. Maintain the irrigation system for optimum performance.
5. Manage the irrigation system to respond to the changing need for water.

See the Irrigation Association's (2001) publication titled "Turf and Landscape Irrigation Best Management Practices" (downloadable from www.irrigation.org) for detailed information on these practices.

In keeping with these overall BMPs, the following guidelines are relevant to the Green Industry:

1. Do not over water—most established vegetation does not require more than one inch per week depending on the season and rainfall. Plants will develop deeper roots and ultimately require less watering, when not over-watered.
2. Never water if the soil is still wet.
3. Irrigate according to the requirements of the plants, not on a fixed schedule. The duration of irrigation is typically what needs to be modified based on evapotranspiration (ET).
4. Apply only enough irrigation to replace water loss by ET. Match irrigation application to soil type and root depth. Avoid applying more water than can be contained in the root zone. Daily observation is optimal to determine the appropriate changes to make to the irrigation system. If impractical, weekly observation should be conducted at a minimum.
5. Water all plants deeply but infrequently to encourage deeper, healthier rooting. Prolonged intervals between watering (short of drought damage) provide maximum encouragement of plant growth.



Head-to-head sprinkler spacing for uniform water distribution.

Source: Stephen Smith, Aqua Engineering.

6. Until plants have developed deep roots, they may need more frequent watering than older established plants.

7. When determining the watering needs of planted areas, dig down about 4 to 6 inches to determine the moisture content of the soil. Do not worry about the dryness of the top inch of soil. If the soil is too dry to form a ball when squeezed in the hand, it needs water.

8. Water early in the morning or between the hours of 6 P.M. and 10 A.M. when temperatures and winds are at their lowest levels to reduce water loss. Sprinklers are also typically more efficient during these times due to better water pressure.

9. Excessive irrigation after fertilization may cause leaching or surface runoff that pollutes waterbodies, while lack of irrigation may result in inefficient utilization of the fertilizer.

10. Water lawns and shrubs/perennial beds separately. (These should be in different irrigation zones.)

11. Water trees and shrubs, which have deeper root systems, longer and less frequently than shallow-rooted plants.

12. When watering plants on slopes, compacted soils, and/or sandy soils, a series of several light applications instead of one continuous application is typically appropriate to account for the lower intake rates of these soils. Consider installing low-angle nozzles on tops of slopes to

improve efficiency. Irrigation systems should also apply more water at the top of the slope and less at the base to prevent excess runoff.

13. Watering too frequently may promote some diseases in the landscape.

14. Irrigation efficiency is equally dependent upon a good design, correct installation and proper maintenance. Use only qualified (e.g., licensed, certified as needed) irrigation professionals for all phases of irrigation management.

Regional or Industry Considerations/Adaptations

1. In greenhouses and retail garden centers, consider the following practices to improve irrigation efficiency:

    - Group plants together that have the same water requirements (i.e., use hydrozoning).
    - Space containers under fixed overhead irrigation to maximize plant irrigation and reduce waste between containers.
    - Use drip tubes or spray sticks for each individual container, when reasonably practical.
    - When using programmable irrigation booms, adjust travel rate and flow rates to crop needs.
    - Choose sub-irrigation systems where appropriate using ebb and flood or capillary mat irrigation technologies with a water capture and reuse system. Fertility rates for most sub-irrigation systems can be reduced 50 percent.
    - Minimize leaching from containers or pulse-irrigate containers. Many textbooks recommend leaching greenhouse and nursery crops to 10 percent excess. This rate can be reduced to close to zero by reducing fertilizer rates and closely monitoring the electrical conductivity or the root substrate.
    - Consider capturing leachate and pot-overspray water for recirculation. Fertility and pathogen levels in the collected water must be monitored. Water pasteurization systems including UV, ozone, chlorine and heat are all acceptable solutions. Storage of recycled water with fertilizers may be an issue. *(See the Pesticide, Fertilizer and Other Chemical Storage, Handling and Disposal BMP for more information.)*
    - Plug sprinkler heads that are not watering plants, keep sprinkler heads as low as possible to the plants and use larger water droplet size to reduce irrigation time.

2. Irrigation systems should be designed to account for local climate variation. ET controllers are one tool that can be used to take local conditions into consideration.

3. Winter watering can be critical to minimize stress to trees, shrubs, plants and turf on the Front Range and other areas receiving low winter precipitation. This is especially likely to be the case with newly planted evergreens.

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Irrigation System Design

BMP Type			
Design			X
Installation			
Maintenance/Operation			
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Design the irrigation system for the efficient and uniform distribution of water.

This BMP is based largely on practice guideline 2 from "Turf and Landscape Irrigation Best Management Practices" (The Irrigation Association 2001).

Basic Practice Guidelines

Design Principles

1. Design irrigation systems based on a comprehensive understanding of soil type and infiltration rate; plant type, treatment and placement; site microclimates; site grading, slopes, exposure to wind and sun; water availability and source; size of irrigated area; available flow and pressure; water quality; water cost; historical evapotranspiration (ET) rate and annual rainfall; and the construction budget.

2. Consider site hydraulics such as pressure, flow principles, friction losses, gravity drainage and extreme pressure circumstances when designing irrigation systems.

3. All irrigation systems should be designed to avoid runoff, low-head drainage, overspray or other conditions where water flows onto adjacent property, non-irrigated areas or hard surfaces such as sidewalks and roads.

4. Meet all applicable plumbing and electrical codes and specify proper protection of the water source (e.g., backflow prevention devices).

5. Follow the "three rules" of maximum safe flow with the lowest safe flow prevailing as the design guideline:

    - The maximum allowable pressure loss through the meter should be less than 10 percent of the inlet pressure at the meter.

    - The maximum flow rate through the meter should be 75 percent of the maximum safe flow for the meter.

    - The velocity of water flow through the service line supplying the meter should not exceed 7 feet per second.

6. Provide for a designed Distribution Uniformity (DU) of 75 for the entire site.

7. Establish an irrigation schedule for all zones that meets peak demand for water.

8. Properly size pipes with no more than 10 percent variation in pressure within a zone between sprinkler heads and not to exceed 5 feet per second flow within the piping system.

9. Base zone layout on soil properties, slope, plant material water requirements, root zone depth, weather conditions, site conditions, supply pressure and minimum acceptable application rates. Irrigation system design goes hand-in-hand with the landscape design—irrigation zones should correspond to hydrozones on landscape plans. Always zone turf separately from plants and shrubs.

10. Specify the size and type of equipment to be used to meet the demands of an efficient system. Properly size valves and pipes to maintain proper pressure and coverage in irrigation systems. Changes in specified equipment should meet or exceed the minimum criteria DU of 75. The selected equipment should be appropriate for the size and use of the area in the landscape to minimize water waste.

11. Design the system in accordance with the manufacturer's recommendations for efficiency.

12. Sprinkler heads and emitters should be selected for proper area coverage, consistent application rates, operating pressure, adjustment capability and ease of maintenance. Never mix different types of sprinkler heads within the same zone, or mix sprinkler heads from different manufacturers.

13. For drip irrigation systems, properly size drip emitters to meet the different water needs of plants. On slopes, drip emitters should be placed uphill of the plants. A properly designed drip system is typically 90 percent efficient or higher.

14. Properly space sprinkler heads based on nozzle performance and pressure requirements to provide uniformity of coverage, making sure to account for influences such as slopes. Since each sprinkler is effective to approximately 60 percent of its radius, the best spacing to obtain uniform coverage is head-to-head. Ensure that irrigation laterals have matched precipitation rates for sprinkler arcs.

15. Ease of installation, operation, repair and maintenance should be considered in the design.

16. Specify equipment such as type of controller, sensors, etc., to facilitate management of the system. The selection of pipe, electrical wire and other materials should be based on environmental conditions and code requirements. The sprinkler head placement should be based on the best performance criteria including pressure, spacing and other site factors or local environmental conditions.

17. Include provisions for future expansion, as needed, such as installation of spare zone control wires or larger upstream components such as mainline pipe, etc.

Alternative Water Sources

18. Use recycled or non-potable water to the greatest extent possible, as limited by supply and/or regulation. Non-potable water supplies should be explored for large landscaped areas such as

parks and golf courses in particular. Designs should be compatible for use with non-potable sources, should they become available.

19. Water should also be harvested from rainfall and snowmelt for landscape irrigation purposes to the extent practicable.

20. When designing systems using reclaimed water, ensure that applicable regulations are followed. For example, provide for required signage and cross-connection inspection in accordance with Colorado Department of Public Health and Environment Water Quality Control Commission *Regulation No. 84: Reclaimed Domestic Wastewater Control Regulation*.

Water Conserving Equipment and Methods

21. Design low-volume irrigation for long, narrow or small irregularly-shaped landscape areas to reduce evaporation losses and to avoid applying water on hardscapes such as roadways, parking areas, driveways, sidewalks, patios and decks. Planting beds and narrow turf strips can be particularly well suited to subsurface and drip irrigation systems. Do not install overhead sprinkler systems for median strips less than 10 feet wide.

22. Install a master valve to minimize system leakage.

23. Use of low-pressure (i.e., less than 50 pounds per square inch) irrigation systems for large turf areas can reduce operational costs, system wear, potential for misting and water waste. Pressure-compensating heads should be used where appropriate to regulate pressure requirements.

24. Consider soil infiltration rate, slope, and design precipitation rate when selecting sprinkler heads to reduce the potential for runoff.

25. Specify low-angle sprinkler heads to mitigate the effects of wind.

26. Specify water-conserving devices such as check valves, pressure regulators or climate sensors such as rain, freeze and wind sensors, etc., to suspend irrigation when unfavorable weather conditions exist. Proper location and installation are necessary in order for these technologies to be effective.

27. Install anti-drain (check) valves in strategic locations to minimize or prevent low-head drainage, or use heads with a built-in anti-drain feature.

28. Regulate water pressure with valves, as needed. Prevent water hammer and line and sprinkler head drainage. Pressure-compensating outlets should be used where pressure varies more than 20 psi or 20 percent from design operating pressure.

29. Specify water-conserving irrigation management methods such as the use of ET controller technology (or ET data) or soil moisture sensors to minimize over-watering.

30. Specify a controller that allows for flexible irrigation scheduling and water management, including features such as the use of repeat cycles to minimize runoff, water budgeting and interfaces with various climate or environmental sensors to manage programmed irrigation schedules.

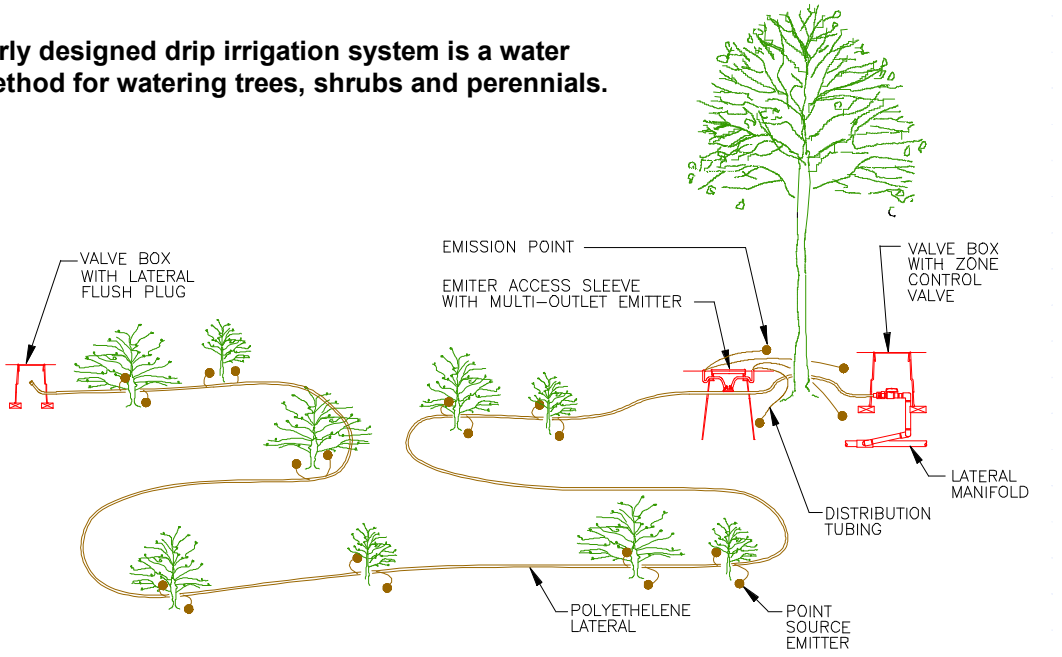
31. Particularly for large landscapes, controllers should have the capability to permit simultaneous multiple-cycle irrigation, seasonally variable programming, manual override and effective use of low-volume irrigation zones (i.e., long run-time at infrequent intervals).

32. Avoid oscillating sprinklers and sprinkler heads that produce mists or fine sprays.

33. Consider pump intake filters for irrigation systems where source water quality is an issue to promote better functioning of irrigation equipment.

34. Consider installing a dedicated water meter or flow sensor with a readable output to measure the flow and quantity of water being applied to the landscape.

A properly designed drip irrigation system is a water efficient method for watering trees, shrubs and perennials.



Source: Stephen Smith, Aqua Engineering.

Documentation and Follow-up

35. Provide for temporary irrigation plans to establish new vegetation.

36. Written irrigation plans should include: the precipitation rate for each zone; the calculated flow rate for each emitter or low-volume zone; a schedule of irrigation for both the establishment and post-establishment periods; and a general operating schedule of run-times based on projected ET for each zone during each week of the irrigation system. The manufacturer and catalogue number of specified parts should also be provided.

37. Assure overall quality of the irrigation system by ensuring that the properly-designed irrigation system is properly installed and maintained.

Regional or Industry Considerations/Adaptations

1. For landscape managers or growers who obtain water from irrigation companies, it is particularly important to identify and understand the method used to measure the amount of water provided, the delivery schedules and water rights issues when designing the irrigation system.

2. In areas where drain ditch water is used, water may not be of sufficient quality for irrigation. A salt test should be conducted on such water prior to selecting plant materials.

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Irrigation System Installation

BMP Type			
Design			
Installation			X
Maintenance/Operation			
Green Industry Relevance			
ASLA		GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Install the irrigation system according to the design specifications, which should be in accordance with manufacturer's specifications, local code requirements and sound principles of efficient and uniform water distribution.

This BMP is based directly on practice guideline 3 from "Turf and Landscape Irrigation Best Management Practices" (The Irrigation Association 2001).

Basic Practice Guidelines

1. Install the irrigation system to meet the design criteria.

2. Contract with a licensed, experienced and reputable irrigation professional to complete the installation.

3. Before commencing installation, verify that water tap, flow rate and pressure meet design criteria.

4. Ensure that the site drainage has not been altered for existing plant communities that are not planned to receive supplemental irrigation.

5. Install the irrigation system's components according to the design specifications and manufacturer's published performance standards.

6. Where deviations from the design are required (e.g., running pipe around a tree or other structure or adding sprinkler heads to an area larger than the plan shows), consult with the designer prior to making the change to ensure that the change is within design performance specifications.

7. Require that the architect, irrigation designer or local water district representative perform one or more field observations during system installation to check for adherence to the design. The purpose of the observation is to check for proper installation and function of the backflow prevention assembly, main line, pipes, valves, sprinkler heads, control wire, controller and water conserving devices.

8. Furnish "as-built" record drawings to the owner of the system. The record drawings should describe the system layout and components including all changes from the original design.

9. Test the irrigation system to verify that the system meets the design criteria.

10. Create an irrigation schedule to meet the needs of the plants. Review the irrigation schedule, specifically its rationale and how to set irrigation days, zone run times and start times. Review

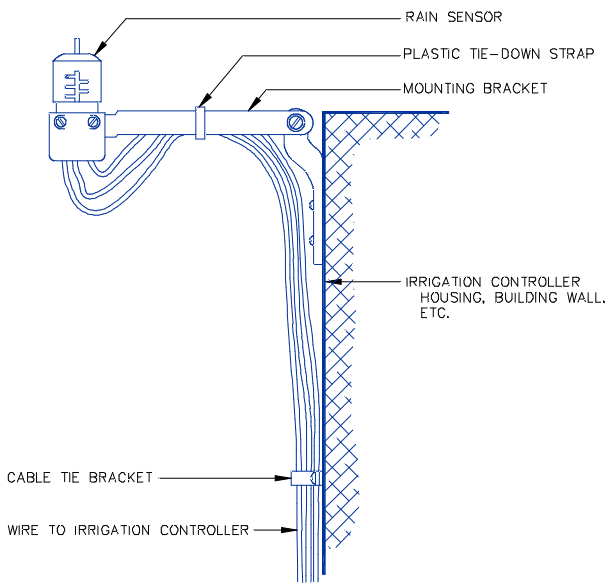
advanced programming features such as multi-cycle irrigation to prevent run-off and the use of the percentage water increase/decrease function.

11. Explain to the end user (or owner) the location and operation of the controller, valves, sensors, pressure regulators, backflow prevention device and sprinkler heads. Educate the owner on features and capabilities of the system including the maintenance requirements.

12. Provide the end user (or owner) with recommendations for landscape water conservation.

13. Provide the end user (or owner) with product warranties and operating instructions for all equipment.

14. Within 60 days of installation of a new system and periodically as set by local standards, a field performance audit should be conducted using an accepted procedure such as the Certified Landscape Irrigation Audit technique from the Irrigation Association. The audit should check the performance of the system for conformance with local requirements including meeting the minimum precipitation rate and distribution uniformity (DU) standards and installation of all system components including appropriate sensors. The audit should also verify that the programmed irrigation schedule meets the water needs of the plants without wasting water. Provide the end user (or owner) with system specifications and a zone performance summary report that includes individual zone precipitation rates in inches per hour. The measured DU should be at least 90 percent of the design DU. A reference of each zone's precipitation rate should be retained at the controller.



Ensure owners and operators understand the function and operation of water saving devices such as this rain sensor.

Source: Stephen Smith, Aqua Engineering.

Regional or Industry Considerations/Adaptations

1. Additional equipment protection may be necessary depending on site conditions. Extreme UV exposure, heat, wind or sub-zero temperatures may affect the equipment's service life.

2. Do not over-tighten a plastic-cased sprinkler onto the riser: it can crack the sprinkler body.

3. Be sure to "flush-out" the irrigation system after installation to ensure that rocks, debris and soil are removed so that the system functions efficiently.

4. When installing reclaimed water irrigation systems, be sure to provide appropriate cross-connection prevention devices and obtain appropriate inspections in accordance with the Colorado Department of Public Health and Environment Water Quality Control Commission *Regulation No. 84: Reclaimed Domestic Wastewater Control Regulation*.

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Irrigation System Maintenance

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Maintain the irrigation system for optimum performance, ensuring efficient and uniform distribution of water. Modify the irrigation system as needed to accommodate the changing water needs of plants.

This BMP is based primarily on practice guidelines 4 and 5 from "Turf and Landscape Irrigation Best Management Practices" (The Irrigation Association 2001).

Basic Practice Guidelines

Basic System Maintenance Practices

1. Establish a systematic maintenance schedule for inspecting, testing and reporting on performance conditions of the irrigation system. Report any deviations from the original design. As part of a systematic maintenance program, it is important to:

    - Check, adjust and repair irrigation equipment on a regular basis, ideally on a weekly schedule and within 24 hours of mowing, whenever possible. Identify irrigation system leaks and repair them promptly. As part of day-to-day maintenance, staff should understand the irrigation system basics and be able to recognize system problems.

    - Inspect the irrigation system after annual activation in the spring and bring the system up to specified operating conditions. Particularly for large systems, make written notes of repairs so that a history profile can be developed to prioritize future improvements to the system.

    - For properties of one acre or more, employ a certified landscape-irrigation auditor at least once every five years to conduct a thorough and comprehensive check for efficiency of water application.

2. Immediately shut off irrigation systems and adjust whenever irrigation water falls or runs onto hard surfaces such as sidewalks, streets or driveways. Signs of leakage include overgrown or particularly green turf areas, soggy areas around spray heads and aboveground hoses, jammed spray heads and torn hoses. In drip systems, leakage problems may be due to damaged tubing from foot traffic or gnawing by animals.

3. Verify that the water supply and pressure are as stated in the design. Differences in the sprinkler system's required design operating pressure and actual water pressure can affect operation and efficiency. Install pressure reducing valves (PRVs) where needed to stop misting due to excessive pressure.

4. Verify that the backflow prevention device is working correctly.

5. Periodically perform a thorough inspection of the system components to verify that the components meet the original design criteria for efficient operation and uniform distribution of water, including:

    - Adjust valves for proper flow and operation. Adjust valve flow regulators for desired closing speed. Valves must always shut off tightly to prevent soggy spots and operate without slamming open or closed to prevent pipe and sprinkler damage from surges.

    - Verify that heads are properly adjusted—check the nozzle, arc, radius, level and attitude with respect to slope.

    - Verify that sensors used in the irrigation system are working properly and are within their calibration specifications.

    - Look for debris (e.g., rocks, sand, dirt) lodged in sprinkler heads and drip emitters and watch for salt build-up around drip emitters.

6. Repair or replace broken hardware and pipes with originally specified materials, thereby restoring the system to the original design specifications. Test all repairs.

7. As plants mature, add or relocate system components as needed to maintain uniform distribution of water. Ensure that system modifications do not exceed the system watering capacity.

8. Establish a "winterization" protocol (if required) and a corresponding process for system activation in the spring.

9. Whenever possible, update and retrofit existing irrigation systems to take advantage of new water-saving technology (e.g., rain shut-off devices, ET controllers, drip irrigation).

10. Ensure that the maintenance contractor is licensed, experienced and reputable. The maintenance contractor should be legally authorized to maintain irrigation systems in the project area.

Maintenance Practices for Managing Changing Water Needs of Plants

11. Manage the irrigation system to respond to the changing/seasonal requirements for water in the landscape. The most efficient systems match irrigation application to landscape water requirements through effective irrigation scheduling. Whenever possible, irrigation scheduling should incorporate the use of evapotranspiration (ET) and precipitation data.

12. Reset automatic controllers according to the seasonal needs of plants. Controllers should be inspected at least bi-monthly to correct run times.

13. Understand the capacities and capabilities of the irrigation system and use them properly. For example, for spray irrigation systems, program the irrigation controller for multiple start times on watering days to reduce runoff and deep percolation below the root zone. For example, if

the total watering time is 18 minutes, set the controller to three cycles of 6 minutes each per cycle started each half-hour. (Drip systems should NOT be cycled in this manner.)

14. Establish a water budget based upon system performance and plant water requirements. Then measure and compare actual water usage to the amount of water needed.

15. Perform irrigation audits (if current data don't exist) to obtain data needed to create irrigation schedules.

16. Understand and use a reliable source for reference ET rates. Appropriately modify the reference ET to calculate local water needs for the various plant materials and turfgrass in the landscape. Identify soil types and root depths of each zone and determine soil water-holding capacities. Calculate the run-time of each zone to supply the needed water based upon the actual precipitation rate of the sprinkler zones, the water-holding properties of the soil, the changing weather conditions and the plant's water requirements. Set the schedule to minimize runoff.

17. Periodically verify that sensors in the irrigation system are working properly.

18. Periodically verify that the plant material is healthy and that soil moisture is adequate. Use a soil probe to visually inspect root depth, soil structure and moisture.

19. The irrigation system is a management tool and cannot replace the sound judgement of trained professionals. The best-designed irrigation system will fail without regular maintenance.

Regional or Industry Considerations/Adaptations

1. Winterize sprinkler systems in cold regions to prevent cracked pipes, broken heads and other problems. Winterization primarily consists of removing all the water from the irrigation system and equipment. This is typically accomplished by turning off the main water supply, opening all drains and blowing the water out of all pipes with compressed air.

2. Large, managed landscapes, such as golf courses and parks, require trained managers for operating irrigation systems. This requires understanding of the irrigation equipment as well as parameters such as ET and infiltration rates. Water audits of these large systems are important to ensure that the system is being managed properly.

3. Large, managed landscapes and commercial operations should prepare a written irrigation management site plan that clearly identifies responses and priorities during water-limited situations such as various stages of drought. The plan should be part of a comprehensive landscape management plan that addresses other management practices such as mowing, fertilizing, etc.

4. Cross-connection and backflow prevention devices must be inspected on an annual basis by a certified cross-connection control technician if recycled domestic water is used. See Colorado Department of Public Health and Environment Water Quality Control Commission Regulation No. 84: Reclaimed Domestic Wastewater Control Regulation.

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Landscape Design

BMP Type			
Design			X
Installation			
Maintenance/Operation			
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Plan and design landscapes comprehensively to conserve water and protect water quality.

Basic Practice Guidelines

Design Principles

1. Consider view, slope, exposure to natural (e.g., wind, sun) and man-made (e.g., pedestrian traffic) elements, soils, availability of natural precipitation and supplemental irrigation, and drainage when designing the overall landscape.

2. Base designs on sound landscaping practices. Consider and implement the seven basic principles of Xeriscape: planning and design, soil improvement, zoning of plants, practical turf areas, efficient irrigation, mulching and appropriate maintenance. *(See the Xeriscape BMP for more information.)*

Irrigation and Drainage

3. Design the site for efficient irrigation, including both state-of-the-practice irrigation technologies and management practices. Landscape plans should also include specific irrigation plans. *(See the Irrigation BMPs for more information.)*

4. Incorporate the concept of "water-wise irrigation zones" to develop planting lists for landscape components. For example, identify zones of high, moderate and low water usage and then identify water requirements and appropriate plants for each zone.

5. Design landscapes to harvest water to avoid losing runoff, especially around parking lots. This results in the greatest possible use of natural precipitation by landscape plants, while minimizing runoff into stormwater drainage systems.

6. Grade landscaped areas to maximize infiltration, while minimizing runoff and ponding.

7. Include decorative berms, grassy swales, and buffer zones to direct water flow to cultivated areas at locations where sediment movement into surface water or drainageways has been observed. Be careful not to create steep, hard-to-manage slopes when designing berms.

8. To the extent possible, design the site to blend with existing topography, following existing contours to preserve the overall natural major drainage patterns. (This should not be confused with localized site grading at the micro-drainage level that can provide water quality and water conservation benefits.)

9. Consider installing terraced gardens on slopes to allow heavy rains to soak in rather than to runoff and cause erosion.

10. Use porous paving materials (e.g., brick, gravel, flagstone) for patios and walkways to keep water in the garden rather than in the gutter.

Soils

11. Obtain at least one soil nutrient analysis prior to completing a project design. Obtain more tests for sites with variable conditions or where imported topsoil is used.

12. Provide appropriate specifications to ensure soils are properly prepared and amended during landscape installation. *(See the Soil Amendment/Ground Preparation BMP for more information.)*

Plant Selection and Placement

13. Group plants with like water needs together. Plants located within the drip line for large trees and shrubs should have similar water requirements as the trees and shrubs. *(See the Plant Selection and Placement BMP for more information.)*

14. Select plants that are well adapted to the climate, topographic and geologic conditions of the site. Native plants and plants with documented lower water requirements should be given priority in landscape design.

15. Where possible, retain significant native vegetation that is already adapted to the site.

16. Consider using groundcovers with lower water requirements for slopes and hard-to-mow locations.

17. When designing plant placement on slopes, place lower-water demand plants at the tops of slopes and higher-demand plants at the bottom.

18. Incorporate trees into the landscape to provide shade, reduce stormwater runoff, stabilize soil and protect against wind. A goal of at least 20 percent canopy coverage for Front Range communities is ideal.

19. When selecting turfgrass, consider the use, aesthetic and design goals of the site, estimated water use and maintenance budget. In areas where irrigation is not planned, a mix of mainly native bunch and sod-forming grasses can be used.

20. Avoid using turf in areas less than 10 feet wide and on slopes steeper than 4:1. (Although turf provides effective erosion-control, maintaining regularly mowed turf on a steep slope can be difficult and/or dangerous.)

21. Use weed barrier fabrics and organic or inorganic (e.g., gravel, rock) materials to reduce weeds while still allowing water and air to penetrate the soil. Do not use black plastic.

22. Landscape bare areas to reduce soil erosion. Landscaping practices can reduce stormwater runoff rates and volumes, sediment loads and pollutants. Turfgrass can be particularly effective in erosion-prone areas and can be used in buffer strips and grassy swales to filter out sediment. Consider installing grassy buffers in areas adjacent to, or contiguous to, open waterways or known recharge areas, to provide extra filtering of runoff.

Buffers and Wetlands

23. Maintain wide, undisturbed riparian (stream) corridors or consider installing wetland "edge" treatments. Check with local regulations for specific setbacks for streams—these may vary from 25 to 200 feet, depending on site conditions and local standards.

24. Protect existing wetlands and consult with the U.S. Army Corps of Engineers prior to dredging, filling or enhancing a wetland. It is illegal to dredge or fill a jurisdictional wetland under the federal Clean Water Act. It is necessary to obtain a 404 permit prior to modifying a wetland.

Water Features

25. When water features are part of designed landscapes, recirculating water should be used to prevent stagnant water and algae build-up. Other factors that should be carefully considered include lining the pond or water feature with impermeable materials, evaporation and addition of make-up water, management of water quality (e.g., nutrients) in the pond, algae control, periodic flushing and disposal of water.

Regional or Industry Considerations/Adaptations

1. Be aware that federal, regional, state and local water quality regulations may require integration of stormwater management facilities (e.g., detention ponds, constructed wetlands) into landscape design. Work closely with the general contractor, civil engineer and U.S. Army Corps of Engineers personnel when these facilities are necessary.

2. Large landscaped areas such as parks and golf courses have special design considerations. On large sites, written landscape plans that include specifications for soil preparation, plant materials, irrigation design, mulch, and maintenance instructions are particularly important. *(See the Parks, Golf Courses and Other Large Landscapes BMP for more information.)*

3. In some parts of Colorado (e.g., Western Slope, parts of the Arkansas River basin), landscaped areas may overlay soil and geologic formations high in salts and selenium where leaching of these constituents into groundwater is a concern. In these areas, practices such as unlined ponds and over-watering that may result in water infiltration into soil below the root zone should be avoided.

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Landscape Installation and Erosion and Sediment Control

BMP Type			
Design			
Installation			X
Maintenance/Operation			
Green Industry Relevance			
ASLA	X	GCC	
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA		WFC	
CNA	X		

Description

Minimize erosion and control sediment leaving the construction site during landscape installation.

Basic Practice Guidelines

Erosion and Sediment Control/Site Protection

1. During construction, protect drainageways from runoff from exposed areas. Applicable practices may include straw bales, silt fences, berms, check dams, sediment basins, etc. See Appendix A for more detail on these measures.

2. Be aware of, and comply with, all stormwater construction permit requirements. As of July 1, 2002, most construction sites disturbing 1 acre or more will require such a permit and corresponding stormwater and erosion and sediment control plans. Coordinate with the General Contractor to ensure that applicable provisions of the permit are followed.

3. Minimize the amount of exposed land area and duration of exposure by phasing construction and landscape installation.

4. Avoid storing topsoil or soil amendments delivered to the site on the street or in the gutter. Dry-sweep residual soil into a wheelbarrow and dispose of it appropriately rather than using a hose to wash residual material into the storm sewer system.

5. During construction, store and protect topsoil for later use. This may require covering the stockpiled soil, and typically requires berms around the stockpile to prevent the soil from washing away during storm events.

6. Roughen slopes to be planted and provide a convex shape to slow water runoff. Apply mulches or netting over seeded slopes in exposed conditions or with a slope of 3:1 or greater to prevent erosion. Slope stabilization should be completed at the earliest practical time and in accordance with the timeframes specified by local regulations (e.g., 14 to 30 days).

7. Protect the root zone of existing trees to be retained on the site. Clearly delineate root zones with protective fencing and by posting “keep out” signs. Maintain positive drainage to these areas and adequate irrigation during and following construction. Grading and trenching in the critical root zone should be avoided.

8. Turfgrass sod provides excellent erosion and sediment control benefits and should be installed as soon as possible in areas where sediment runoff is likely. Temporary cover crops and other groundcovers may also be installed to protect these areas.

9. Repair and stabilize areas of excessive erosion.

10. Properly handle, store and dispose of pesticides, fertilizers, equipment maintenance products (e.g., oil, fuel) and other waste used during landscape installation. *(See the Chemical and Equipment Handling BMP for more detail.)*

Planting and Landscape Installation

11. Perform a comprehensive soil analysis and apply fertilizer and other amendments if specified. Slow-release type fertilizers should be used to reduce weed growth and protect water quality.

12. Properly amend soil prior to planting or laying sod. This typically requires 3 to 5 cubic yards (1 to 3 inches) of organic material per 1,000 square feet of the site. If the site has been compacted, tilling to a depth of approximately 4 to 6 inches or more is also recommended. Proper soil preparation can substantially reduce irrigation requirements.

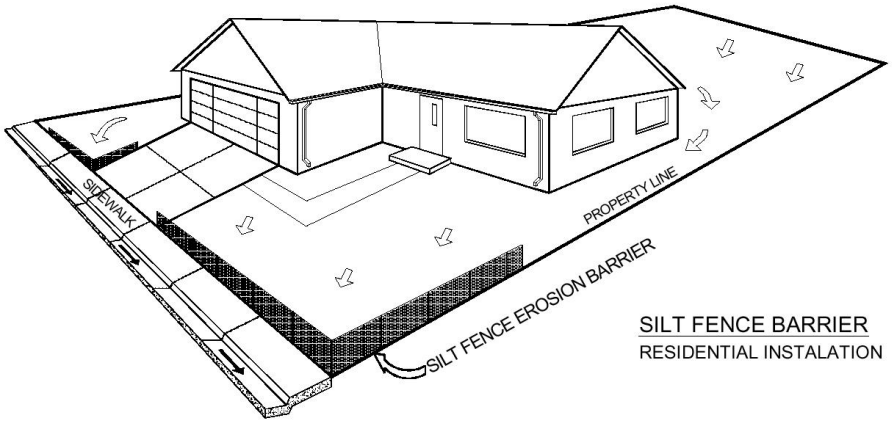
13. For landscape areas being started from seed, sow seed mixtures at the proper time of year specified for the mixture.

14. Mulch all seeded areas and adequately secure the mulch. Maintain mulch by adding and redistributing, as necessary.

15. Keep all containerized nursery stock in a live and healthy condition prior to installation.

16. Provide adequate irrigation during the vegetation establishment period.

17. Routinely inspect landscapes following planting to implement follow-up measures to increase success. Immediate attention to a problem (e.g., weed infestation, failure of seed to germinate) can prevent total failure later.



Proper placement of residential erosion control barriers.

Source: Urban Drainage and Flood Control District (1999) and City of Broomfield.

Regional Considerations or Industry Adaptations

1. As a rule of thumb along the Front Range and in the mountains, the latter part of May and first part of June typically experience frequent storm events. During this time, landscapers

should be particularly aware of the impact of the weather and phase construction/installation accordingly.

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Landscape Maintenance

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	
CGGA		WFC	
CNA			

Description

Practice landscape maintenance appropriate for the site including practices such as pruning, weeding, mulching, fertilization and attention to the irrigation system.

Basic Practice Guidelines

1. Implement regular maintenance schedules that include checking, adjusting and repairing irrigation equipment; resetting the automatic irrigation controller; aerating turf; replenishing mulch; applying fertilizer; pruning and weeding. *See the related GreenCO BMP fact sheets on these specific topics for more detailed information.*

2. Keep leaves, grass clippings and other turf wastes cleared off sidewalks and streets so they don't wash into storm drains and ultimately into streams and ponds. Power blowers should be used to blow clippings onto grass for fertilizer, not blow them into the gutter.

3. Frequently remove dead or dying plants and all weeds that compete with healthy plants for available water. Clean up plant litter and remove weeds before they go to seed.

4. Maintain a buffer zone along waterways where chemicals are not applied in accordance with product labels, local ordinances and state and federal regulations. The purpose of this practice is to keep pesticides, herbicides and fertilizers out of surface waterbodies. Recommended buffer widths may vary based on the sensitivity of the waterbody, slope, soils, vegetation, type of chemicals used, etc.

5. Before moving directly to chemical methods to control weeds, consider the following practices:

   - Mechanical: physically remove weeds by hand pulling, digging or cultivation.

   - Exclusion/Cultural: maintain dense stands of desirable plants that will successfully out-compete weeds, or consider using mulches to exclude weeds.

   - Biological: using specific insects and plant pathogens to control weeds is an area of growing research. When such methods are demonstrated to be appropriate and effective, consider their use.

6. Aerate turf in the spring and in the fall, if needed, to eliminate compaction and improve the turf's ability to take up moisture, nutrients and air.

7. Monitor landscape quality to identify strengths and weaknesses of existing landscape management. Results should be used to revise management and maintenance strategies.

8. Frequently and routinely inspect equipment (e.g., mowers, irrigation system) to determine when maintenance and repair are needed. Maintain equipment for optimum performance. This is particularly critical for irrigation systems. *(See the Mowing and Irrigation System Maintenance BMPs for more information.)*

9. When maintaining equipment such as lawn mowers, tractors, etc., properly capture and dispose of oil, grease, fuel, etc., so that it does not damage turf areas and enter storm drains and waterbodies.

10. When sediment is found on impervious surfaces, such as streets, gutters, sidewalks, and driveways, these materials should be shoveled and disposed so they do not end up in runoff and streams.

Well-designed and maintained landscapes provide multiple values such as stormwater management, recreation and aesthetic benefits.

Source: Wright Water Engineers, Inc.

Regional or Industry Considerations/Adaptations

1. Regional variations in soil moisture, air temperature, water quality and soil chemistry will all affect maintenance schedules.

2. Check local utility department websites for watering restrictions and practice recommendations during drought conditions. Also see CSU Cooperative Extension websites for specific recommendations during drought.

3. Be aware of state and county-specific noxious weeds that must be controlled.

4. Limited fall and winter watering may be required in some cases (e.g., newly planted trees, golf courses) to prevent root damage and winter desiccation. If required, only water when air and soil temperatures are above freezing.

5. Particularly for large sites, keep records to document changes on the site including turf quality, irrigation system efficiency, water quality, pest levels, etc. A computerized database or spreadsheet is recommended for large landscapes.

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Lawn Aeration

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	
ALCC	X	ISA	
CALCP	X	RMSGA	X
CGGA		WFC	
CNA			

Description

Aerate lawns to improve nutrient and water uptake, reduce runoff, reduce compaction and help to control thatch.

Basic Practice Guidelines

1. Aeration, or core cultivation, reduces soil compaction and helps control thatch in lawns while helping water and fertilizer move into the root zone.

2. A lawn can be aerated at any time the ground is not frozen, but should not be done when it is extremely hot and dry. Heavy traffic areas will require aeration more frequently.

3. Aeration is most effective when actual cores or plugs of soil are pulled from the lawn. Do not use spike-type aerators, which compact the soil. Holes should be two to three inches deep and no more than two to four inches apart. Lawns should be thoroughly watered the day before aerating so plugs can be pulled more deeply and easily. Mark all sprinkler heads, shallow irrigation lines and cable TV lines before aerating so those lines will not be damaged.

4. On thatchy lawns, it is important to leave the cores on the lawn, allowing them to work back into the grass. Otherwise, core removal is optional. Lawns may be fertilized and seeded immediately after aeration. There is no need to top dress lawns following aeration.

5. Aerate turf once or twice per year, as needed, in the early spring and/or late fall to aid in capturing the natural precipitation during non-weed germination periods and prior to adding organic materials and fertilizers.

Regional or Industry Considerations/Adaptations

None identified.

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Lawn Waste Disposal/Composting

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Dispose of yard waste to minimize adverse impacts to the environment by keeping waste out of storm drains. Recycle and compost organic materials whenever possible.

Basic Practice Guidelines

Disposal

1. Keep lawn clippings and debris out of gutters.
2. Leave grass clippings on the lawn to provide supplemental nitrogen.
3. When blowing walkways or mowing lawns, direct equipment so that the clippings blow back onto the lawn rather than into the street.
4. Chip and use trimmings of woody plant material from shrubs and trees as mulch for water conservation.
5. Leave spruce and pine needles under evergreen trees.
6. When site constraints require off-site disposal of lawn waste, use landfills and recycling/composting facilities designed for yard waste, whenever practical.

Composting

7. Compost organic plant material for later use as a soil amendment.
8. Select the compost location in an area with partial shade and protected from the wind.
9. Ensure that the plant material is not diseased or weed containing. Also, generally avoid plants treated with weed killers. Exceptions include soil-inactive glycophosphate products such as Roundup or Kleenup, when used in small quantities.
10. Alternate different types of plant material in 6 to 8 inch layers. Composting is effective on most yard wastes such as leaves, vegetable and flower plant parts, straw and a limited amount of woody prunings and grass clippings. Moderate sized plant materials of ½ to 1½ inches are most effective—avoid materials that are too large or too fine.
11. Avoid highly resinous wood and leaf prunings from plants such as junipers, pine, spruce and arborvitae. Although some grass clippings can be incorporated, they are best left on the lawn to recycle nutrients to the soil.
12. Compost should be kept moist, but not soggy.

13. Mix equal parts of green and dry material to maintain the best nitrogen balance.

14. Routinely mix and turn the compost to provide uniform aeration.

15. Rather than constantly adding new material to almost-finished compost, start a new compost pile.

Regional or Industry Considerations/Adaptations

1. Colorado winter temperatures may extend the time necessary to produce "finished" compost. Additionally, Colorado's dry climate may require addition of supplemental moisture to compost to maintain microbial activity.

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Mowing

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	
ALCC	X	ISA	
CALCP	X	RMSGA	X
CGGA		WFC	
CNA			

Description

Mow lawns to the proper height and at the proper frequency to maintain turfgrass health, thereby minimizing the need for pesticide and fertilizer application and reducing water usage.

Basic Practice Guidelines

1. Mow the lawn frequently enough so that no more than one-third of the grass blade is removed during a single mowing. For example, if maintaining the grass at a height of 2½ inches, cut the grass by the time it reaches 3¾ inches tall. This requires changing the mowing schedule to reflect how quickly the grass grows. This can range from four to ten days between mowing.

Proper mowing, irrigation and maintenance of turfgrass results in deeper, more drought resistant root systems.

Source: International Turf Producers Foundation.

2. Grass undergoes less stress when the amount of blade left on the plant can still function efficiently. The preferred height of Colorado turfgrass species such as Kentucky bluegrass and long fescue is 2½ to 3 inches. The minimum height is two inches. Mowing grass to a height of less than two inches can reduce drought and heat tolerance, and cause a higher incidence of insect, disease and weed pest problems. "Scalping" is never recommended.

3. Leaving clippings on the lawn can be beneficial to the plants and save mowing time. Clippings break down quickly, which allows nitrogen and other nutrients to be recycled. Clippings can also encourage the growth of beneficial soil microorganisms. Studies show that it takes less

time to mow more often and leave clippings on the lawn than to mow less often and catch and bag clippings for disposal.

4. Keep grass clippings and leaves off of streets and out of gutters. Using a mulching lawn mower to keep lawn clippings on the lawn is especially useful. Do not use a power blower to blow clippings into the gutter.

5. Keep grass extra-long during the hot summer months to reduce water needs. Remember to decrease irrigation when implementing this practice.

6. Mowing equipment should be well maintained. Sharpen blades several times per season. Shredded or white tips of grass blades are an indication of a dull or damaged mower blade that needs sharpening. Use the operating and service instruction manual provided with the mower, and consistently perform the suggested maintenance. A competent service person should thoroughly inspect the mower on a regular basis in accordance with manufacturer specifications.

Regional or Industry Considerations/Adaptations

1. Mowing can be an effective practice for weed control in unmanicured areas.

2. For commercial lawn care maintenance companies, proper mowing can usually be accommodated on the typical 7-10 day schedule, provided that the site is not over-fertilized or over-irrigated.

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Mulching

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	
CGGA	X	WFC	
CNA	X		

Description

Use organic mulches to reduce water loss through evaporation, to reduce soil loss due to exposure to wind and runoff, to suppress weeds and to provide a more uniform soil temperature.

Basic Practice Guidelines

1. Heavily mulch planting beds with partially composted organic material in a layer three-to-four inches deep to reduce weeds, keep roots cool, keep soil moist and reduce the frequency of required watering. Also mulch tree and shrub bases as appropriate for each species.

2. Apply mulch to the soil surface, not against the plant stem or high against the base of tree trunks to minimize disease.

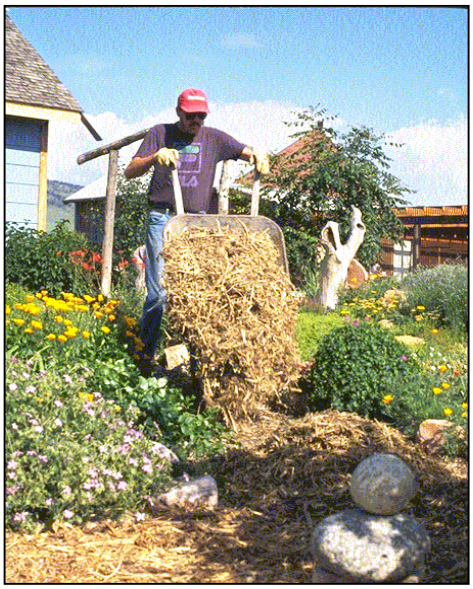
3. Organic mulch material includes bark, wood chips, chopped leaves and pine needles. Potentially appropriate inorganic mulch material includes gravel, pebbles and woven ground cloth. Fabric material can be placed underneath the mulch to reduce weeds. Some plants are better suited to inorganic mulches due to propensity to root rot, so check with nursery professionals regarding suitable mulches for specific plants.

4. Apply mulch to areas of disturbed soil to prevent erosion and sediment transport to drainageways. In areas prone to significant runoff, inorganic mulches that are less easily washed away than bark should be used.

5. Check mulched areas on a routine basis, at least monthly, and replace mulch as needed.

Mulch planted areas to help conserve water.

Source: Denver Water.



Regional or Industry Considerations/Adaptations

None identified.

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Park, Golf Course and Other Large Landscape Design and Management

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA		WFC	
CNA			

Description

Large landscaped areas such as parks and golf courses should be well designed and properly managed to be an aesthetically-pleasing environmental amenity and to minimize runoff to waterbodies.

This BMP is based primarily on "Guidelines for Water Quality Enhancement at Golf Courses Through the Use of Best Management Practices" (Wright Water Engineers and Denver Regional Council of Governments 1996).

Basic Practice Guidelines

The basic practice guidelines for large landscapes are categorized into the design, construction and maintenance phases.

Design

1. A pre-design natural resources inventory and evaluation should provide the basis for subsequent planning and design, to avoid impacts to natural resources. It is essential to include appropriate parties such as the engineer, the landscape contractor and the golf course superintendent or park manager. A full range of issues should be considered such as aquatic life, terrestrial life, riparian corridors, wetlands, open space, native and endangered species, hydrology and drainage, soils, stream standards, irrigation, stormwater, groundwater, water rights, water sources, geology, geomorphology, topography, etc.

2. Identify applicable pollutant source controls early in the design stage by taking a "management unit" approach consistent with the principles of Integrated Pest Management (IPM). Think about maintenance issues up-front as part of the design process.

3. When designing overall site drainage, use "natural" drainage practices when possible such as:

   - Preserving or enhancing natural drainages, wetlands and ponds, etc.
   - Maintaining wide, undisturbed riparian (stream) corridors.
   - Avoiding flow concentration on site and to adjacent hydrologically connected areas.
   - Site-grading to maximize infiltration in the large available pervious areas.
   - Reverse-grading in localized areas to limit direct discharges into wetlands and streams where necessary.

4. Large landscaped areas may require implementation of engineered stormwater retention facilities such as retention ponds (wet ponds) and detention basins (dry ponds). Such features should be designed in accordance with local drainage criteria regulations.

5. Utilize "edge treatments" or buffer zones of natural vegetation along ponds, waterways and riparian corridors to provide water quality protection and stormwater management benefits.

6. Uniform, dense grass buffer strips and grass-lined swales can be designed for sheet-flow conditions to treat return flows or natural runoff, improve water quality and limit the quantity of runoff, and to help protect wetland and sensitive areas from fertilizer and pesticide contamination. These features should be designed so that water does not "pond" for more than two days.

7. Structural BMPs that control runoff velocities may be required in drainages at the boundaries of golf courses or within drainages on the course. Examples include drop structures and other energy dissipaters. These BMPs help to control erosion and water quality problems associated with sediment loading.

8. Stream crossings should be minimized and, where necessary, should be designed with minimal impact. Always consult with the U.S. Army Corps of Engineers and obtain required permits when altering streams and wetlands.

9. Man-made wetlands can be incorporated into site designs to enhance water quality where soil and hydrologic conditions are appropriate.

10. Large landscape design should be based on advanced irrigation design principles. Water application rates should correspond to consumptive use requirements. Return flow reuse, stormwater reuse and use of treated wastewater effluent for irrigation should be used when environmentally, legally (e.g., water rights) and agronomically feasible. Recycled water must meet all applicable standards and not pose a health risk in accordance with Colorado Department of Public Health and Environment Water Quality Control Commission *Regulation No. 84: Reclaimed Domestic Wastewater Control Regulation*.

Construction

11. Minimize exposure of large areas to wind and water erosion by developing a grading plan that minimizes the total acres graded and left exposed without a surface protection strategy. Proper scheduling and timing are essential.

12. Minimize disturbance of areas designated for native species. Replacement of native species is more difficult and costly than species protection. Protected habitats should be isolated during construction by a barrier system (e.g., fence).

13. Seed mixes used during erosion control and stabilization during construction should be compatible with the final seeding selection for the landscape.

14. Topsoil removed during construction should be carefully stored and treated as an important resource. Berms should be placed around topsoil stockpiles to prevent runoff during storm events.

15. Appropriate sediment control measures should be implemented to minimize off-site transport of pollutants. *(See Appendix A for more information.)*

Maintenance

16. IPM should be implemented. This includes measures such as "prescriptive" pest control on a "management unit" basis; use of pest-resistant turfgrass and other plant cultivars; establishing populations of natural pest enemies; maintaining balanced turfgrass ecosystems; use of competitive species that put weeds and pests at a disadvantage; use of traps and attractants; and careful irrigation and fertilization.

17. Proper irrigation is a key component of an IPM system. Irrigation system design should consider the water resource, need for reuse, drainage requirements and water quality issues.

18. Proper fertilization is a key component of IPM. Fertilizer for each management unit should be based on soil or vegetation tests. Over-application of fertilizers can contaminate surface runoff and groundwater.

19. Landscaping and vegetative practices can reduce stormwater runoff rates and volumes, sediment loads and pollutants. A landscape and vegetation management plan should be established as part of the IPM plan.

20. A turf management plan that considers irrigation, fertilization, IPM and environmental constraints is vital to evaluate ongoing maintenance and operation.

21. Ponds and lakes require special attention to limit eutrophication. For example, runoff from fertilized areas should be controlled and in-lake management techniques such as aeration or maintaining flow-through conditions may also be required.

22. Proper storage and handling of pesticides, fertilizers, fuel and other maintenance chemicals is necessary to minimize pollutant loading. Be aware of regulatory requirements such as Community-Right-to-Know requirements, Material Safety Data Sheets (MSDS) and Spill Prevention Control and Countermeasures (SPCC) Plans for maintenance facilities.

23. Monitoring is useful to identify strengths and weaknesses of existing golf course management. Results should be used to revise management strategies.

24. Record keeping is important to document changes in turf quality, pest levels and water quality. A computerized database or spreadsheet is recommended.

25. Consult with state and local wildlife and water quality authorities on strategies for controlling water-quality impacts (e.g., fecal coliform) of high-density geese populations and burrowing animals that can damage drainage structures.

26. The best-designed BMPs will fail without regular maintenance including regular monitoring, repairs and other adjustments.

Regional or Industry Considerations/Adaptations

1. Some local governments may have landscape and stormwater control ordinances in place with specific requirements that must be followed.

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Pesticide and Herbicide Application

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Apply pesticides and herbicides at minimal levels in accordance with the label and targeted to specific disease and weed problems.

Basic Practice Guidelines

General Guidelines

1. Apply pesticides and herbicides according to the label—it's the law!

2. Apply pesticides and herbicides only when needed and use in a manner to minimize off-target effects.

3. Ensure chemical applicators receive thorough training and proper certification prior to chemical use. Individuals and companies hired to apply pesticides must be licensed in the appropriate categories by the Colorado Department of Agriculture (CDA). Limited commercial applicators and public applicators applying restricted pesticides must register with the CDA. Limited commercial applicators and public applicators not applying restricted pesticides who have submitted to the jurisdiction of the CDA, must follow all record-keeping and other procedures as established by the CDA.

4. Know characteristics of the application site, including soil type and depth to groundwater. Be aware of any drinking water wells downgradient of the operation.

5. Select pesticides and herbicides best suited to the characteristics of the target site and the particular pest or weed. Half-life, solubility and adsorption should be compared to site characteristics to determine the safest chemical. Choose least toxic and less persistent sprays whenever possible based on comparison of labels and associated material safety data sheets (MSDSs).

6. Employ application techniques that increase efficiency and allow the lowest effective application rate. Carefully calibrate application equipment and follow all label instructions.

7. Recognize that no landscape should be completely pest-free or weed-free.

8. Accurately diagnose the pest. Disease and insect symptoms can mimic each other in many plants. A fungicide will not control an insect, and an insecticide will not control a disease.

Integrated Pest Management (IPM)/Plant Health Care (PHC)

9. Use an Integrated Pest Management (IPM)/Plant Health Care (PHC) approach, integrating a variety of management tools (e.g., scouting, monitoring, cultural practices, targeted pesticide

application). The pros and cons of various tools should be weighed and used in an integrated manner to achieve pest control objectives in a safe, effective and cost-effective manner.

10. Consider spot treatments of pests rather than treating the entire area.

11. Consider pest occurrence and history when developing pest management strategies.

12. Time pesticide application to minimize host plant damage and maximize pest control.

13. Rotate annual garden plants to reduce the buildup of soil-borne pests.

14. Clean up plant litter and remove weeds before they go to seed.

15. Remove infested plant residue from the garden in the fall so that pests do not over-winter there.

16. Implement cultural controls such as proper plant selection, planting time and planting method to reduce susceptibility to insects, pests and diseases, thereby reducing pesticide usage.

17. Implement mechanical and physical controls where practical as an alternative to chemical application. Examples include a wide variety of practices such as "collars" around seedlings, mulching, solar heating, syringing, handpicking, mowing, hoeing and traps.

18. Use biological controls where appropriate to reduce pesticide usage. For example, introduce natural enemies of pests such as lady beetles and green lacewings. (Note: pesticides may kill these natural enemies.)

19. Consider applying environmentally friendly chemical alternatives such as insecticidal soaps, horticultural oils and other such measures when practical and effective.

Careful scouting for pests is a key component of integrated pest management/plant health care.

Source: Denver Water.

Application Practices

20. Do not apply pesticides or herbicides during high temperatures or windy conditions or immediately prior to heavy rainfall or irrigation.

21. Treat for and control noxious weeds prior to installing the landscape using an herbicide targeted to the weeds that are present and applied in accordance with the product label.

22. Be aware that some pesticide formulations are not compatible with other pesticides and combining them may result in increased potency and phytotoxicity.

23. Maintain a buffer zone around wells or surface water where pesticides are not applied. Consult local regulations and landscape ordinances, as well as the product label, for distances, which may vary depending on the type of chemical and the sensitivity of the waterbody. The purpose of this practice is to keep pesticides and herbicides out of surface waterbodies.

Disposal and Record-Keeping

24. Maintain records of all pesticides applied (both restricted and non-restricted use), including brand name, formulation, EPA registration number, amount and date applied, exact location of application, and name, address and certification number of applicator. Combine and file this information with irrigation water data, crop growth records and notes on effectiveness of alternative pest control measures to help identify and track measures to both save money and reduce pesticide usage.

25. Properly handle and dispose of containers, rinse water and waste. Store pesticides in secure and covered areas. Never pour lawn and garden chemicals down storm drains or sanitary drains and keep off impervious surfaces during application. Use local recycling centers to dispose of chemicals. (*See the Pesticide, Fertilizer and Other Chemical Storage, Handling, and Disposal BMP for more information.)*

Regional or Industry Considerations/Adaptations

1. See the Production Practices for Nurseries, Greenhouses and Growers BMP for more detailed guidance for these industries.

2. Be familiar with existing state and federal regulations on pesticide application, certification and weed control, as well as CSU Cooperative Extension horticultural guides. Several federal and state laws control the handling, storage, application, disposal and reporting of chemical spills. Examples include the Colorado Pesticide Applicator's Act, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the Superfund Amendments and Reauthorization Act (SARA), the Emergency Planning and Community-Right-to-Know Act (EPCRA) and Occupational Safety and Health Administration (OSHA) requirements, particularly the Hazard Communication Standard. The Colorado Water Quality Control Act (25-8-601 and 25-8-606) also contains requirements for notification of the Colorado Water Quality Control Division of spills and accidental discharges and provides the Division with the authority to

order cleanups. It may also be necessary to file information with the local fire department based on these and other laws.

3. Senate Bill 90-126, The Agricultural Chemicals and Groundwater Protection Act, identifies special requirements for facilities handling more than 3,000 pounds (or 500 gallons) of bulk-formulated pesticides. Even if this threshold is not reached, the general principles of this act provide good guidance for pesticide users.

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Pesticide, Fertilizer and Other Chemical Storage, Handling and Disposal

BMP Type	
Design	
Installation	
Maintenance/Operation	X

Green Industry Relevance			
ASLA		GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Pesticides, herbicides, fertilizers, fuel and other maintenance chemicals must be properly applied, stored, handled and disposed of to prevent contamination of surface water and groundwater. Misuse of pesticides and herbicides can result in adverse impacts to aquatic life, even at low concentrations. Misuse of fertilizer can result in algae overgrowth in waterbodies due to excessive phosphorus and nitrogen loading.

Basic Practice Guidelines

Application and Handling

1. Apply fertilizers, pesticides and other chemicals according to manufacturer's directions. The label is the law for pesticide usage. *(See the Pesticide Application and Fertilizer Application BMPs for more discussion on proper application.)*

2. Keep pesticide and fertilizer equipment properly calibrated according to the manufacturer's instructions and in good repair. Recalibrate equipment periodically to compensate for wear in pumps, nozzles and metering systems. Calibrate sprayers when new nozzles are installed.

3. All mixing and loading operations must occur on an impervious surface.

4. To prevent possible backflow and contamination of a water supply, never submerge a water supply hose in a chemical tank or container. Provide proper backflow prevention devices where required by the Colorado Plumbing Code.

5. Do not apply pesticides during high temperatures or windy conditions.

6. Avoid application of any pesticide, herbicide or fertilizer immediately prior to forecasted or inclement heavy rainfall or irrigation that would result in runoff of the chemicals.

7. Keep records of pesticide application and provide signage as required by law.

Storage

8. Storage areas should be secure and covered, preventing exposure to rain and unauthorized access. Basic safety equipment such as fire extinguishers, warning signs (e.g., "no smoking"), adequate light and ventilation and spill clean-up materials should be present. Floors and shelves should be non-porous (e.g., metal, concrete) to prevent sorption of chemicals. If possible, temperature control should be provided to avoid excessive heat or cold. Storage areas should be kept clear of combustible material and debris.

9. Many above-ground fuel storage tanks require a concrete enclosure (secondary containment) in the event of a tank rupture. Also, greenhouses and nurseries that are storing recycled water laden with fertilizer often are required to do the same.

10. Store nitrate-based and other oxidizing fertilizers separately from solvents, fuels and pesticides to reduce fire risk. Follow the general principle of storing like chemicals together.

11. Store chemicals in their original containers, tightly closed, with labels intact. Also inspect them regularly for leaks.

12. Dry chemicals should be stored above liquids and on pallets to ensure that they do not get wet.

13. Locate chemical storage and maintenance areas, as well as vehicle refueling and maintenance areas, away from wells and surface waterbodies in accordance with local regulations, typically at least 50 to 100 feet away.

14. Make available all Material Safety Data Sheets (MSDSs) in a readily accessible area. A list of all hazardous chemicals in the work place must be completed to ensure that all MSDSs are readily available.

15. Do not store large quantities of pesticides for long periods of time. Adopt the "first in-first out" principle, using the oldest products first to ensure that the shelf life does not expire. Buy smaller quantities of pesticides and fertilizers, thereby reducing storage issues.

Spills and Disposal

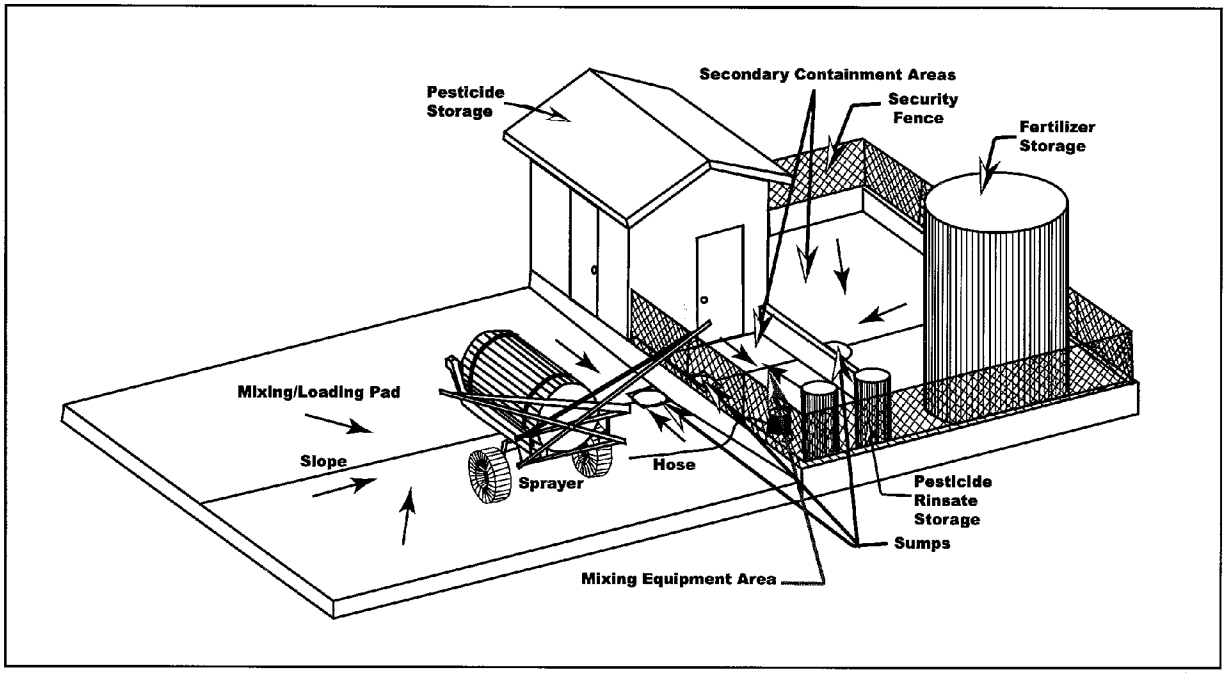
16. Keep chemical spill cleanup equipment, personal protective equipment and emergency phone numbers available when handling chemicals and their containers.

17. Properly manage chemical spills by cleaning them up as soon as possible, controlling actively spilling or leaking materials, containing the spilled material (e.g., with absorbents, sand), collecting the spilled material, storing or disposing of the spilled material, and following relevant spill reporting requirements. “Washing down” a spill with water is not an appropriate cleanup approach.

18. Basic spill reporting requirements include: name, address and phone number of person reporting and of person responsible for release; date and time; type, name and estimated amount of substance released; location/address of released substance; size/description of affected area; containment/cleanup actions taken; and other agencies/persons contacted.

19. Never pour lawn and garden chemicals or rinse water down storm drains (or sanitary drains) and keep chemicals off of impervious surfaces (e.g., streets, gutters) during application. Use local recycling centers to dispose of chemicals.

20. Follow label directions for disposal. This typically involves triple-rinsing empty containers, puncturing and crushing. All visible chemicals should be cleaned from the container prior to disposal.



Example: Suggested design for a combination mixing and storage area for pesticide and fertilizer handling which would meet Colorado regulations.

Source: Designing Facilities for Pesticide and Fertilizer Containment. (MWPS-37)
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Regional or Industry Considerations/Adaptations

1. Be familiar with existing state and federal regulations on pesticide application, certification and weed control, as well as CSU Cooperative Extension horticultural guides. Several federal and state laws control the handling, storage, application, disposal and reporting of chemical spills. Examples include the Colorado Pesticide Applicator's Act, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the Superfund Amendments and Reauthorization Act (SARA), the Emergency Planning and Community-Right-to-Know Act (EPCRA) and Occupational Safety and Health Administration (OSHA) requirements, particularly the Hazard Communication Standard. The Colorado Water Quality Control Act (25-8-601 and 25-8-606) also contains requirements for notification of the Colorado Water Quality Control Division of spills and accidental discharges and provides the Division with the authority to order cleanups. It may be necessary to file information with the local fire department based on these and other laws.

2. Colorado Senate Bill 90-126, The Agricultural Chemicals and Groundwater Protection Act, identifies special requirements for facilities handling more than 3,000 pounds (or 500 gallons) of bulk-formulated pesticides. Even if this threshold is not reached, the general principles of this act provide good guidance for pesticide users.

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Plant Selection and Placement

BMP Type			
Design			X
Installation			
Maintenance/Operation			
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Select appropriate plants for the site, place plants in appropriate locations and group plants according to similar water needs (i.e., "hydrozoning").

Basic Practice Guidelines

1. Select plants that are well adapted to the climate, topographic and geologic conditions of the site. Native plants and plants with documented lower water requirements should be given priority in landscape design.
2. Choose plants with lower water requirements for areas with southern and western exposures.
3. Group plants together that have the same water requirements. Plants located within the drip line for large trees and shrubs should have water requirements similar to the trees and shrubs.
4. Preserve existing healthy trees—established plants have often developed a root system that is adapted to lower water conditions. Preserving healthy trees means following industry standards to protect canopies, trunk and critical root zones during construction and when modifying the landscape.
5. Remove species that are designated state noxious weeds, especially ornamental species such as purple loosestrife, oxeye daisy, tamarisk, myrtle spurge and yellow toadflax. (See www.ag.state.co.us/DPI/weeds/weed.html for a complete listing of such weeds.)
6. Determine water requirements for all existing landscape plants and water accordingly.
7. Consider using plants with low water requirements. Information on water requirements for various plants can be obtained from the GreenCO website (www.greenco.org).
8. When selecting plants, consider factors such as the size of the area to be covered, soil type, exposure conditions, steepness of slope, pedestrian traffic, area usage, drainage conditions and maintenance requirements along with the aesthetic desires.
9. A good rule of thumb is to place plants with higher water use in lower-lying drainage areas, near downspouts or in the shade of other plants.
10. On steep slopes, select plant species that produce dense, fibrous roots to help prevent soil erosion. Maintenance safety issues should also be considered in selecting plants for these areas. For example, mowing may not be safe on steep slopes; therefore, alternatives to manicured turf should be explored.

11. A temporary "nurse crop" of grasses and legumes may be required to provide immediate soil stabilization on steep slopes. Consult with the Natural Resources Conservation Service, CSU Cooperative Extension Service or the Colorado State Forest Service for information to avoid planting overly aggressive species that may compete with permanent ground cover.

12. A variety of grass species exist, so it is also important to select the appropriate grass for the intended use. Consider using improved blends and mixes that with lower water requirements. For example, buffalo grass works well in low-use areas. Tall fescue grows deep roots and requires less irrigation when planted on well-prepared soils. Tall fescue also tolerates wear and tear from children playing. Kentucky bluegrass is excellent for high use areas. (See http://www.turfgrasssod.org/trc/grass.html for characteristics of various grasses.)

Thoughtful plant selection, placement and maintenance contribute to a water efficient, aesthetically pleasing landscape.

Source: Denver Water.

Regional Considerations and Industry Adaptations

1. Nurseries and garden centers can help promote use of lower-water-requiring plants by providing a good selection of plants that are drought-tolerant or require less water and by educating customers on the value of selecting these plants.

2. In mountain areas, consider length of growing season, soil and exposure before selecting plants. Select these shrubs from northern sources, when possible, and plant these shrubs in the spring. Ground covers in mountain areas may take two to three years to become established. See the Colorado State University Cooperative Extension (1998) Yard Gardening Series publications "Ground Covers for Mountain Communities (no. 7.413)" and "Shrubs for Mountain Communities (no. 7.407)" by J.R. Feucht for lists of species appropriate to mountain areas.

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Production Practices for Nurseries, Greenhouses and Growers

BMP Type			
Design			
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA		GCC	
ALCC		ISA	X
CALCP		RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Nurseries, greenhouses and other growers should implement a variety of source, structural, cultural and managerial controls to minimize pollution of water resources. Irrigation practices that minimize off-site transport of pollutants also typically conserve water.

This BMP is based primarily on and is condensed from "Pollution Prevention in Colorado Greenhouses, XCM-206" (Colorado State University Cooperative Extension, 1998).

Basic Practice Guidelines

1. Manage irrigation to minimize transport of chemicals from the soil surface or immediate crop root zone and to conserve water. Follow these key practices:

   - Schedule irrigation according to crop needs and growing-medium water depletion. Watering requirements will vary and should be adjusted based on time of year, weather, methods of storage and type and stage of the plant (e.g., dormancy). Plants need less water during cool, rainy weather than during hot, dry, windy weather.

   - Upgrade irrigation equipment to improve application efficiency. For example, a computerized irrigation scheduler using a drip system can reduce overwatering and excessive leaching compared to an overhead system.

   - Implement closed irrigation techniques (water recycling system) whenever water rights and site constraints allow. (Note: recycled water should be ozonated or otherwise treated to remove pathogens from the water to prevent spread of disease.)

   - Reduce water application rates to ensure no runoff or percolation occurs during chemigation.

   - Group plants together that have the same water requirements (i.e., use hydrozoning).

   - When ball-and-burlapped stock and containerized stock is received, it should be kept out of the wind and sun. Ideally, balls should be covered with moisture-retaining materials such as sawdust or wood chips if stock will be stored for a long time.

   - Plug sprinkler heads that are not watering plants, keep sprinkler heads as low as possible to the plants and use larger water droplet size to reduce irrigation time.

   - Proper backflow prevention devices are necessary to prevent cross-contamination of public water supplies. This is particularly critical if chemigation is used.

2. Use integrated pest management (IPM)/plant health care (PHC) in pest control decisions. This integrated approach keeps pests and their damage at acceptable levels. Follow these key practices:

    - Host Resistance: Select crops and plant varieties with few insect and disease problems.

    - Eradication/Sanitation: Remove and dispose of diseased plants or plant parts. Also, properly disinfect tools and other equipment.

    - Avoidance: Avoid introduction of plant diseases by procuring disease-free plant material and isolating, inspecting and treating newly arrived plants.

    - Cultural Practices: Implement practices that create an unfavorable environment for disease development. Some key practices include:

        - Avoid overhead irrigation and frequent, light watering to reduce leaf spot diseases caused by many fungal and bacterial pathogens.

        - Do not extend the period of leaf wetness beyond 12 hours to reduce disease problems.

        - Time pesticide application to minimize host plant damage and maximize pest control.

        - Continually monitor all stock for signs of insect or disease problems.

        - Spot-treat problem areas, rather than the entire greenhouse or nursery.

        - Improve plant vigor and pest tolerance by supplying adequate light, nutrients and water and by adjusting the greenhouse environment for optimum growth. It is important to monitor the nutrient needs of plants in nurseries. A newly containerized plant may need to have nutrients added. A container shipped from a grower and held in nursery for more than one season, may need additional nutrients.

    - Crop Rotation: Rotate crops in greenhouses and nurseries to prevent the spread of disease.

    - Implement Chemical Alternatives: Only about 10 percent of plant diseases in Colorado require chemical controls. Use the controls described above plus beneficial insects and other biological controls whenever possible.

3. Apply pesticides only when needed and use in a manner to minimize off-target effects. Follow these key practices:

    - Always follow the label—it's the law!

    - Ensure chemical applicators receive thorough training and proper certification prior to chemical use.

- Know characteristics of the application site, including soil type and depth to groundwater under the greenhouse or nursery. Be aware of any drinking water wells downgradient of the operation.

- Compare chemical leaching hazard, persistence and toxicity to site-specific conditions to determine suitability of the pesticide at each location.

- Be aware that some pesticide formulations are not compatible and may result in increased potency and phytotoxicity.

4. Maintain records of all pesticides applied (both restricted and non-restricted use), including brand name, formulation, EPA registration number, amount and date applied, exact location of application, and name, address and certification number of applicator. Combine this information with irrigation water data, crop growth records and notes on effectiveness of alternative pest control measures to help identify and track measures to both save money and reduce pesticide usage.

5. Protect groundwater and surface water from spills and leaks of pesticides by properly designing pesticide storage, mixing and loading facilities. Follow these key practices:

   - Store all pesticides in a locked building with cement floors, located at least 100 feet away from any water supply.

   - Equip storage facilities with secondary containment dikes designed to contain liquid spills or leaks.

   - Use impermeable mixing/loading pads at pesticide loading sites.

   - Make material safety data sheets (MSDSs) available at the mixing station.

   - Provide worker safety features such as showers, protective clothing and spill cleanup kits in accordance with MSDS requirements.

6. Protect wellheads from potential sources of contamination. Follow these key practices:

   - Regularly inspect and maintain wells.

   - Install backflow prevention devices.

   - Stay at least 100 feet away from the well when mixing, loading and storing agricultural chemicals.

   - Monitor well water quality periodically and know site-specific variables affecting aquifer vulnerability.

7. Protect surface water from contaminated runoff. Follow these key practices:

- Recover irrigation water and store it in impermeable tanks or reservoirs.
- Keep greenhouse open runoff channels, condensate gutters and reservoirs separate from rainwater flows and catchment basins to prevent contamination of surface runoff.
- Keep roof and site drainage directed away from greenhouse structures and separated from spill containment structures for petroleum, fertilizers and pesticides.
- Monitor surface water periodically to determine whether pollution is occurring.

Regional or Industry Considerations/Adaptations

None identified.

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Regulatory Awareness

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	X
CNA	X		

Description

A variety of local, state and federal environmental regulations impact landscaping and nursery operations. Green Industry professionals should be aware of these regulations and comply with their requirements.

Basic Practice Guidelines

Green Industry professionals should be aware that environmental regulations apply to a variety of activities. See Appendix C for a list of specific regulations with contact information. Potential regulatory issues include the following:

1. Pesticide Application, Handling and Disposal—state and federal regulations mandate specific requirements and certifications for those applying, handling and storing pesticides. Regulations also exist for reporting spills of these chemicals.

2. Riparian Buffer Zones—local regulations may limit disturbance of riparian areas along streams or near wetlands. This is typically in the form of a "setback" requirement, which may vary considerably (e.g., 25 to 200 feet) based on local conditions.

3. Wetlands—Section 404 of the federal Clean Water Act restricts the dredging and filling of jurisdictional wetlands. Consult with the local U.S. Army Corps of Engineers prior to initiating any activity that affects wetlands.

4. Stormwater Management/Erosion and Sediment Control—the Phase II stormwater regulations require a discharge permit for construction activities disturbing one acre or more. Local permits may also be required for land disturbance. Landscape contractors should work with the general contractor and/or civil engineer to ensure that requirements of state and local permits are met, particularly with regard to erosion and sediment control during construction. Additionally, permanent engineered stormwater management facilities (e.g., retention ponds, wetlands, infiltration basins) may be required aspects of landscape design.

5. Groundwater Protection—Particularly in areas overlying shallow groundwater, regulations may exist that require special precautions when applying chemicals or including ponds as part of landscape and stormwater management features (e.g., retention ponds, detention ponds, infiltration basins).

6. Noxious Weeds—State and county regulations are in place regarding control of noxious weeds. (See www.ag.state.co.us/DPI/weeds/weed.html for a complete listing of such weeds and to contact the county weed coordinator.)

7. Water Rights—Always check with the landowner to ensure that adequate water supplies/water rights are in place prior to installing water or irrigation-dependent landscape

features. The Colorado State Engineer's Office administers water rights under the "prior appropriation" doctrine in Colorado.

8. Landscaping Ordinances—Some local governments in Colorado have landscaping ordinances in place, which specify the types of landscaping and irrigation practices that are acceptable. Before designing a landscape or irrigation system, check with local authorities to determine applicable requirements. Guidelines associated with these ordinances may be helpful in selecting appropriate plant species for a site.

9. Backflow Prevention—Backflow prevention devices are required for irrigation systems to prevent cross-contamination of municipal water supplies. See the Colorado Unified Plumbing Code for guidance.

10. Cross-connection Controls—Cross-connection controls are required for irrigation systems using reclaimed or non-potable water.

11. Fire—Local fire departments may prescribe landscape practices near fire hydrants and in fire-prone areas.

12. Wildlife—Local "overlay" districts may affect landscaping with regard to certain wildlife species. Additionally, some habitats may be protected through the federal Endangered Species Act and the Migratory Bird Treaty Act, as administered by the Colorado Division of Wildlife and the U.S. Fish and Wildlife Service. Contact these agencies for specific information.

13. Utilities—Landscaping must conform to local requirements with regard to utilities such as power line rights-of-way and locating underground utilities prior to excavation.

14. Other—A variety of other regulations may exist that do not directly pertain to water resources (e.g., air regulations, public safety, frontage setbacks) and are not included in this list.

Regional or Industry Considerations/Adaptations

1. Local regulations may vary and should be considered prior to landscaping activities. Mountain areas where sensitive streams (e.g., trout fisheries) are present or areas that are particularly drought-prone may have stricter regulations than some Front Range communities.

Key References

See Appendix C for a detailed list of references and contacts.

Retail Practices for Nurseries, Greenhouses and Garden Centers

BMP Type	
Design	
Installation	
Maintenance/Operation	X

Green Industry Relevance			
ASLA		GCC	X
ALCC		ISA	X
CALCP		RMSGA	X
CGGA	X	WFC	X
CNA	X		

Description

Retail businesses should operate in a manner to maintain the health of plants, to conserve water and to promote water conservation and water resource protection to the general public.

Basic Practice Guidelines

1. Group plants together that have the same water requirements (i.e., use hydrozoning) and water accordingly.

2. Schedule irrigation according to plant needs and growing-media water depletion. Watering requirements will vary and should be adjusted based on time of year, weather, methods of storage and type and stage of the plant (e.g., dormancy). Plants need less water during cool, rainy weather than during hot, dry, windy weather.

3. Properly educate retail employees on the water needs of various plants so that both over-watering and under-watering are minimized.

4. Upgrade irrigation equipment to improve application efficiency.

5. Promptly repair leaking irrigation equipment—including hoses, bibs and couplings. Don't leave hoses running on the ground.

6. Implement closed irrigation techniques (water recycling system) whenever water rights and site constraints allow. Treat for water-transmitted root disease organisms before using recycled water for irrigation.

7. Plug sprinkler heads that are not watering plants, keep sprinkler heads as low as possible to the plants and use larger water droplet size to reduce irrigation time. Preventing water from being wasted on pathways not only saves money, but also reinforces water-wise practices to the visiting public.

8. Avoid introduction of plant diseases by procuring disease-free plant material and isolating, inspecting and treating newly arrived plants.

9. Implement cultural practices that create an unfavorable environment for disease development. For example, avoiding overhead irrigation and frequent, light watering can reduce spot diseases.

10. Protect plant vigor and pest tolerance by supplying adequate light, nutrients and water.

11. Offer plants with lower water requirements or those adapted to local conditions and appropriately identify them in displays.

12. Be properly educated about the water requirements of plants when communicating with the public and recommend plants with lower water requirements or those native to local climate conditions. Don't be fooled by marketing campaigns touting low-water usage or native plants without the data to back up their claims.

13. Follow proper storage and handling requirements for pesticides and fertilizers. In cases of containers breaking or leaking, follow manufacture's directions for cleanup and disposal. See the *Pesticide, Fertilizer and Other Chemical Storage, Handling and Disposal BMP* for additional guidelines.

14. In the event of broken bags of compost and soil, sweep up spilled materials and dispose of them rather than washing them into the gutter.

15. Consider establishing displays, signage, information brochure distribution shelves, or pilot-demonstration test sites for the purposes of effectively educating the public on water conservation and water quality protection practices.

Regional or Industry Considerations/Adaptations

None identified.

Key References

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Revegetation of Drainageways

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA		WFC	
CNA			

Description

Establishing a robust vegetation cover is critical to the proper functioning of engineered drainage structures such as grass-lined channels, detention basins, retention ponds and wetlands. Vegetation serves multiple purposes, including stabilizing structures to prevent excessive erosion and removing pollutants from stormwater. Because of the semi-arid nature of Colorado's climate, prevalence of introduced weeds and variety of soil types, prompt implementation of a revegetation plan is critical if revegetation is to be successful.

This BMP has been adapted directly from the Urban Drainage and Flood Control District's Storm Drainage Criteria Manual, Volume 2, "Chapter 12 Revegetation" (UDFCD 2001).

Basic Practice Guidelines

When landscaping engineered drainage facilities, Green Industry professionals should work closely with the engineer responsible for the facility design. A planting plan should be developed and followed that addresses soil bed preparation; plant species, types and sizes to be used; planting methods; mulching and fertilization; and a planting schedule. The basic practice guidelines below are categorized according to plant selection, site preparation, seeding and planting and maintenance.

Plant Selection

1. The form(s) of vegetation and species used should be adapted to the soil and moisture conditions and use of the area (e.g., conveyance of flow, side slopes, etc.). The bottom, side slopes and areas immediately adjacent to a facility have differing moisture regimes that should be taken into consideration. Different plant forms (e.g., grasses, shrubs and trees) may also be limited to specific areas to enable proper functioning of the facility. For example, planting trees and shrubs along the bottom of a channel can reduce the hydraulic capacity of the channel, increase maintenance requirements and cause the plugging of downstream bridges and culverts when uprooted by higher flows.

2. Native, perennial species should be used to the extent possible.

3. Use of plant species requiring irrigation and high maintenance should be avoided except along maintained park settings or where other uses dictate such maintenance.

4. Sod-forming grasses are preferred over bunch grasses.

5. Use containerized nursery stock for wetland, tree and shrub plantings to the extent feasible.

6. The Urban Drainage and Flood Control District recommends that wetland plantings should not include cattails because they tend to proliferate and out-compete other wetland species. If plants are to be purchased, it is more desirable to select a variety of wetland species that will flourish such as sedges, rushes, etc., if cattails are not initially introduced. (Note: other resource agencies may have different recommendations regarding cattails.)

7. Maintenance requirements should be considered in plant selection (e.g., tall grasses should not be used in urban areas unless regular mowing will occur).

8. Live stakes, willow bundles and cottonwood poles should be obtained from local, on-site sources, whenever possible.

Site Preparation

9. All areas to be planted should have at least 6 inches of topsoil suitable to support plant growth. Native topsoil should be stripped and saved for this purpose whenever a site is graded.

10. The upper 3 inches of the soils in areas to be seeded should not be heavily compacted and should be in a friable condition. An 85 percent standard proctor density is acceptable.

11. When necessary, soil amendments should be added to correct topsoil deficiencies (e.g., soil texture, pH or percent organic matter). (If topsoil and native seed mixes are used, fertilizer is often not needed.)

12. Fertilizer and other amendments should be used if specified by a soil analysis. Slow-release (controlled-release) type fertilizers should be used to reduce weed growth and protect water quality. Fertilizer should be worked into soil during seedbed preparation.

Seeding and Planting

13. Seed mixtures should be sown at the proper time of year specified for the mixture.

14. Seed should be drill seeded, whenever possible. Broadcast seeding or hydro-seeding may be substituted on slopes steeper than 3(H):1(V) or on other areas not practical to drill seed.

15. Seeding rates should be doubled for broadcast seeding or increased by 50 percent if using a Brillion drill or hydro-seeding.

16. Broadcast seed should be lightly hand-raked into the soil.

17. Seed depth should be ¼ to ½ inch for most mixtures.

18. All seeded areas should be mulched and the mulch should be adequately secured.

19. If hydro-seeding is conducted, mulching should be conducted as a separate, second operation.

20. All containerized nursery stock should be kept in a live and healthy condition prior to installation.

21. Containerized trees and shrubs should be installed properly to ensure success.

22. Live stakes, poles and willow bundles should be installed when dormant (late winter and early spring) according to the planting details provided by the UDFCD (2001).

23. Beaver protection should be provided for trees and shrubs for species known to be attractive to beavers if beavers are known to be in the area.

Maintenance

24. Sites should be routinely inspected following planting to implement follow-up measures to increase success. Immediate attention to a problem (e.g., weed infestation, failure of seed to germinate) can prevent total failure later.

25. Access to and grazing on recently revegetated areas should be limited with temporary fencing and signage while plants are becoming established (normally the first year).

26. Weed infestations should be managed using appropriate physical, chemical or biological methods as soon as possible.

27. Stakes and guy wires for trees should be maintained. Dead or damaged growth should be pruned.

28. Beaver protection cages should be used around tree plantings.

29. Mulch should be maintained by adding additional and redistributing mulch, as necessary.

30. Areas of excessive erosion should be repaired and stabilized.

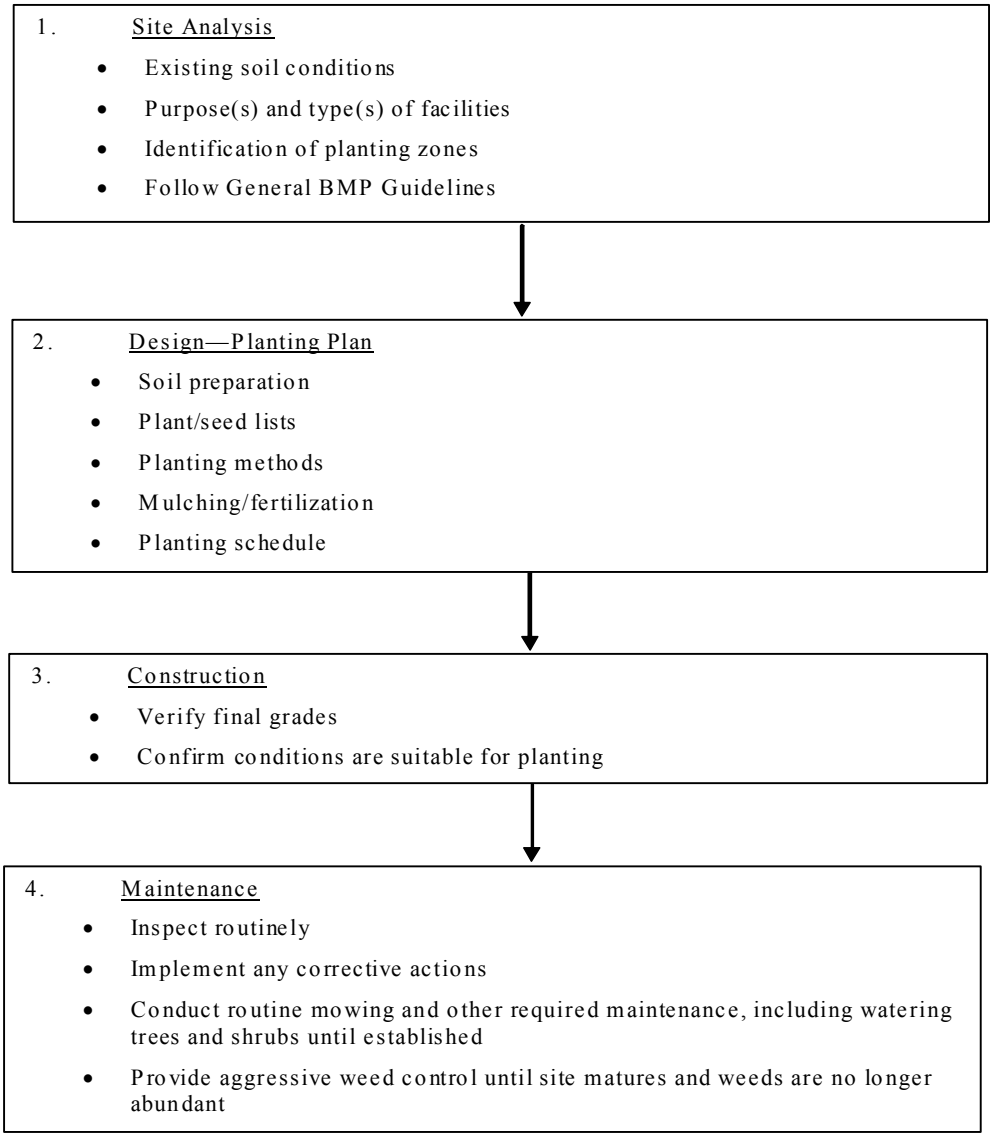
31. Planted trees and shrubs should be watered as needed from April through September until established.

Regional or Industry Considerations/Adaptations

1. See local Colorado State University Cooperative Extension office, the Natural Resources Conservation Service or other local government recommendations for seed mixes and revegetation species.

Revegetation Process Flow Chart

(Adapted from UDFCD 2001)



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Riparian Buffer Preservation

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	
ALCC	X	ISA	X
CALCP	X	RMSGA	
CGGA		WFC	
CNA			

Description

Preserve wide, undisturbed natural riparian areas along streams. These buffers help protect water quality by filtering pollutants, sediment and nutrients from runoff and aid in flood control, streambank stabilization and stream temperature control.

Basic Practice Guidelines

1. Protect and retain existing riparian vegetation whenever possible. Consider enhancing the existing buffer area by planting site-appropriate, native plants. Make the natural riparian area an integral part of the site design.

2. Clearly mark the riparian area to be protected on landscape plans. Generally, when landscaping in a riparian area do not clear existing vegetation, disturb soil by grading or stripping, or fill in these areas. Exceptions may include removal of dead/diseased vegetation, stream restoration and stabilization activities, installation of stormwater BMPs, etc.

3. Plan site drainage so that the hydrology of the riparian buffer area is maintained.

4. Restore natural vegetation in riparian areas whenever possible when it has been disturbed by development.

5. Check local regulations for buffer setback requirements, typically ranging from 25 feet to more than 100 feet. Features such as erodable soils, unstable streambank conditions, steep slopes, presence of a wildlife migration corridor, poor vegetative cover, property usage involving hazardous materials, etc., may warrant larger setbacks. Permits may be required to disturb land within the setback requirement.

6. Clearly specify landscape maintenance practices that are acceptable within buffer zones. For example, the use, storage and application of pesticides are generally not appropriate for these areas, with a few exceptions such as spot spraying of noxious weeds. Landscape maintenance equipment (e.g., mowers) should not be maintained in these areas.

7. Manage the riparian buffer canopy to maintain maximum vigor of the overstory and understory.

Regional or Industry Considerations/Adaptations

1. Land development in the Rocky Mountains is occurring rapidly. Because of the terrain associated with this mountainous area, most of the development occurs along valley floors. This growth pattern focuses development around streams, rivers, wetlands and lakes. Without adequate planning and management, development around these water features can degrade water quality, water quantity (pre-development hydrology) and riparian habitat.

Preserving undeveloped riparian corridors in high mountain valleys is an important commitment to help protect water quality and aquatic life.

Preservation of wide, undisturbed riparian corridors helps to protect water quality.

Source: Wright Water Engineers, Inc.

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Soil Amendment/Ground Preparation

BMP Type			
Design			
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Evaluate soil and improve it, if necessary, to promote efficient water usage and healthy plants.

Basic Practice Guidelines

1. The best soils for growing plants are uniform in texture throughout the root zone and have a good balance of minerals, air and organic matter. Soil improvement is a continual process.

2. Test soils frequently and especially prior to planting to identify the correct amount and type of nutrients—only apply nutrients the plants can use. Before adding nutrients to the soil, it is good practice to determine first whether a problem is due to inadequate nutrition or a physical soil property such as poor texture.

3. Ideally, improve soil before planting and installing the irrigation system.

4. Add proper organic matter to the soil, as indicated by soil analysis, to increase the water-holding capacity and plant productivity. If a soil is too sandy or too high in clay, the solution to both extremes is basically adding organic matter.

5. Proper soil and ground preparation is critical to the success of a lawn or garden. A rule of thumb is to work 3 to 5 yards of organic matter into the soil to a depth of at least 4 to 6 inches for every 1,000 square feet of area to be seeded, planted or sodded. (Note: Many experts recommend cultivating the soil to a depth of 12 inches; however, in many situations, this cannot be achieved practically.) See http://www.turfgrasssod.org/trc/soilprep.html for more detailed soil preparation guidance.

6. Some composts and manures are high in salts and have a high pH. Avoid horse manure, which contains seeds for weeds and undesirable grasses unless it is well composted. Also avoid cattle manure because it is high in salt and fine textured. These precautions are particularly important for soils already high in salts, or when growing salt-sensitive species. Sphagnum peat and compost from purely plant sources are low in salts and good choices for such locations.

7. When soil tests indicate that salts are a problem, this should be corrected (if possible) prior to planting. In situations where this problem cannot be corrected, select plants tolerant of the salt conditions.

8. Soil pH is important in determining which plants are appropriate and may also affect the plants' fertility and responses to fertilization. Soil testing should be performed to obtain an initial pH, phosphorus and nitrogen level, organic matter content and soluble salt level.

When establishing irrigation rates, take into consideration the water holding capacity of soil.

Source: Stephen Smith, Aqua Engineering.

9. When planting balled-and-burlapped or container stock, avoid soil interface problems by amending the backfill slightly (up to one-third) to provide a transition between the soil in the root ball and the surrounding soil. Scarify or break up the soil on the sides of the hole to help in this transition.

10. Information on soil water uptake rates, water holding capacity and maximum allowable depletion are needed to establish appropriate irrigation rates.

11. Liquid soil treatment products are not a substitute for soil amendments.

12. Wood products (e.g., sawdust, bark) used as soil amendments can result in nitrogen deficiency in plants.

13. Aerate the lawn and cultivate planting beds periodically, to decrease compaction and improve penetration of water, air and nutrients into root zones.

Regional or Industry Considerations/Adaptations

1. Consider regional soil conditions when determining watering requirements. See Swift (2001) "Watering Established Lawns in Western Colorado, Colorado State University Cooperative Extension Tri-River Area" for recommendations for water requirements for soils in western Colorado.

2. See the Turf Management BMP for information on working with alkaline and high salt soils.

3. The only soils that can benefit from adding gypsum are sodic (sodium absorption ratio greater than 15) or black alkali soils, which are typically found where there is a high water table and poor drainage.

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Turf Management

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	
ALCC	X	ISA	
CALCP	X	RMSGA	X
CGGA		WFC	
CNA			

Description

Plan, properly install and maintain practical turf areas. Healthy, properly maintained turf can reduce stormwater runoff rates and volumes, sediment and pollutant loads, reduce heat island effects and provide other environmental benefits.

Basic Practice Guidelines

Design

1. Design and allocate appropriate space for turf areas based on desired functional, recreational and/or aesthetic benefits.

2. Select turfgrass species that will best meet the requirements and purposes of the lawn area. Areas that receive wear and tear will require sod-forming species such as Kentucky bluegrass. Areas that are difficult to mow, or are only for visual appeal, may be appropriate for slower-growing, lower maintenance, lower-water-requiring species such as buffalograss or blue grama. Soil conditions, such as soluble salt level, should also be taken into consideration when selecting turfgrass species.

3. Consider turf alternatives for some areas (e.g., narrow strips, hard-to-water areas, steep slopes, low-usage areas) such as native or low-water-use plantings, patios, decks or mulches or low-water turfgrasses, when these alternatives meet the needs of the area and do not create a negative environmental impact.

4. When considering lower-water-requiring alternatives to Kentucky bluegrass, base turf selection on the results of a soil analysis. In sandy soils in particular, some alternative species do not perform as well.

5. When possible, avoid placing turf in long narrow areas, on steep slopes, hard-to-maintain corners and isolated islands due to difficult mowing and irrigation challenges. Turf is better suited to larger, relatively flat areas.

6. Good surface drainage can be achieved by sloping the lawn away from buildings and properly grading low areas and steep slopes to prevent future trouble spots. Where appropriate, grade to allow water-harvesting techniques.

Installation

7. Although turf can be established from seed or sod, sod provides the additional benefits of lower initial water use, quick establishment and the ability to handle heavy rains with less susceptibility to erosion. (See http://www.rockymountainsodgrowers.com/install.html for more detailed sod installation guidance.)

8. Prepare the site prior to the arrival of the sod.

    - Remove weeds and debris.
    - Establish a rough grade and eliminate low spots.
    - Spread and rototill a minimum of three cubic yards of organics per 1,000 square feet at least four inches deep.
    - Level and rake the installation site until it is smooth.
    - Grade areas along sidewalks and driveways approximately one and one-half inches below top of concrete.

9. Have on site all hoses and sprinklers for the initial watering.

    - Make sure sprinkler system is performing properly.
    - Understand the operation of the sprinkler clock for proper watering of the new and established lawn.

10. Order sod to be delivered once site is prepared and the sprinkler system is understood and operating properly.

11. Install the sod immediately after delivery.

    - Arrange the rolls so there is a minimum amount of traffic on the prepared soil and the newly installed grass.
    - Lay sod in a horizontal brick pattern.

    - Once an area of approximately 15 feet by 15 feet has been laid, rolled and fertilized, water immediately. The objective is not to let the sod dehydrate.
    - Butt ends and sides of the sod strips making sure there is no overlapping.
    - Fit the sod around obstacles or in smaller places by merely cutting the dirt side with a sod knife.

12. Water properly, as follows:

- Once all the sod is laid, begin watering to build up the sub-soil moisture. This is the most critical time to apply water. Up to one-half inch of water per day for the first two to three days may be required. Probe the soil to determine if the moisture has penetrated at least four inches.

- During the following two weeks, the amount of water needed will be similar to the chart below. Each day may require more than one application depending upon wind and temperature. The reason for several light applications is to keep the root zone and blades moist.

- Week three is used as a transition period from daily watering with frequent applications per day to an increased number of days between watering. During this time the grass should be ready for routine maintenance. By the end of the establishment period, the grass should be able to go several days between waterings depending on the season and weather.

13. After initial three weeks, adjust watering times and sprinkler clocks to conform to any water restriction program in your area.

14. When starting a lawn from seed, amend the lawn in a manner similar to sod and work in a starter fertilizer at the rate recommended on the label. Frequent, light waterings are needed until the seed has germinated and should then be reduced.

Maintenance

15. The approximate amount of water that needs to be applied each week for an average, traditional lawn to supplement normal rainfall is listed in the following chart:

Approximate Supplemental Water for an Average Traditional Lawn (inches per week)

April	May	June	July	Aug	Sept	Oct
1/4"	3/4"	1 1/4"	1 1/4"	1"	3/4"	1/2"

The above data are based on historical averages and should be used as a guideline and not as a substitute for good judgment, reason and common sense. Under less-than-average rainfall conditions, the amounts shown in the chart should be increased. If there is greater-than-normal rainfall, then the amount of supplemental water should be reduced.

16. Measure the water applied by using rain gauges or cans placed on the lawn in areas covered by sprinklers.

17. Become aware of dehydration signs: 1) Stage 1: grass has a purplish tint; 2) Stage 2: blades turn steel gray and foot prints are left when walked upon; and 3) Stage 3: grass blades turn straw color.

18. Mulch-mowing turfgrass at a height of 2.5 to 3.0 inches helps turfgrass develop deeper root systems. Mulched grass clippings can return roughly 25 to 30 percent of the needed nitrogen that grass requires to be healthy, thereby reducing fertilizer requirements. Avoid throwing grass clippings onto streets and sidewalks to reduce nutrient pollution to surface waterbodies.

19. If thatch deeper than ½ inch is present, aerate the lawn with a core-aerator to allow grass penetration into the root zone and water infiltration. Minimize thatch development by mowing frequently, avoiding overwatering, preventing overfertilization and aerating the lawn.

20. Fertilize the turfgrass at a rate appropriate to the turfgrass species, season and soil conditions. Over-application of fertilizer can result in runoff and leaching. Slow-release fertilizers may reduce the chances of nutrients leaching into groundwater or running off-site. *See the Fertilizer Application BMP for more information.*

21. Apply fertilizer timed to the needs of the plants. Cool season grasses such as Kentucky bluegrass need to be fertilized when the growing season is cool. Apply no more than one pound of nitrogen per thousand square feet at each application. Warm season grasses such as buffalograss need less fertilizer and are best fertilized when the temperature is hot. One application about mid-June and another at the beginning of August is usually sufficient.

22. Water the lawn uniformly until the soil is moist to a depth of 4 to 6 inches to encourage deep roots. Frequent, light sprinklings moisten only the surface and may cause shallow-rooted turf and increase weed seed germination.

23. Proper irrigation can minimize the amount of fertilizer and other chemicals that are leached below the root zone of the grass or washed away by runoff. Properly maintain the irrigation system to ensure that the irrigation is being applied at appropriate rates and to the turfgrass, not the sidewalk. (*See the Irrigation BMPs for more information* and http://www.rockymountainsodgrowers.com/irrigation.html.

24. Follow a proper maintenance schedule to prevent stress, disease and turf injury. (See http://www.rockymountainsodgrowers.com for guidance.)

Regional or Industry Considerations/Adaptations

1. Particularly during recent drought conditions, Kentucky bluegrass has received significant attention as a high-water use plant. However, field studies have shown that bluegrass, with a base of properly prepared soil and proper irrigation, performs well at half of the recommended rate (evapotranspiration or ET) for supplemental irrigation. Therefore, the water use for bluegrass is not so much the grass itself, but how it is cultivated. For more information, see http://www.ncwcd.org/ims/ims_turfandurban_demos.asp.

2. Some areas of Colorado, particularly the western slope, have serious problems with high salt levels in soils. A soil test should be conducted to determine the salt level. Salt in soils can be reduced by improving internal drainage through addition of good-quality organic matter mixed to a depth of at least 6 inches then watering heavily to help flush salts below the root zone. In cases where the irrigation water has high salts, alternative grass species may be required. Kentucky bluegrass does poorly where salt levels are greater than 6 mmhos/cm. Use perennial ryegrass, fine fescue, tall fescue, wheatgrass or alkaligrass for lawns where salt levels are high. Nurseries and garden centers serving areas with salt problems should carry these more salt-tolerant grass species. More information on salt-tolerant grasses can be obtained from www.ext.colostate.edu/pubs/garden/07227.html.

3. In areas with salt problems, a high water table may aggravate the salt problem. In these cases, a tile drain or gravel-filled trench system may be required to move salt-laden water away. Prior to installing such a system, consult with relevant local, state and/or federal officials to determine any regulatory constraints or permit requirements.

4. Sodic soils ("black alkali") contain an excess of sodium and often need to be amended prior to planting turfgrass. Before leaching sodic soils, test the soil through a reputable lab to determine if amendments such as gypsum are required. Leach the soil only after addition of any required amendment.

5. Turf water requirements for the western slope can be obtained from Swift (2001) "Watering Established Lawns in Western Colorado," Colorado State University Cooperative Extension Tri-River Area, www.coopext.colostate.edu/TRA/PLANTS/lawnwat.html.

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Water Budgeting

BMP Type			
Design			X
Installation			
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Calculate the water needs of irrigated landscapes based on plant types, land area and irrigation system efficiency. Use the calculated water budget to apply water according to the needs of the plants and manage irrigation. Overall property water budgets can be developed to include both indoor and outdoor water requirements.

Basic Practice Guidelines

1. The landscape design process should incorporate a general outdoor annual water budget to be used as a guideline for irrigation design and long-term landscape management. The water budget should be developed by the landscape architect or designer as part of the plant selection and grouping process (turf, trees, shrubs, ground covers, etc.).

2. The irrigation maintenance process should be based on calculation of a monthly and annual water budget for existing sites.

3. Calculate the site landscape water budget by summing the water requirements calculated for each hydrozone of the landscape using either of these general formulas:

   Approach #1, when Reference ET is known:

$$\text{Water Budget} = \frac{(ET_o)(K_c)(LA)(0.623)}{IE}$$

   Where:

   Water Budget = Water Needed for Plants (gallons per year)
   ET_o = Reference evapotranspiration (inches per year) for bluegrass in your area
   K_c = Crop coefficient for plant type (See Appendix E for more information.)
   LA = Landscaped Area (square feet)
   0.623 = Conversion Factor (to gallons per square foot)
   IE = Irrigation Efficiency (varies based on irrigation system)

Approach #2, when Reference ET is not known:

Water Budget = Land Area (sq. ft.) x Estimated Plant Water Use (gallons/sq. ft.)

Where:

Estimated Plant Water Use = Estimated Water Use in gallons/sq. ft. for the metro-Denver Front Range area, as contained in Appendix D. For other areas, water use estimates may need to be increased or decreased based on climate and location characteristics. Water use estimates may also be reduced when more efficient irrigation systems such as drip irrigation are used.

Example Using Both Water Budgeting Approaches:

For purposes of a simple example, assume that 70% of a 5,000 sq. ft. of a northern Front Range landscape is Kentucky bluegrass irrigated with a properly designed automatic irrigation system with an 80% irrigation efficiency reported by the irrigation contractor. The remaining 30% of the landscape is "low to very low" water use plants irrigated with a drip irrigation system with a 90% irrigation efficiency reported by the irrigation contractor. The seasonal reference ET value for this northern Front Range location is 26.69 inches for cool season grass mowed at 5 inches. For the turf area, a crop coefficient (Kc) of 0.9 is applied to represent a nice quality Kentucky bluegrass lawn mowed at a 3-inch height. The "low to very low" water use plants require about 25% of reference ET, so the resulting water budget for the landscape would be:

Water for Turf Area = [(26.69"*0.9)*3500 sq.ft.*0.623]/0.8= 65,472 gal/yr

\+ Water for Other Area = [(26.69"*0.25)*1500 sq.ft.*0.623]/0.9 = 6,928 gal/yr

Total Landscape Water Requirement = 72,400 gal/yr

This example results in an average water requirement of about 14.5 gallons/sq. ft. of irrigated area.

Using Approach #2, one would assume the 3,500 sq. ft. of bluegrass would use about 18-20 gal/sq. ft./yr and the 1,500 sq. ft. of low water plants would require about 5 gal/sq. ft., resulting in the following calculation:

19 gal/sq. ft. * 3,500 sq. ft. = 66,500 gal/yr
\+ 5 gal/sq. ft. * 1,500 sq. ft. = 7,500 gal/yr

Total Landscape Water Requirement = 74,000 gal/yr, or about 14.8 gallons/sq. ft. of irrigated area.

4. The water budget provides the total gallons per year that the site needs to thrive in addition to natural precipitation. The annual water budget assumes a normal year of natural precipitation (14 inches of annual precipitation for the Front Range area). In either wetter or drier years, the water budget will need to be adjusted.

5. The rate at which plants use water is called evapotranspiration (ET). Temperature, humidity, wind and light all influence the ET rate. When watering, it is only necessary to replace the amount of water that has been lost due to ET.

6. In order for water budgets to be accurate, it is necessary to provide accurate information on factors such as crop coefficients. See the GreenCO web site (www.greenco.org) and Appendix E for recommended crop coefficients to be used in calculating water budgets.

7. It should be noted that the ET_0 (reference ET) in the water budget equation does not reflect the fact that Kentucky bluegrass can be attractive and viable at much lower ET rates and can be very drought tolerant. For properly established turf, the actual irrigation water needs of turf can vary, depending on desired appearance.

8. The water budget does not apply to the initial establishment period of plantings, which can vary from a 2-4 weeks for annuals to several growing seasons, depending on plant type and the timing of planting. One year is typical for many perennials and shrubs to become established.

9. Water features, outdoor pool(s), and/or any other outdoor water uses should be included in the water budget.

10. If a property manager/landscaper knows the water budget for each month, he/she can compare actual use to the site water budget and adjust irrigation practices accordingly. Excessive water use may also be attributed to irrigation system deficiencies, which should be corrected.

11. Evapotranspiration (ET) or "smart" irrigation controllers are one tool that can facilitate landscape irrigation according to the needs of the plants (and therefore the water budget).

    a. Low water use plants don't automatically save water (they are easily and most likely over-watered). Using a "smart" controller can insure the proper irrigation is applied to low water use plants.

    b. High water use plants (such as turf) don't automatically waste water. They are often over-watered. Using a "smart" controller can insure the proper irrigation is applied to higher water use plants.

12. Often the retrofitting of poor irrigation systems and the use of "smart" controllers will provide a payback in saved water. In order to calculate the payback time, use the water budget to measure how much water is actually needed, versus how much has historically been used.

13. GreenCO provides a simple water budget calculator on its website at www.greenco.org and as shown in Appendix D. Green Industry professionals can use this calculator with customers to demonstrate that water budgeting is a manageable approach to understanding water needs for a given property and adjusting watering practices accordingly.

Regional or Industry Considerations/Adaptations

1. Water budgets can be incorporated into development project financial models and incorporated into projected budget and fees for Homeowners Associations, office parks, etc.

2. Water budgets can be used by water utilities to determine how much water they need versus how much they sell or have. The difference is how much water could be saved, or how much more water needs to be purchased.

3. Water budgeting approaches adopted by utilities typically include ET-based irrigation scheduling combined with tiered pricing for increasing water usage. Tiered pricing provides incentive to conserve because it gradually increases the price of larger quantities of water. At the time of this manual's publication, this approach had been adopted in other water-limited states such as California and Arizona. See Centennial Water and Sanitation District in Highlands Ranch, Colorado, for information on their program http://www.highlandsranch.org/6/6-1a.html.

4. Colorado's *Water Efficient Landscape Design Model Ordinance* (see www.dola.state.co.us/smartgrowth/) is based on water-budgeting with a goal of 15 gallons/square foot/year of water required for the landscaped area.

5. Check the GreenCO website (www.greenco.org) for more information on water budgeting techniques.

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Woody Plant Care

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	
CGGA	X	WFC	
CNA	X		

Description

Properly plant and maintain trees, shrubs and other woody plants to maximize the plants' health.

Basic Practice Guidelines

1. Plant and prune trees in accordance with the International Society for Arboriculture (ISA) standards.

2. Proper tree planting with the root collar at grade or one to two inches above grade helps in better establishment and long-term health of a tree. In irrigated turf areas, the root collar should be at least two inches above grade. Planting holes should be shallower than the root ball for this to occur.

3. When planting balled-and-burlapped or container stock, avoid soil interface problems by amending the backfill to provide a transition between the soil in the root ball and the surrounding soil. Do not amend soil beneath the root ball. Place root balls on firm, compacted soil. Also score root balls and the sides of the hole to aid in transition.

4. When planning irrigation for trees, zone them separately from turf because trees adapt better to the site with deep, less frequent waterings.

5. Regular watering of trees is important because moisture stress is a precursor to many diseases and insect problems. Trees may be deceiving in that they may not show stress for several years after drought damage. It is also important to keep in mind that too much water can also cause problems.

6. Trees and other woody plants typically require additional watering for one to two growing seasons to become established (As a rule of thumb, trees require one year per inch of caliper to become established). This includes winter watering for newly planted trees, particularly evergreens when snow is absent.

7. Tree root systems can spread two to three times wider than the height of the tree. Most of the tree's absorbing roots are in the top 12 inches of the soil. Water should be applied within and beyond the dripline, deeply and slowly. Apply water so it moistens the critical root zone to a depth of 12 inches. For evergreens, water should also be applied three to five feet beyond the dripline. Methods for watering include a deep root fork or needle, soaker hose or soft spray wand. Apply water to many locations under dripline. If a deep root fork or needle is used, insert the device no deeper than eight to ten inches into the soil.

8. During prolonged dry periods in the fall and winter (October –March), water trees one to two times per month. Water only when temperatures are above 40 degrees and no snow cover exists.

9. The desired water application rate for trees varies by trunk diameter and irrigation device, see http://www.watersaver.org/saveourshade.asp for recommended application rates by tree size, watering device and season. A general "rule of thumb" for small and medium size trees is to use approximately 10 gallons of water per inch of trunk diameter (measured at knee height) for each watering. The frequency for small trees (1-3") is to water weekly throughout the season. Medium size trees (4"-8") will only require watering three times per month throughout the season. Water large trees (10"+) twice per month at a rate of 15 gallons of water per inch of trunk diameter throughout the season. Modify if rain occurs.

10. Apply organic mulch within the dripline at a depth of four inches to conserve moisture. Leave a six-inch space between the mulch and trunk of trees. Mulch materials may include wood chips, bark, leaves and evergreen needles.

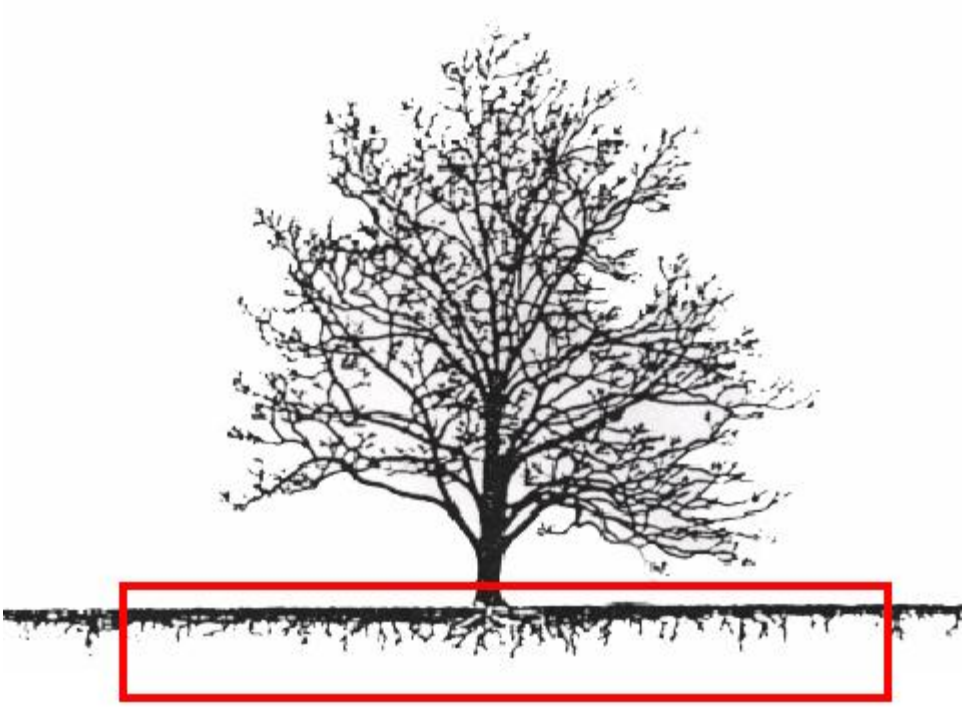
11. Practice plant health care (PHC) programs and proper tree maintenance to create healthy trees and landscapes.

12. Properly prune young trees to develop structures so they are well suited to the site and their intended landscape function.

13. Prune trees to remove dead, broken, insect-ridden and diseased branches to maximize plant health and to minimize pest invasion. For branches that are heavily infested with scale insects, pruning can be an effective management strategy. Do not "top" trees.

14. Protect young trees from winter sun damage by wrapping the trunk with tree wrap. A general rule is to wrap on November 1 and unwrap on April 1. It is important to remove the wrap in the spring to prevent insects and diseases from harboring beneath it.

15. Many tree species are harmed by herbicides used in the lawn. Trees already stressed by drought can be harmed by a heavy application of herbicide in the root zone.



Deeply and slowly water trees beneath the dripline.
Source: WaterSaver.Org. 2004. Save Our Shade Web Site: http://www.watersaver.org/saveourshade.asp.

Regional or Industry Considerations/Adaptations

1. In Front Range communities, a goal of 20 percent canopy coverage is recommended. The "urban forest" provides multiple benefits such as reducing stormwater runoff, providing shade and protecting against wind.

2. For trees planted near streams and drainages, it may be necessary to install wire baskets around trunks to prevent beaver damage.

3. Trees that have recently received root injury due to construction work need supplemental watering if the root system has been compromised.

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Xeriscape

BMP Type			
Design			X
Installation			X
Maintenance/Operation			X
Green Industry Relevance			
ASLA	X	GCC	X
ALCC	X	ISA	X
CALCP	X	RMSGA	X
CGGA	X	WFC	
CNA	X		

Description

Implement the seven basic landscape principles of xeriscape: planning and design, soil improvement, hydrozoning of plants, creating practical turf areas, efficient irrigation, mulching and appropriate maintenance.

General Note: The term "Xeriscape" was coined by Denver Water in 1981. The seven Xeriscape principles are included as individual GreenCO BMPs. Integration of these seven BMPs provides a comprehensive approach that can be very effective for conserving water.

Basic Practice Guidelines

1. Plan and design landscaping comprehensively. Start with a site inventory and analysis, where existing conditions such as drainage, exposures, soil types, views, existing plants, etc., are noted. Next, develop a list of activities ("a program") and their support facilities that need to be included in the design. Continue by diagramming possible locations for the activities from the program, while also allowing for planned traffic patterns and access or screening. Finally, use this information to develop a plan that integrates plants into the overall scheme. *(See the Landscape Design BMP for more information.)*

2. Evaluate soil and improve, if necessary. Improve soil before planting and installing the irrigation system. Soil improvement promotes better absorption of water, improved water-holding capacity and drainage of the soils. It also allows for better oxygen transfer within the root zone. *(See the Soil Amendment/Ground Preparation BMP for more information.)*

3. Create practical turf areas. Include turf areas where they provide defined functions (i.e., recreation, traffic areas, etc.). Grass is best separated from plantings of trees, shrubs, ground covers and flowers so it can be watered separately. Often, portions of turf areas can be replaced with more water-efficient ground covers and mulches. Choose the appropriate grass for the desired use. No one grass is ideal for all locations. Alternative grasses for some areas, depending on the area's purpose, may include tall fescue, buffalograss, blue grama and wheat grass. *(See the Turf BMP for more information.)*

4. Use appropriate plants and group according to their water needs (i.e., "hydrozoning"). Plants with lower water requirements such as native species adapted to Colorado's climate should be considered. However, other plants can have a place in xeriscape designs, even if they require larger amounts of water. The key is to use those plants in appropriate locations and not to interplant them with others that have very different, lower water requirements. In effect, the groupings of plants are separated into "zones" based on their water requirements, which allows them to be irrigated efficiently. *(See the Plant Selection and Placement BMP for more information.)*

5. Water efficiently with a properly designed irrigation system. Irrigate according to the condition of the plants, not on a fixed schedule. Well-planned sprinkler systems can save water when properly installed and operated. Turf areas should be watered separately from beds, shrubs and trees. Apply only as much water as the soil can absorb to avoid runoff. Trees, shrubs, flowers and ground covers can be watered more efficiently with low volume drip emitters. To promote deep rooting, water infrequently, but deeply. *(See the Irrigation Efficiency BMP for more information.)*

6. Use organic mulches to reduce surface evaporation of water and weeds. Mulched planting beds are an ideal replacement for expansive turf areas. Mulches cover and reduce temperature extremes in the soil, minimize evaporation, reduce weed growth and slow erosion. Mulches also provide landscape interest. Organic mulches are typically bark chips, wood grindings or pole peelings. Inorganic mulches include rock and various gravel products. Place mulch directly on the soil or on breathable fabric. Do not use impermeable sheet plastic beneath mulched areas. *(See the Mulching BMP for more information.)*

7. Practice appropriate landscape maintenance. Proper pruning, weeding, mowing and fertilization, plus attention to the irrigation system, are needed to maximize water savings. Regular maintenance preserves the intended beauty of the landscape and saves water and maintenance costs. Always water according to plant needs and current soil moisture conditions and not on a rigid schedule. Remember that frequent, shallow watering promotes shallow roots, which defeats the purpose of xeriscaping. *(See the Landscape Maintenance BMP for more information.)*

A well-designed and maintained Xeriscape not only conserves water, but is also aesthetically pleasing, incorporating a variety of landscaping.

Source: Denver Water.

Special Regional or Industry Considerations/Adaptations

1. Xeriscape principles are applicable industry-wide and in all locations in Colorado.

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Appendix A: Basic Erosion and Sediment Control Practices

Sediment is one of the most prevalent nonpoint source runoff components associated with urban development and construction activities. Similar BMPs are applicable to both stormwater runoff in urban areas and construction site runoff.

Detailed guidance on erosion and sediment control practices can be obtained from the Urban Drainage and Flood Control District (1999) *Storm Drainage Criteria Manual, Volume 3* and the Denver Regional Council of Governments (1998) *Keeping Soil on Site: Construction Best Management Practices*. These practices are designed for use with urban development and other construction activities and they are applicable to all urban areas and construction activities in Colorado. The Colorado Nonpoint Source Task Force also recommends these BMPs. The following discussion provides a general overview of key erosion and sediment control practices.

1. Sediment and Erosion Control Plan

The objective of erosion control is to limit the amount and rate of erosion occurring on disturbed areas. The objective of sediment control is to capture the soil that has been eroded before it leaves the construction site. Despite the use of both erosion control and sediment control measures, it is recognized that some amount of sediment will remain in runoff leaving the construction site.

An erosion and sediment control plan is comprised of three major elements.

- The erosion control measures that will be used to limit erosion of soil from disturbed areas at a construction site;
- The sediment control measures that will be used to limit transport of sediment to off-site properties and downstream receiving waters; and,
- The drainageway protection measures that will be used to protect streams and other drainageways located on the construction site from erosion and sediment damages.

Erosion control planning should occur early in the site development process. The planning process can be divided into five separate steps:

- Gather information on topography, soils, drainage, vegetation and other predominant site features.
- Analyze the information in order to anticipate erosion and sedimentation problems.
- Devise a plan that schedules construction activities and minimizes the amount of erosion created by development.
- Develop an Erosion and Sediment Control Plan which specifies effective erosion and sediment control measures
- Follow the Erosion and Sediment Control Plan and revise it when necessary.

2. Erosion Control

The planning for the installation of permanent or temporary soil erosion controls needs to begin in advance of all major soil disturbance activities on the construction site. After construction begins, soil surface stabilization should be applied within 14 days to all disturbed areas that may not be at final grade but will remain dormant (undisturbed) for periods longer than an additional 30 calendar days. Soil surface stabilization protects soil from the erosive forces of raindrop impact, flowing water, and wind. Erosion control practices include surface roughening, mulching, establishment of vegetative cover, and the early application of gravel base on areas to be paved. Stabilization measures to be used should be appropriate for the time of year, site conditions and estimated duration of use.

Surface roughening provides temporary stabilization of disturbed areas from wind and water erosion. It is particularly useful where temporary revegetation cannot be immediately established due to seasonal planting limitations. All disturbed areas must be mulched, or seeded and mulched, within 14 days after final grade is reached on any portion of the site not otherwise permanently stabilized. Areas that will remain in an interim condition for more than one year should be seeded.

A viable vegetative cover should be established within one year on all disturbed areas and soil stockpiles not otherwise permanently stabilized. Vegetation is not considered established until a ground cover is achieved which, in the opinion of the city or county of jurisdiction, is sufficiently mature to control soil erosion and can survive severe weather conditions. Areas to be re-vegetated should have soil conditions capable of supporting vegetation. Over-lot grading will often bring to the surface subsoils that have low nutrient value, little organic matter content, few soil microorganisms, and conditions less conducive to infiltration of precipitation. Under certain conditions, soil amendments and treatments may be necessary to provide an adequate growth medium to sustain vegetation.

Temporary revegetation is required on all disturbed areas having a period of exposure prior to final stabilization of one year or longer. All temporary seeding should be protected with mulch. To provide vegetative cover on disturbed areas not paved or built upon for a period of two years or longer, or for an indeterminate length of time, a perennial grass mix should be planted. Each site will have different characteristics, and a landscape professional should be contacted to determine the most suitable seed mix for a specific site.

Road cuts, road fills, and parking lot areas should be covered with the appropriate aggregate base course on the surfaces to be paved in lieu of mulching. Early application of road base is suitable where a layer of coarse aggregate is specified for final road or parking lot construction. This practice may not be desirable in all instances, and is not needed when final pavement construction will take place within 30 days of grading to final contours. All non-paved portions of road cut, fill, and parking lot areas should be seeded and mulched as soon as possible after final grading has occurred, but in no case later than 14 days after grading has been completed.

3. Sediment Control

Sediment control will be site specific and can include vehicle tracking controls; sod buffer strips around the lower perimeter of the land disturbance; sediment barriers, filters, dikes, traps or sediment basins; or a combination of any or all of these measures. Sediment controls must be constructed before land disturbance takes place. Earthen structures such as dams, dikes, and diversions should be mulched within 14 days of installation. Earthen structures that are expected to remain in place for more than one year must be seeded and mulched.

Wherever construction vehicles enter onto paved public roads, provisions must be made to prevent the transport of sediment (mud and dirt) by runoff or by vehicles tracking onto the paved surface. Cut-and-fill slopes must be designed and constructed to minimize erosion. This requires consideration of the length and steepness of the slope, the soil type, up-slope drainage area, groundwater conditions and other applicable factors. Slopes that are found to be eroding excessively will require additional slope stabilization until the problem is corrected. A temporary diversion dike is a horizontal ridge of soil placed perpendicular to the slope and angled slightly to provide drainage along the contour. Temporary diversion dikes can be constructed by excavation of a V-shaped trench or ditch and placement of the fill on the down-slope side of the cut.

The drainage system provided for roads will define to some extent the length and area of individual slope segments within the disturbed area. Sediment can be controlled on slopes that are particularly steep by the use of terracing. During grading, relatively flat sections, or terraces, are created and separated at intervals by steep slope segments. The steep slope segments are prone to erosion, however, and must be stabilized in some manner. Retaining walls, gabions, cribbing, deadman anchors, rock-filled slope mattresses and other types of soil retention systems are available for use. These should be specified in the plan and installed according to manufacturer's instructions.

There are certain instances when runoff must be directed down a slope within the disturbed area. A temporary slope drain can be used to protect these hill-slope areas from scour and additional erosion. A number of alternative designs and materials can be used for a slope drain. Sediment entrapment facilities are necessary to reduce sediment discharges to downstream properties and receiving waters. Sediment entrapment facilities include straw bale barriers, silt fences, sod filter strips, sediment traps and sediment basins. The type of sediment entrapment facility to be used depends on the tributary area, basin slope and slope length of the upstream area.

Straw bales can be placed at the base of a hill-slope to act as a sediment barrier. These are not recommended for use within a swale or channel. Straw bales are temporary in nature and may only perform for a period of weeks or months. Proper installation and maintenance is necessary to ensure their performance. A silt fence is made of a woven synthetic material and acts to filter runoff. Silt fences can be placed as a temporary barrier at the base of a disturbed area but are not recommended for use in a channel or swale.

Vegetated filter strips act to cause deposition of sediment within the area of vegetation. Buffer strips of natural vegetation can be left at the time of site grading, or can be created by using sod. A dense ground cover is necessary or runoff will channelize within the area. A minimum width

of 20 feet is recommended. A sediment trap is a temporary structure that is designed to fill with sediment. A sediment trap can be constructed by either excavating below grade or building an embankment across a swale. Excavated traps are less prone to failure than embankments. No pipe is used at the outlet, as in a sediment basin, and an open-channel spillway must be included in the design. A minimum of 1,800 cubic feet of storage volume must be provided for each tributary acre.

Areas draining more than five acres must be routed through a sediment basin. If the site is to include a stormwater quality or flood detention basin, the permanent detention facility may be used as the temporary sediment basin, provided the outlets are modified upon completion for this purpose. Such permanent detention facilities should be restored to design grades, volumes, and configurations after site development is completed and the project is finalized.

4. Topsoil Preservation and Reuse

Topsoil preservation and reuse involves the preservation of a scarce and irreplaceable natural resource. Topsoil is valuable for the establishment and maintenance of protective vegetation and ornamental landscaping. Topsoil is the uppermost, usually darker colored, horizon of a natural soil, possessing the most favorable characteristics for plant growth, including a good supply of organic matter, nutrients, biological activity, and good structure which promotes the infiltration and circulation of water and air and the development of healthy root systems in plants.

At a minimum, topsoil preservation and reuse involves the removal, stockpiling, and re-spreading of the surface with six to eight inches of natural soil. Salvaged topsoil should be stockpiled in an area where it is protected from off-site surface drainage, wind and water erosion, and weed invasion. The stockpile should be located and protected so that unavoidable erosion does not pose a threat to off-site property or water quality. Man-altered landscapes (i.e., fills, cuts, dumps, etc.) may possess surface soils that are inferior to natural soils and undesirable for plant growth. These sites must be individually evaluated for physical and chemical properties that influence plant growth.

Topsoil should be re-spread on sites that are being prepared to receive permanent vegetative stabilization or landscaping. On large areas graded for residential development, topsoil re-spreading should be performed for each individual home site after the basement is excavated and spoils are removed or re-spread. If basement excavation spoils will be hauled away, then topsoil can be re-spread over the entire site after final grading and before home construction.

Topsoil in many parts of Colorado is thin compared to other regions of the United States that have more plentiful rainfall. Yet topsoil is arguably more valuable here, because our subsoils, with their accumulations of clay, low permeability, high pH, and concentrations of salts, tend to be much more hostile to plant growth compared with subsoils of other regions. Our subsoils, even amended with fertilizers and conditioners, cannot be easily transformed into good plant growth media.

Topsoil preservation and reuse has important implications for the conservation of water supplies, as well as for protecting water quality. Water efficient, sustainable landscaping depends on good

soil. Good soil enables efficient irrigation water management. Poor soil produces unhealthy plants and undermines attempts at efficient landscape and irrigation water management.

5. Drainageway Protection

At times construction activities must occur adjacent to or within a drainageway. Whenever this occurs, bottom sediments will be disturbed and transported downstream. The movement of sediments resulting from construction activities that take place within any drainageway should be minimized. Temporary facilities can be installed to divert flowing water around sediment-generating construction activities within drainageways.

Limiting construction activities within actively flowing water will significantly reduce sediment movement downstream from these activities. This can be done by using a temporary diversion facility that carries water around construction activities taking place within a waterway. To protect adjacent downstream properties from erosion due to concentrated flows, a stable outlet or channel is necessary. If there is no stable outlet, one may have to be constructed. In lieu of constructing a temporary or permanent outlet to the storm drainageway system, temporary total retention of the runoff from a 24-hour, 100-year storm may be provided. All storm sewer inlets which are made operable during construction must be protected to prevent sediment-laden runoff from entering the conveyance system without first being filtered or otherwise treated to remove sediment.

6. Material Storage Practices

Materials are sometimes used at a construction site that present a potential for contamination of stormwater runoff. These include fuel, oil, lubricants, paints, solvents, concrete-curing compounds and other liquid chemicals such as fertilizers, herbicides and pesticides.

Areas at the construction site used for storage of toxic materials and petroleum products should be designed with an enclosure, container, or dike located around the perimeter of the storage area to prevent discharge of these materials in runoff from the construction site. These barriers will also function to contain spilled materials from contact with surface runoff. Areas used for collection and temporary storage of solid or liquid waste should be designed to prevent discharge of these materials in runoff from the construction site. Collection sites should be located away from the storm drainage system. Consideration should be given to covering waste storage areas, fencing these areas, if necessary, to contain windblown materials, and construction of a perimeter dike to exclude runoff.

7. Underground Utility Construction

The construction of most underground utility lines should be subject to the following criteria:

- No more than 200 feet of trench is to be opened at one time (local criteria may be more restrictive).

- Where consistent with safety and space considerations, excavated material should be placed on the uphill side of trenches.

- Trench dewatering devices must discharge in a manner that will not adversely affect flowing streams, wetlands, drainage systems, or off-site property.

- Whenever soil erosion from the excavated material has the potential for entering the storm drainage system, storm sewer inlet protection should be provided.

8. Disposition of Temporary Measures

All temporary erosion and sediment control measures should be removed and disposed of within 30 days after final site stabilization is achieved, or after the temporary measures are no longer needed, whichever occurs earliest, or as authorized by the city or county of local jurisdiction. For example, a site containing only one building will have temporary erosion control measures removed after building construction is complete and final landscaping is in place. Temporary erosion control measures may be removed from a commercial construction site or residential subdivision only after streets are paved and all areas have achieved final stabilization. Trapped sediment and disturbed soil areas resulting from the disposal of temporary measures must be returned to final plan grades and permanently stabilized to prevent further soil erosion.

9. Maintenance

All temporary and permanent erosion and sediment control practices should be maintained and repaired by the owner during the construction phase as needed to assure continued performance of their intended function. Straw bale barriers or silt fences may require periodic replacement and all sediment accumulated behind them must be removed and disposed of properly. Sediment traps and basins will require periodic sediment removal when the design storage level is one-half full. All facilities must be inspected by the owner or owner's representative following each heavy precipitation or snowmelt event that results in runoff.

Appendix B: Permanent Stormwater BMPs

1. Overview

This appendix provides an overview of guidance for the selection and siting of structural best management practices (BMPs) for new development. The guidance is provided within the context of a four-step process that may be followed for new site developments and significant redevelopments. This appendix has been adapted directly from "BMP Planning for New Development and Significant Redevelopment" from Volume 3 of the *Urban Storm Drainage Criteria Manual* (UDFCD 1999).

Detailed descriptions, sizing and design criteria, and design procedures for these BMPs are provided in the chapter titled "Structural Best Management Practices" from Volume 3 of the *Urban Storm Drainage Criteria Manual* (UDFCD 1999).

The selection of BMPs for a development site is intended to be made collaboratively as a result of coordination between the developer and the local jurisdiction. It is recommended that discussions regarding proposed BMPs occur early in each project between the developer's planner and engineer and municipal staff.

2. Four-Step Process

The following four-step process is recommended for selecting structural BMPs in newly developing and redeveloping urban areas:

- Step 1. Employ Runoff Reduction Practices. To reduce runoff peaks and volumes from urbanizing areas, employ a practice generally termed "minimizing directly connected impervious areas" (MDCIA). The principal behind MDCIA is twofold -- to reduce impervious areas and to route runoff from impervious surfaces over grassy areas to slow down runoff and promote infiltration. The benefits are less runoff, less stormwater pollution, and less cost for drainage infrastructure. There are several approaches to reduce the effective imperviousness of a development site:

  - Reduced Pavement Area. The use of smaller roadway cross sections is encouraged. Sometimes, creative site layout can reduce the extent of paved areas, thereby saving on initial capital cost of pavement and then saving on pavement maintenance, repair, and replacement over time.

  - Porous Pavement. The use of modular block porous pavement or reinforced turf in low-traffic zones such as parking areas and low use service drives such as fire lanes can significantly reduce site imperviousness. This practice can reduce the extent and size of the downstream storm sewers and detention.

  - Grass Buffers. Draining impervious areas over grass buffers slows down runoff and encourages infiltration, in effect reducing the impact of the impervious area.

- Grass Swales. The use of grass swales instead of storm sewers, like grass buffers, slows down runoff and promotes infiltration, also reducing effective imperviousness. It also can reduce the size and cost of downstream storm sewers and detention.

- Step 2. Provide Water Quality Capture Volume (WQCV). A fundamental requirement for any site addressing stormwater quality is to provide WQCV. One or more of six types of water quality basins, each draining slowly to provide for long-term settling of sediment particles, may be selected. These six BMPs include:

  - Porous Pavement Detention
  - Porous Landscape Detention
  - Extended Detention Basin
  - Sand Filter Extended Detention Basin
  - Constructed Wetland Basin
  - Retention Pond

- Step 3. Stabilize Drainageways. Drainageway, natural and manmade, erosion can be a major source of sediment and associated constituents, such as phosphorus. Natural drainageways are often subject to bed and bank erosion when urbanizing areas increase the frequency, rate, and volume of runoff. It is important that drainageways adjacent to or traversing development sites be stabilized. One of three basic methods of stabilization may be selected.

  - Constructed Grass, Riprap, or Concrete-Lined Channel. This method of channel stabilization has been in practice for some time; it is described in Volume 2 of the *Urban Storm Drainage Criteria Manual* (UDFCD 2000). The water quality benefit associated with these channels is the reduction of severe bed and bank erosion that can occur in the absence of a stabilized channel. On the other hand, the hard-lined low flow channels that are often used do not offer much in the way of water quality enhancement or wetland habitat. The Urban Drainage and Flood Control District does not recommend the use of riprap or concrete lined flood conveyance channels, but does recommend the use of rock lined low-flow channels.

  - Stabilized Natural Channel. This method of channel stabilization is also addressed in Volume 2 of the *Urban Storm Drainage Criteria Manual*. However, in practice, many natural drainageways in and adjacent to new developments in the Denver area are frequently left in an undisturbed condition. While this may be positive in terms of retaining desirable riparian vegetation and habitat, urban development may cause the channel to become destabilized. When degradation occurs in these drainageways, significant erosion, loss of riparian and aquatic habitat, and elevated levels of sediment and associated pollutants can result. Therefore, it is recommended that some level of stream stabilization always be considered. Small grade control structures sized for a 5-year or larger runoff event are often an effective means of establishing a mild slope for the baseflow channel and arresting stream degradation. Severe bends or cut banks may also need to be stabilized. Such efforts to stabilize a

natural waterway also preserves and promotes natural riparian vegetation which can provide paybacks in terms of enhanced aesthetics, habitat, and water quality.

One additional method of drainageway stabilization gives special attention to stormwater quality and is the constructed wetland channel.

- Step 4. Consider Need for Industrial and Commercial BMPs. If a new development or significant redevelopment activity is planned for an industrial or commercial site, the need for specialized BMPs must be considered. Examples include covering of storage/handling areas and spill containment and control.

3. Other BMPs

The structural BMPs identified above were selected after a comprehensive screening of known structural BMPs with representatives of a number of cities and counties in the Denver metropolitan area, Colorado Department of Transportation, Colorado Water Quality Control Division, industry, homebuilders, and a municipality located outside the Denver metropolitan area. Final selection by this group was based on the review of documentation on potential effectiveness in a semiarid climate, local applicability, maintenance considerations, and cost.

Other BMPs include manufactured devices such as water quality vaults and inlets, infiltration trenches, oil/grease separators, fabric inserts for inlets, and stream buffer setbacks. Some of these BMPs show promise but need further independent research to determine their pollutant removal effectiveness in a semiarid climate and to develop cost-effective design criteria to insure that they are properly designed, constructed, and maintained. As additional BMPs are field tested, and as supporting information becomes available, they may be added to the *Urban Storm Drainage Criteria Manual*.

4. Implementing Step 1. Employ Runoff Reduction Techniques

4.1 Benefits of Reducing Imperviousness

Reducing imperviousness offers the following benefits:

- Increased infiltration and decreased rate and volume of site runoff
- Decreased WQCV and, in turn decreased size of required WQCV facilities
- Decreased 2-year and 5-year peak runoff rates and volumes for downstream conveyance and detention facilities
- Reduced need for irrigation
- Less curb and gutter
- Smaller storm sewer systems

- Decreased pavement
- Decreased runoff rates and volumes further downstream in watershed, especially if MDCIA is used on a widespread basis

4.2 BMPs for Minimizing Effective Imperviousness

Described next are structural BMPs that minimize effective imperviousness.

Grass Buffer (GB)

Uniformly graded and densely vegetated area of turf grass. This BMP requires sheet flow to promote filtration, infiltration, and settling to reduce runoff pollutants.

Grass Swale (GS)

Densely vegetated drainageway with low-pitched side slopes that collects and slowly conveys runoff. Design of longitudinal slope and cross section size forces the flow to be slow and shallow, thereby facilitating sedimentation while limiting erosion.

Modular Block Porous Pavement (MBP)

Modular block porous pavement consists of open void concrete slab units underlain with gravel. The surface voids are filled with sand. This BMP is intended to be used in low traffic areas to accommodate vehicles while facilitating stormwater infiltration near its source. A variation of this BMP is termed stabilized-grass porous pavement, consisting of plastic rings affixed to filter fabric underlain with gravel. The surface voids are filled with sand and grass sod/or seed.

4.3 Applying MDCIA to a Site

Minimizing directly connected impervious area requires a basic change in land development design philosophy. This change seeks to reduce paved areas and directs stormwater runoff to landscaped areas, grass buffer strips, and grass-lined swales to slow down the rate of runoff, reduce runoff volumes, attenuate peak flows, and encourage filtering and infiltration of stormwater. Traditional land development practices do not focus on water quality enhancement. Instead, they promote runoff from rooftops, parking lots, driveways, and roads to quickly flow to a curb and gutter and to a formalized stormwater conveyance system. This practice concentrates runoff quickly, which results in a fast responding system and relatively large peak runoff rates during small storms.

Minimizing DCIAs can be made an integral part of landscape and drainage planning for any development. Roof collection systems can direct flow to landscaped areas, infiltration areas, grassed buffer strips, and to grass swales. Instead of using solid curbing, eliminate curbing or use slotted curbing along with stabilized grass shoulders and swales. Residential driveway runoff can be redirected from flowing directly into the street. Large parking lots can reduce DCIAs by using modular block or stabilized grass porous pavement in less used portions of the lot to encourage local infiltration or storage.

Site slopes should be capable of directing stormwater runoff by gravity in a sheet flow away from buildings, roads, and parking lots toward grass-covered or porous pavement covered areas. The runoff then needs to flow as a sheet over these porous surfaces before it reaches swales, storage, stormwater collection, and stormwater conveyance systems. As a result, in areas of high permeability soils (Hydrologic Soil Class A and B soils), the ground can provide for infiltration of large portions of surface runoff. Where less permeable soils are present, significant runoff losses can also be achieved, while the use of sand trenches with underdrains under grass swales can be used to prevent the nuisance of standing water.

Steep sites with average terrain slopes exceeding 4 percent may not lend themselves well to implementing some aspects of this BMP. Some of the difficulties can be dealt with by using terracing and retaining walls. Nevertheless, most sites with general terrain slopes flatter than 4 percent should be suitable for this BMP; the flatter the better.

Minimizing DCIAs can be implemented in varying degrees. Two general levels associated with minimizing DCIAs have been identified for the purpose of the *Urban Storm Drainage Criteria Manual* and are described below:

- Level 1. The primary intent is to direct the runoff generated by impervious surfaces to flow over grass-covered areas, and to provide sufficient travel time so as to encourage the removal of suspended solids before runoff leaves the site, enters a curb and gutter, or enters another stormwater collection system. Thus, at Level 1, *all* impervious surfaces are made to drain over grass buffer strips before reaching a stormwater conveyance system.

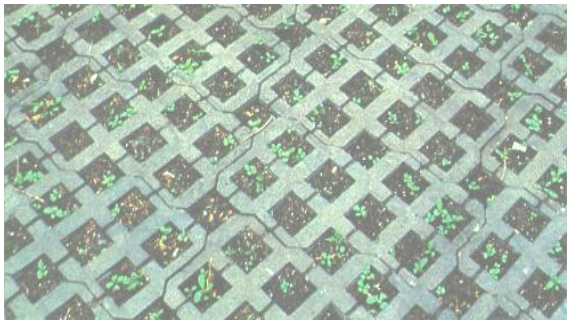
- Level 2. As an adjunct to Level 1, this level replaces street curb and gutter systems with low-velocity grass-lined swales and pervious street shoulders. Conveyance systems and storm sewer inlets will still be needed to collect runoff at downstream intersections and crossings where stormwater flow rates exceed the capacity of the swales. Small culverts will be needed at street crossings and at individual driveways until inlets are provided to convey the flow to a storm sewer.

5. Implementing Step 2. Provide Water Quality Capture Volume (WQCV)

These BMPs are designed to capture and provide treatment for a specific volume of stormwater runoff (about half of the runoff from a 2-year storm). This volume is equivalent to the runoff from an 80^{th} percentile storm, meaning that 80 percent of the most frequently occurring storms are fully captured and treated and larger events are partially treated. Detention periods range from 6- to 40-hours, depending on the type of facility. The primary pollutant removal mechanism consists of physical settling of suspended sediments and associated adsorbed pollutants. Secondary pollutant removal mechanisms include filtering, biological uptake, and adsorption.

The WQCV treatment facilities described herein have been selected because they have demonstrated proven results in the Denver area, are relatively cost-effective and are necessary at any site addressing stormwater quality. Runoff from 100 percent of the impervious surfaces of a site must flow through a properly designed installation of one or more of the six WQCV BMPs that are listed herein. Alternate designs may be considered, but they must have equivalent functional requirements of these six BMPs as to WQCV and drain times.

A brief description of the six types of WQCV facilities follows.



Porous Pavement Detention (PPD)

Porous pavement detention consists of modular block porous pavement that is installed flat and is provided with a 2-inch deep detention zone above its surface to temporarily store the WQCV from the tributary drainage area including its own surface. Runoff infiltrates into the void spaces of the gravel base course through the sand filter and slowly exits through an underdrain.

Porous Landscape Detention (PLD)

Porous landscape detention consists of a low-lying vegetated area underlain by a sand bed with an underdrain. A shallow surcharge zone exists above the porous landscape detention for temporary storage of the WQCV. This BMP allows small amounts of WQCV to be provided on parking lots or adjacent to buildings without requiring the set aside of significant developable land areas.

Extended Detention Basin (EDB)

An extended detention basin is appropriate for larger sites and is designed to totally empty out sometime after stormwater runoff ends. The extended basin uses a much smaller outlet than a flood control detention basin, which extends the emptying time for the more frequently occurring runoff events to facilitate pollutant removal.

Sand Filter Extended Detention Basin (SFB)

A sand filter extended detention basin consists of a sand bed and underdrain system. Above the vegetated sand bed is an extended detention basin sized to capture the WQCV. A sand filter extended detention basin provides pollutant removal through settling and filtering and is generally suited to offline, onsite configurations where there is no base flow and the sediment load is relatively low.

Constructed Wetland Basin (CWB)

A constructed wetland basin is appropriate for large catchments and is a shallow retention pond, which requires a perennial supply of water to permit the growth of rushes, willows, cattails, and reeds. It treats runoff by slowing it down to allow time for settling and biological uptake.

Retention Pond (RP)

A retention pond is appropriate for larger catchments. It has a permanent pool of water that is replaced with stormwater, in part or in total, during storm runoff events. In addition, a temporary extended detention volume is provided above this permanent pool to capture storm runoff and enhance sedimentation. It requires a perennial supply of water to maintain the pool.

Appendix C: Summary of Potentially Applicable Regulations

Appendix C
Summary of Potentially Applicable Regulations

Potential Regulatory Requirements	Regulation Description	Potential BMP Application	Contact	Contact Number & Website
Local/County/Tribal				
Air Quality Control	Regulations to protect air quality	Soil disturbance/bare ground for extended time causing air pollution, heavy equipment emissions, other emissions	Contacts vary based on location.	
Development/Building Permits	Regulations addressing setbacks and other issues	Landscape and irrigation system planning and installation.		
Floodplain Management	Regulations limiting activities in the floodplain	Landscape and irrigation system planning and installation.		
Land Disturbance	Regulations may address wetlands and wildlife, zoning and setbacks.	Landscape and irrigation system planning and installation.		
Landscaping Requirements	Some local governments may have ordinances requiring certain landscaping practices.	Landscape and irrigation system planning and installation.		
Water Quality Control	Regulations may address water quality, pollution prevention, stormwater management and water conservation	Erosion and sediment control due to disturbed soil, organic disposal, chemical disposal.		
Noxious Weed Control	County regulations addressing control of noxious weeds.	Landscape maintenance and installation		
State				**www.state.co.us**
Colorado Air Quality Control Commission Regulations	Regulations 1-13 to protect air quality	Soil disturbance/bare ground for extended time causing air pollution, heavy equipment emissions, other emissions	Jim Geier	303-692-3100 Main 303-692-3167 Direct James.Geier@state.co.us
Colorado Discharge Permit System Construction Dewatering Permit	Discharge water associated with construction activities	Earthwork, landscape design/installation/maintenance, building construction, irrigation system installation/maintenance	Chris Gates	303-692-3539 Chris.gates@state.co.us
Colorado Discharge Permit System Construction Stormwater Management Permit and Plan	Colorado Water Quality Control Act (25-8-101) et seq. CRS 1973 and the Federal Water Pollution Control Act (33 U.S.C. 1251)	Earthwork, landscape design/installation/maintenance, building construction, irrigation system installation/maintenance	Nathan Moore or Kathy Dolan	303-692-3500 Nathan.moore@state.co.us or Kathy.dolan@state.co.us
Reclaimed Domestic Wastewater Control Regulation	Reclaimed Domestic Wastewater Control Regulation, Regulation 84	Special requirements when using reclaimed wastewater for irrigation. For example, cross-connection control, signage, inspection	Michael Liuzzi	303-692-3588 Michael.liuzzi@state.co.us
Minimal Wastewater from Industrial Facilities (MINDI)	For facilities discharging wastewater of small volume or over a short time period which are amenable to control through BMP type technologies. Permission to discharge into conveyances, stormwater systems, or ditches must be obtained.	Greenhouses, nurseries and other landscaping operations requiring minimal discharges	Chris Gates	303-692-3539 Chris.gates@state.co.us
Noxious Weed Control	County regulations addressing control of noxious weeds.	Landscape maintenance and installation	Eric Lane	www.ag.state.co.us/DPI/weeds/weed html
Underground Storage Tank (UST) or Above Ground Storage Tank (AST) Registration	7 CCR 1101-14 effective February 1, 1999 and Colorado Revised Statutes 8-20.5	Earthwork, building construction, landscape design, irrigation system design	Oil Inspectors Section	Oil Inspectors Section Colorado State Oil Inspection 303-620-4300 TEL oil.cdle.state.co.us
Colorado Pesticide Applicator's Act	Restricted use of pesticides and pesticide applicator training	Chemical application in industrial, commercial or agricultural use	Water Quality Control Division	www.cdphe.state.co.us/wq 303-692-3500 (TEL) 303-692-0390 (FAX)
Colorado Uniform Plumbing Code	Title 12, Article 58, of the Colorado Revised Statutes	Pipe design including irrigation system design, installation and maintenance indoor or outdoor	Colorado Department of Regulatory Agencies	www.dora.state.co.us/plumbing 303-894-2300 (TEL) 303-894-2310 (FAX)
Air Quality Permit for Construction	Colorado Revised Statutes, Article 12, Section 25-12-101	Soil disturbance causing air pollution, heavy equipment emissions, other emissions	Air Quality Control Division	www.cdphe.state.co.us/ap 303-692-3100 (TEL)
Resource Conservation and Recovery Act of 1976 (RCRA)	40 CFR Parts 260 and 261	Chemical usage, record-keeping, reporting, spill-cleanup and disposal	Hazardous Materials & Waste Management Division	www.cdphe.state.co.us/hm 303-692-3300 (TEL) 888-569-1831 (Toll-Free) 303-759-5355 (FAX)
Colorado Groundwater Management Act and Groundwater Protection Act	Groundwater quality protection and preservation	Any disturbance that potentially affects groundwater	State Engineer's Office	303-866-3581 (TEL)
Colorado Water Quality Control Commission Regulations	Water quality pollution prevention	Erosion and sediment control due to disturbed soil, chemical disposal, pollution prevention	Water Quality Control Commission	303-692-2023 (TEL)
Section 401 Water Quality Certification	5 CCR 1002-82. Project proponents are responsible for choosing appropriate BMPs and providing operation and maintenance procedure and schedules for their projects that could affect water quality	Projects which require issuance of a Federal Section 404 permit by the USACE also require a Section 401 Certification for projects not covered by a Nationwide or General Permit.	United States Army Corps of Engineers and Water Quality Control Division	Nationwide & Individual Permits 303-979-4120 (TEL) www.cdphe.state.co.us/wq 303-692-3500 (TEL) 303-692-0390 (FAX)
Minimum Instream Flows	Senate Bill 97 established minimum instream flow requirements for aquatic life protection	Irrigation system planning.	Colorado Water Conservation Board	cwcb.state.co.us and dan.mcauliffe@state.co.us
Cultural Resources - State Historic Preservation Officer	State of Colorado Historic Landmarks and Preservation	Land disturbance or building demolition	Colorado Historical Society	303-866-2390 (TEL) 1-800-305-3442 (TOLL FREE)
Wildlife Issues	Impact on migration routes, wintering and calving areas and fisheries	Any disturbance of threatened or endangered species	Colorado Division of Wildlife	Dept. of Natural Resources 303-866-3311 (TEL) Division of Wildlife 303-297-1192 (TEL)
Federal				www.epa.gov
Clean Air Act - Title V	Air pollution prevention, monitoring, reporting, permitting and protection	Soil disturbance causing air pollution, heavy equipment emissions, process off-gases	Check with City, County and State regulations as they may follow more strict and detailed guidelines than federal requirements. Land owned by the federal government follows federal regulations.	
Clean Water Act	Water pollution prevention, monitoring, reporting, permitting and protection	Erosion and sediment control due to disturbed soil, chemical disposal		
Section 404 of the Clean Water Act	Wetland permitting	Projects which require issuance of a Federal Section 404 permit by the United States Army Corps of Engineers		
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Registration, licensing, approved techniques, human health protection/training/certification, reporting, and permitting	Any activities with insect, fungus or rodent eradication for installation, building or maintenance activities		
Federal Emergency Management Agency (FEMA)	Floodplain/floodway/floodfringe determination and design requirements	Design, installation or maintenance activities		
Migratory Bird Treaty Act of 1918	Protection of birds, threatened and endangered species	Areas of disturbance inhabited by migrating species		
Federal Endangered Species act of 1973	Protection of threatened and endangered species	Areas of disturbance inhabited by threatened or endangered species		
Superfund Amendment and Reauthorization Act of 1986 (SARA)	Includes emergency planning notification, emergency and hazardous chemical inventory, community right-to-know act and toxic chemical releases. County or fire district may have reporting thresholds stricter than the federal and state regulations.	Hazardous chemical treatment, storage, disposal and spill reporting		
Occupational Safety and Health Act (OSHA)	OSHA, 29 CFR 1910.1200, Hazard Communications Standard & Material Safety Data Sheets	Safety practices associated with chemical handling, landscape and irrigation system installation.		

Disclaimer: Additional regulations may be applicable that have not been summarized in this table.

Appendix D: GreenCO Water Budget Calculator

Enter your Data in the White Areas

Name	Enter Customer's name
Acct #	999999
Address	99 Any Lane, My City
Agency	ncwcd

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1 Home/Interior Water Consumption Estimate

Enter Number of Residents	1	Persons
Low Flow Plumbing?	Yes	

2 Landscape Water Consumption Estimate

Enter Turf Area	1,000	sq.ft.	Automatic Sprinklers?	Yes
Enter Shrubs/Ground cover Area	1,500	sq.ft.		
Enter Xeriscape Area	0	sq.ft.		
Or Total Area	0	sq.ft.	OK	

3 Total Water Budget

Water Restriction	0	% Target

** Units in Gallons*

2a. Acres to Sq.Ft. Calculator:

	Acres	sq.ft.
Enter Acres	2.00	87,120

	Defaults Are:	Local Average ET (in) [enter if different than default]		Actual Usage*	Base Year Use
	0.00	Jan	0.00	9,520	9,000
	0.00	Feb	0.00	7,850	8,000
	0.00	Mar	0.00	12,690	12,500
	4.00	Apr	4.00	24,700	24,500
	4.95	May	4.95	25,620	25,500
	6.20	Jun	6.20	28,990	29,000
	6.60	Jul	6.60	40,125	40,000
	5.50	Aug	5.50	38,600	39,000
	4.00	Sep	4.00	34,256	34,000
	2.80	Oct	2.80	32,890	33,000
	0.00	Nov	0.00	16,456	12,000
	0.00	Dec	0.00	9,900	9,000

Home or Single Meter Water Budget Calculator

Data in blue boxex comes from the "Input Table"

Site Info	
Name	Enter Customer's name
Acct #	999999
Address	99 Any Lane, My City
Agency	ncwcd

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1 Home/Interior Water Consumption Estimate

Number of Residents	1	Persons
Low Flow Plumbing?	Yes	
Gallons Per Home Per Day	**55**	

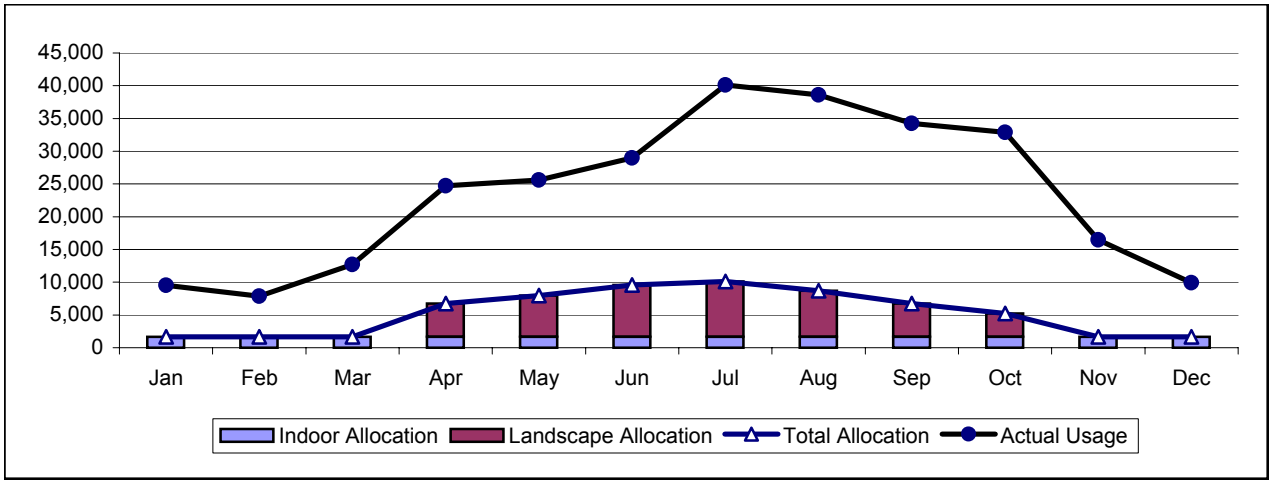
2 Landscape Water Consumption Estimate

Turf Area	1,000	sq.ft.	Automatic Sprinklers?	Yes
Shrubs/Ground cover Area	1,500	sq.ft.		
Xeriscape Area	0	sq.ft.		
Or Total Area	0	sq.ft.	OK	

3 Total Water Budget

Restriction Budget	0	% Target

** Units in Gallons*



Month	Indoor Allocation	Landscape Allocation	Total Allocation	Actual Usage	Savings Potential	Drought Budget	Base Year Use
Jan	1,650	0	1,650	9,520	7,870	1,650	9,000
Feb	1,650	0	1,650	7,850	6,200	1,650	8,000
Mar	1,650	0	1,650	12,690	11,040	1,650	12,500
Apr	1,650	5,115	6,765	24,700	17,935	6,765	24,500
May	1,650	6,330	7,980	25,620	17,640	7,980	25,500
Jun	1,650	7,928	9,578	28,990	19,412	9,578	29,000
Jul	1,650	8,440	10,090	40,125	30,035	10,090	40,000
Aug	1,650	7,033	8,683	38,600	29,917	8,683	39,000
Sep	1,650	5,115	6,765	34,256	27,491	6,765	34,000
Oct	1,650	3,581	5,231	32,890	27,660	5,231	33,000
Nov	1,650	0	1,650	16,456	14,806	1,650	12,000
Dec	1,650	0	1,650	9,900	8,250	1,650	9,000

WATER BUDGET CALCULATOR QUICK GUIDE

DOWNLOAD FILE FROM SITE

Save as (user defined) it stores on customer's hard disk.

INPUT TABLE:

Customer information

Enter as much information as you can (that is for customer's records only)

1 Home/Interior Water Consumption Estimate

- Number of residents:
  how many people live at home (or average-year round)
- Low Flow plumbing:
  Most likely, your home has Low Flow plumbing when: The majority of your showerheads, kitchen, bathroom and faucet aerators were purchased (or have been retrofitted) after 1992. For toilets, the cut-off year is 1994.

2 Landscape Water Consumption Estimate

- Turf Area:
  Measure all your turf (grass) irrigated area and enter the total here.
- Shrubs/Ground cover Area:
  Measure all your non-turf (grass) irrigated area and enter the total here.
- Xeriscape Area:
  Measure all the areas that are non-turf and have medium to low-water use plants and/or native plants.
- Total area:
  If you do not have time to measure all the different parts of your landscape, just enter your total landscape irrigated area.
- Automatic sprinklers?
- 2a. Acres to Sq.Ft. Calculator:
  Use this section to convert acres to square feet for large or commercial landscapes.

3 Total Water Budget

- Water Restriction:
  If your area has a "conservation goal" or a target percent of water reduction, enter it here. Otherwise, use zero.
- Local Average ET (in):
  This is the yearly average Evapotransporation rate (reference of the amount of water plants need in your area). We use this number, combined with the crop coefficient (Kc) for turf, shrubs/ground cover, and/or xeriscape, to calculate a water budget for every month.
  If you know the ET values of your microclimate, you can enter them.

- Actual usage:
  If you kept all your monthly water bills from your water retailer, you can enter the gallons used every month.
- Base Year Use:
  This is usually provided to us by your water retailer. It is an average use for an "average home" in your area.

RESULTS TABLE:

All data entered on the Input Table will show up here. The actual budget is calculated at the bottom of the page.

3 Total Water Budget:

- **Indoor Allocation**:
  Calculation based on the number of residents and if there are low flow plumbing devices present.
- **Landscape Allocation**:
  Calculation based on the local historical ET and the irrigated areas and their square footage.
- **Total Allocation**:
  The sum of the calculated indoor and outdoor allocations.
- **Actual Usage**:
  Same numbers taken from the Input Table
- **Savings Potential**:
  The difference between Total Allocation and Actual Usage. If Actual Usage exceeds Total Allocation, the Savings Potential will be a positive number.
- **Drought Budget**:
  Is the total allocation minus the X % entered on the Input Table
- **Base Year Use**:
  Same numbers taken from the Input Table. These are usually provided to us by your water retailer. It is an average use for an "average home" in your area.

Appendix E: Plant Water Requirement Estimates (GreenCO/CSU 2004 Crop Coefficient (Kc) Survey)

In response to the extreme drought experienced by Colorado in 2002, GreenCO and Colorado State University initiated a program to document the water needs of landscape plants and to rank each species according to its relative water usage or crop coefficient (Kc). A crop coefficient is the amount of water a species needs compared to a standard crop. For ornamental horticulture this standard crop is cool-season turf, specifically Kentucky bluegrass. The evapotranspiration rate (the combined water loss by transpiration and from evaporation from soil and plant surfaces) for Kentucky bluegrass is known as reference ET, or ET_0. Each species' crop coefficient (Kc) is a percentage of ET_0.

Through a survey of horticulturists from around the region, best professional opinions regarding crop coefficients have been compiled for the common landscape plants of Colorado. The survey was designed with guidance from Dr. Jim Klett of Colorado State University and Tom Ash, Director of Conservation Alliances, Hydropoint Data Systems. Little Valley Wholesale Nursery provided computer support and data compilation. The survey results reflect opinions only; future research at CSU will validate or modify these crop coefficients. The GreenCO website www.greenco.org should be checked for possible changes to this list.

The attached table summarizes the annual estimated irrigation application requirement for each plant based on the categories in Table 1.

Table 1

Estimated Annual Required Irrigation Application

Water Use Category	Percentage of Reference ET (ET_0 = cool season turfgrass)	Approximate Irrigation Requirement for Metro-Denver Front Range Locations[1]
High	75 – 100%	15-20 gal/sq. ft.
Medium	50 – 75%	10-14 gal/sq. ft.
Low	25-50%	5-9 gal/sq. ft.
Very Low	0-25%	0-4 gal/sq.ft.

[1]Water use estimates will be significantly higher in areas such as Pueblo and Grand Junction and significantly lower in mountainous areas such as Steamboat Springs and Vail.

The results in the spreadsheet are further categorized according to water needs for various regions of Colorado based on elevation, including the East Slope (<6,500 ft), West Slope (6,500 to 8,500 ft), and Mountain Areas (>8,500 ft). The number of survey participants providing an opinion is also listed. Survey instructions specified that participants should not comment on species for which they have no experience.

One of the primary benefits of using ET data is that it enables the user to adjust irrigation rates according to the needs of the plants throughout the growing season. Typically, irrigation application rates are adjusted in terms of inches per week or inches per month. Table 2 provides approximate required application rates at varies levels of reference ET in terms of inches per week and inches per month. Actual application rates will be affected by climate conditions.

Table 2

Approximate Weekly Irrigation Application Rates in Inches

	100% ET		75% ET		50% ET		25% ET		0% ET	
Month	Inches/ Month	Inches/ Week	Inches/ Month	Inches/ Week	Inches/ Month	Inches/ Week	Inches/ Month	Inches/ Week	Inches/ Month	Inches/ Week
April	1.00	0.25	0.75	0.17	0.50	0.12	0.25	0.06	0.00	0.00
May	4.25	1.00	3.19	0.72	2.13	0.48	1.06	0.24	0.00	0.00
June	6.50	1.50	4.88	1.13	3.25	0.76	1.63	0.38	0.00	0.00
July	6.50	1.50	4.88	1.11	3.25	0.74	1.63	0.37	0.00	0.00
Aug	5.50	1.25	4.13	0.94	2.75	0.63	1.38	0.31	0.00	0.00
Sept	4.25	1.00	3.19	0.74	2.13	0.49	1.06	0.25	0.00	0.00
Oct	2.00	0.50	1.50	0.34	1.00	0.23	0.50	0.11	0.00	0.00
Total Inches Applied	30.00		22.50		15.00		7.50		0.00	

Appendix E
Plant Water Requirement Estimates (GreenCO-CSU Crop Coefficient Survey 2004)

Estimated Water Usage for Plant: VL=Very Low < 25%; ET_0 L=Low 25%-50%; ET_0 M=Medium 50%-75%; ET_0 H=High >75% ET_0
Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Abeliophyllum distichum	Forsythia, White	S	M	10					M	10
Abies balsamea 'Nana'	Fir, Dwarf Globe Balsam	T	M	17	M	3	M	2	M	22
Abies concolor	Fir, White	T	M	43	M	10	M	12	M	65
Abies fraseri	Fir, Fraser	T	M	16	M	4	M	4	M	24
Abies koreana 'Horstmann's Silberlocke'	Fir, Silver Korean	T	M	7	M	3	M	3	M	13
Abies lasiocarpa	Fir, Subalpine	T	M	19	M	7	M	9	M	35
Acer campestre	Maple, Hedge	T	M	24	L	7	M	5	M	36
Acer ginnala	Maple, Amur	S T	L	45	L	9	L	10	L	64
Acer glabrum	Maple, Rocky Mountain	S	L	29	L	4	L	8	L	41
Acer grandidentatum	Maple, Bigtooth	S T	L	39	L	8	L	6	L	53
Acer griseum	Maple, Paperbark	T	M	19	M	4	M	3	M	26
Acer japonicum 'Aconitifolium'	Maple, Cutleaf Fullmoon	S	H	8	L	2	M	1	M	11
Acer miyabei	Maple, Miyabi	T	M	11	M	3	L	2	M	16
Acer negundo	Box Elder	T	L	34	M	9	L	4	L	47
Acer nigrum 'Greencolumn'	Maple, Greencolumn Black	T	M	9	M	2	M	1	M	12
Acer palmatum	Maple, Japanese	T	M	25	H	3	H	2	H	30
Acer platanoides	Maple, Norway	T	M	36	M	5	M	3	M	44
Acer pseudoplatanus	Maple, Sycamore	T	M	14	M	2	M	1	M	17
Acer rubrum	Maple, Red	T	M	35	M	5	M	3	M	43
Acer saccharinum	Maple, Silver	T	M	40	M	6	M	3	M	49
Acer saccharum	Maple, Sugar	T	M	28	M	4	M	3	M	35
Acer tataricum	Maple, Tatarian	S T	L	38	L	9	L	7	L	54
Acer truncatum	Maple, Shantung	T	M	8	M	2	M	1	M	11
Acer x freemanii	Maple, Freeman	T	M	27	M	5	M	4	M	36
Achillea 'Coronation Gold'	Yarrow, Golden Yellow	P	L	31	L	6	L	4	L	41
Achillea 'Moonshine'	Yarrow, Moonshine	P	L	31	L	7	L	5	L	43
Achillea 'Summer Pastels'	Yarrow, Mixed Pastels	P	L	28	L	6	L	5	L	39
Achillea ageratifolia	Yarrow, Greek	P	L	25	L	5	L	3	L	33
Achillea filipendulina	Yarrow, Tall Yellow	P	L	25	L	6	VL	5	L	36
Achillea lanulosa	Yarrow, Wooly White	P	L	21	L	4	L	3	L	28
Achillea millefolium	Yarrow, Common White	P	L	30	L	7	L	7	L	44
Achillea ptarmica 'The Pearl'	Yarrow, The Pearl	P	L	21	L	4	L	3	L	28
Achillea serbica	Yarrow, Serbian	P	L	21	L	4	L	1	L	26
Achillea tomentosa	Yarrow, Wooly Yellow	P	L	24	L	5	L	3	L	32
Aconitum columbianum	Monkshood, Columbian	P	H	11	M	1	H	1	H	13
Aconitum napellus	Monkshood, Garden	P	M	19	H	3	H	2	H	24
Aconitum x cammarum	Monkshood, Bicolor	P	M	11					M	11
Actinidia arguta	Kiwi, Hardy	P	M	8					M	8
Actinidia kolomikta	Kiwi, Variegated	V	M	10					M	10
Adiantum pedatum	Fern, Western Maidenhair	P	H	11	H	2			H	13
Aegopodium podograria	Bishop's Weed	GCP	M	26	M	4	M	3	M	33
Aesculus glabra	Buckeye, Ohio	T	M	37	M	5	M	3	M	45
Aesculus hippocastanum	Horsechestnut	T	M	33	M	3	H	2	M	38
Aesculus octandra	Buckeye, Yellow	T	M	19	M	3	L	2	M	24
Aesculus parviflora	Buckeye, Bottlebrush	S	M	14	M	2	H	2	M	18
Aesculus x carnea	Horsechestnut, Red	T	M	23	M	3	M	3	M	29
Aethionema coridifolium	Stonecress, Lebanon	P	L	9	M	3	M	1	L	13
Aethionema grandiflorum	Stonecress, Persian	P	L	11	L	3			L	14
Agapanthus africanus	Lily of the Nile	A	M	14			M	1	M	15
Agastache 'Blue Fortune'	Hyssop, Blue Fortune Anise	P	L	21	L	3	L	1	L	25
Agastache aurantiaca 'Coronado'	Hyssop, Coronado	P	L	30	L	3	L	1	L	34
Agastache barberi	Giant Hummingbird's Mint	P	L	20	L	3	L	1	L	24
Agastache cana	Double Bubblemint	P	L	28	L	4	L	1	L	33
Agastache foeniculum	Hyssop, Anise	P	L	18	L	2	L	1	L	21
Agastache rupestris	Hyssop, Sunset	P	L	31	L	4	L	2	L	37
Ageratum houstonianum	Ageratum	A	M	18	L	3	M	4	M	25
Agropyron cristatum	Crested Wheatgrass	TU	L	20	L	3	L	2	L	25
Agrostis palustris	Bentgrass	TU	H	10			H	1	H	11
Ajania pacifica	Daisy, Pacific	P	L	6	L	1	L	1	L	8
Ajuga genevensis 'Pink Beauty'	Carpet Bugle, Pink Beauty	GC	M	19	M	3	L	2	M	24
Ajuga pyramidalis 'Metallica Crispa'	Carpet Bugle, Pyramid	GC	M	19	M	2			M	21
Ajuga reptans	Carpet Bugle, Green	GC	M	26	M	2	M	2	M	30
Akebia quinata	Chocolate Vine	V	M	7					M	7
Alcea rosea	Hollyhock	P	L	32	L	4	L	3	L	39
Alchemilla alpina	Lady's Mantle, Alpine	P	M	12	L	1	L	1	M	14
Alchemilla erythropoda	Lady's Mantle, Red	P	M	9	M	2			M	11
Alchemilla mollis	Lady's Mantle	P	M	24	M	2	L	1	M	27
Allium cernuum	Nodding Onion	P	L	17	L	1	L	2	L	20
Allium geyeri	Geyer Onion	P	L	10	L	1	M	1	L	12
Allium schoenoprasum	Chives	P	L	25	M	1	M	1	L	27
Alnus glutinosa	Alder, Black	S T	H	28	M	7	M	6	M	41
Alnus rubra	Alder, Red	S	H	9	H	2	H	2	H	13
Alnus tenuifolia	Alder, Thinleaf	S T	M	37	M	8	M	9	M	54
Alyssum montanum 'Mountain Gold'	Basket of Gold, Mountain	P	L	27	L	5	L	3	L	35
Alyssum sp.	Alyssum	A	M	23	L	2	L	4	M	29
Amaranthus spp.	Amaranth	A	L	15	M	2	L	2	L	19
Amelanchier alnifolia	Serviceberry, Saskatoon	S	L	32	L	9	L	8	L	49
Amelanchier canadensis	Serviceberry, Shadblow	S T	L	39	L	9	L	9	L	57
Amelanchier laevis	Serviceberry, Allegheny	S T	M	28	L	4	L	4	L	36
Amelanchier lamarckii	Serviceberry, Lamarck	S T	L	20	L	5	L	5	L	30
Amelanchier stolonifera	Serviceberry, Running	S	L	14	L	4	L	5	L	23
Amelanchier utahensis	Serviceberry, Utah	S	L	18	L	5	L	5	L	28
Amelanchier x grandiflora	Serviceberry, Apple	S T	M	27	L	6	L	5	L	38
Amorpha canescens	Leadplant	S	VL	31	VL	6	VL	1	VL	38
Amorpha fruticosa	False Indigo	S	L	25	L	5	L	4	L	34

Appendix E
Plant Water Requirement Estimates (GreenCO-CSU Crop Coefficient Survey 2004)

Estimated Water Usage for Plant: VL=Very Low < 25%; ET_0 L=Low 25%-50%; ET_0 M=Medium 50%-75%; ET_0 H=High >75% ET_0
Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Amorpha nana	Fragrant False Indigo	S	VL	20	VL	3	VL	2	VL	25
Ampelopsis brevipendunculata	Porcelain Berry Vine	V	M	16	M	1			M	17
Amsonia jonesii	Jones' Bluestar	P	L	12	M	2			L	14
Anacyclus pyrethrum var. depressus	Daisy, Mt. Atlas	P	L	21	L	3	M	1	L	25
Anaphalis margaritacea	Pearly Everlasting	P	L	12	L	3	L	3	L	18
Anchusa spp.	Bugloss	A P	M	17	L	2	L	1	M	20
Andropogon gerardii	Bluestem, Big	P	L	23	L	3	L	1	L	27
Andropogon saccharoides	Bluestem, Silver	P	L	15	L	1	L	1	L	17
Anemone biarmiensis	Anemone, Yellow	P	M	10	M	3	L	2	M	15
Anemone canadensis	Anemone, Meadow	P	M	15	M	3	L	1	M	19
Anemone cylindrica	Thimbleweed	P	M	10	M	3	M	1	M	14
Anemone multifida	Windflower	P	M	15	M	3	M	3	M	21
Anemone sylvestris	Anemone, Snowdrop	P	M	19	L	2	M	1	M	22
Anemone tomentosa 'Robustissima'	Anemone, Grape-leaved	P	M	16	M	2	M	1	M	19
Anemone x hybrida	Anemone, Hybrid	P	M	18	M	2	M	1	M	21
Angelonia spp.	Summer Snapdragon	A	M	9					M	9
Antennaria dioica 'Rubra'	Pussytoes, Pink	P	L	25	VL	3	VL	4	L	32
Antennaria parvifolia	Pussytoes, Dwarf	P	L	24	VL	5	VL	5	VL	34
Anthemis marschalliana	Daisy, Filigree	P	L	8	L	1			L	9
Anthemis tinctoria	Daisy, Marguerite	P	L	18	L	2	L	1	L	21
Antirrhinum majus	Snapdragon	A	M	19	L	4	M	4	M	27
Aquilegia alpina	Columbine, Alpine	P	M	24	M	5	L	4	M	33
Aquilegia barnebyi	Columbine, Barneby's	P	L	15	L	4	M	2	M	21
Aquilegia caerulea	Columbine, Rocky Mountain	P	M	36	M	8	M	8	M	52
Aquilegia canadensis	Columbine, Dwarf Red	P	M	22	M	6	L	4	M	32
Aquilegia chrysantha	Columbine, Yellow	P	L	32	M	7	L	4	L	43
Aquilegia cultivars	Columbine	P	M	27	M	5	M	6	M	38
Aquilegia discolor	Columbine, Spanish	P	M	11	M	3	M	2	M	16
Aquilegia elegantula	Columbine, Dwarf Red	P	M	18	M	3	M	3	M	24
Aquilegia flabellata 'Kurilensis'	Columbine, Compact Pink	P	M	15	M	4	M	2	M	21
Aquilegia formosa	Columbine, Western Red	P	M	15	M	4	M	2	M	21
Aquilegia saximontana	Columbine, Dwarf Blue	P	M	21	M	4	M	3	M	28
Aquilegia vulgaris	Columbine, Garden	P	M	21	M	3	M	4	M	28
Arabis blepharophylla 'Spring Charm'	Rockcress, Spring Charm	P	M	13	L	3	L	2	L	18
Arabis caucasica 'Snowcap'	Rockcress, White Alpine	P	L	19	L	4	L	2	L	25
Arctostaphylos nevadensis	Bearberry, Nevada	GCP S	L	26	L	5	L	2	L	33
Arctostaphylos patula	Manzanita, Greenleaf	S	L	17	L	3	VL	1	L	21
Arctostaphylos uva-ursi	Kinnikinnick	GCP S	L	36	L	8	L	9	L	53
Arenaria montana	Sandwort, Mountain	P	L	14	L	3	L	2	L	19
Argyranthemum	Marguerite Daisy	A	M	14			M	1	M	15
Aristolochia durior	Dutchman's Pipe	V	M	13					M	13
Armeria 'Victor Reiter'	Sea Pinks, Victor Reiter	P	M	12	L	2	M	1	M	15
Armeria maritima	Sea Pinks	P	M	24	M	3	M	1	M	28
Armeria pseudarmeria	Sea Pinks, Wide-leaved	P	M	10	L	2			M	12
Arnica cordifolia	Arnica, Heartleaf	P	M	7	L	2	L	2	M	11
Aronia arbutifolia 'Brilliantissima'	Chokeberry, Brilliant Red	S	M	24	L	4	L	3	M	31
Aronia melanocarpa	Chokeberry, Black	S	L	29	L	5	L	3	L	37
Aronia x prunifolia	Chokeberry, Purple	S	L	17	L	2	L	2	L	21
Artemisia 'Powis Castle'	Sage, Powis Castle	P	L	22	L	6	L	3	L	31
Artemisia abrotanum	Sage, Southernwood	S	L	16	VL	3	VL	3	VL	22
Artemisia absinthium	Sage, Common Wormwood	P	VL	11	VL	2	VL	1	VL	14
Artemisia cana	Sagebrush, Silver	S	VL	26	VL	5	VL	6	VL	37
Artemisia filifolia	Sagebrush, Sand	S	VL	25	VL	6	VL	6	VL	37
Artemisia frigida	Sage, Fringed	P S	VL	34	VL	8	VL	8	VL	50
Artemisia ludoviciana	Sagewort, Prairie	S	VL	19	VL	5	VL	6	VL	30
Artemisia schmidtiana	Sage, Silver Mound	P	L	25	VL	3	VL	2	L	30
Artemisia stellerana 'Silver Brocade'	Sage, Silver Brocade	P	L	18	L	4	VL	2	L	24
Artemisia tridentata	Sagebrush, Tall Western	S	VL	32	VL	9	VL	9	VL	50
Artemisia tripartita	Sagebrush, Three Parted	S	VL	18	VL	3	VL	3	VL	24
Aruncus dioicus	Goats Beard	P	M	13	L	1			M	14
Arundo donax	Grass, Giant Reed	P	M	10	H	1			M	11
Asclepias incarnata	Milkweed, Swamp	P	M	17	H	1	H	1	M	19
Asclepias speciosa	Milkweed, Showy	P	L	14	L	2	L	2	L	18
Asclepias tuberosa	Gay Butterfly	P	L	23	L	5	L	1	L	29
Aster 'Wood's Purple'	Aster, Wood's Purple	P	M	12	M	3	M	2	M	17
Aster alpinus	Aster, Alpine	P	L	22	L	4	L	1	L	27
Aster bigelovii	Aster, Plains	P	L	14	L	2	M	1	L	17
Aster laevis	Aster, Smooth	P	L	11	L	2	L	2	L	15
Aster novae-angliae	Aster, New England	P	M	21	M	3	M	2	M	26
Aster novi-belgii	Aster, Dwarf Fall	P	M	26	M	5	VL	1	M	32
Aster porteri	Aster, Porter	P	L	11	L	1			L	12
Aster tongolensis 'Wartburg Star'	Aster, Purple	P	M	15	L	2			M	17
Aster x frikartii 'Monch'	Aster, Monch Frikart's	P	M	22	L	3	M	1	M	26
Astilbe chinensis	False Spirea, Chinese	P	H	17	M	3	H	1	H	21
Astilbe x arendsii	False Spirea	P	H	16	M	3	H	1	H	20
Astilbe x japonica	False Spirea	P	H	15	M	3	M	1	H	19
Astilbe x simplicifolia '	False Spirea, Star	P	H	11	M	1	H	1	H	13
Astilbe x thunbergii	False Spirea	P	H	10	H	2	H	1	H	13
Astrantia carniolica	Masterwort, Giant	P	M	5	H	1			M	6
Astrantia major	Masterwort	P	M	8	H	1			M	9
Athyrium filix-femina	Fern, Lady	P	H	12	H	1	H	1	H	14
Athyrium nipponicum 'Pictum'	Fern, Japanese Painted	P	H	14	H	1	M	1	H	16
Atriplex canescens	Saltbush, Four Wing	S	VL	26	VL	7	VL	4	VL	37
Atriplex confertifolia	Saltbush, Spiny	S	VL	18	VL	3	VL	2	VL	23
Atriplex corrugata	Saltbush, Mat	S	VL	14	VL	4	VL	2	VL	20

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Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Atriplex garderni	Saltbush, Gardner's	S	VL	9	VL	3	VL	2	VL	14
Aubrieta deltoidea 'Purple Gem'	Rockcress, Purple	P	L	18	L	2	L	1	L	21
Aubrieta x cultorum	Rockcress, Hybrid	P	L	11	M	1			L	12
Aurinia saxatilis 'Gold Ball'	Basket-of-Gold Alyssum	P	L	27	L	5	L	3	L	35
Baccharis glutinosa	Seep-Willow	S	L	5	H	1	H	1	M	7
Baccharis pilularis	Coyote Brush	S	L	5	H	1	H	1	M	7
Bacopa spp.	Water Hyssop	A	M	10			M	2	M	12
Baileya multiradiata	Desert Marigold	P	VL	8	L	2	L	1	VL	11
Baptisia australis	False Indigo	P	L	21	L	3	L	2	L	26
Begonia semperflorens	Wax Begonia	A	H	17			H	2	H	19
Belamcanda chinensis	Lily, Blackberry	P	L	14	M	1			L	15
Bellis perennis	Daisy, English	A P	M	10			M	1	M	11
Bellium minutum	Daisy, Miniature Mat	P	M	10					M	10
Berberis koreana	Barberry, Korean	S	L	25	L	3	L	2	L	30
Berberis thunbergii	Barberry, Japanese	S	L	36	L	4	L	4	L	44
Berberis x 'Tara'	Barberry, Emerald Carousel	S	L	18	L	3	L	2	L	23
Berberis x gladwynensis 'William Penn'	Barberry, William Penn	S	M	14	L	2	M	3	M	19
Berberis x mentorensis	Barberry, Mentor	S	L	26	L	3	L	2	L	31
Bergenia cordifolia	Bergenia, Heart-Leaved	P	M	21	L	2			M	23
Berlandiera lyrata	Chocolate Flower	P	L	20	VL	3	L	1	L	24
Betula 'Crimson Frost'	Birch, Crimson Frost	S T	H	25	H	4	M	4	H	33
Betula fontinalis /occidentalis	Birch, Native River	S T	H	34	M	6	M	6	M	46
Betula jacquemontii	Birch, Himalayan White	S T	H	21	M	3	M	3	H	27
Betula maximowicziana	Birch, Monarch Clump	T	H	12	H	1	H	1	H	14
Betula nigra	Birch, River	T	H	37	H	4	M	3	H	44
Betula papyrifera	Birch, Paper	T	H	35	H	3	M	3	H	41
Betula pendula	Birch, Weeping	T	H	31	H	3	M	3	H	37
Betula platyphylla	Birch, White	T	H	22	H	2	H	2	H	26
Betula x 'Rocky Mountain Splendor'	Birch, Rocky Mt Splendor	T	M	15	M	2	H	3	M	20
Boltonia asteroides	Boltonia	P	M	18	L	2	L	1	M	21
Bouteloua curtipendula	Grass, Side Oats Grama	P	L	15	L	6	L	3	L	24
Bouteloua gracilis	Grass, Blue Grama	P TU	VL	25	VL	5	VL	4	VL	34
Brachycome iberidifolia	Daisy, Swan River	A	M	11			M	2	M	13
Brassica oleracea	Ornamental Cabbage or Kale	A	M	14			M	3	M	17
Bromus inermis	Smooth Brome	TU	L	10	VL	1	M	3	L	14
Browallia speciosa	Bush Violet	A	M	11			H	1	M	12
Brunnera macrophylla	False Forget-Me-Not	P	M	20	L	2	M	1	M	23
Buchloe dactyloides	Buffalograss	TU	VL	28	VL	4	VL	2	VL	34
Buddleja alternifolia	Butterfly Bush, Alternate	S	L	30	L	5	L	2	L	37
Buddleja davidii	Butterfly Bush	S	M	38	L	4	L	2	M	44
Buddleja x weyeriana	Butterfly Bush, Yellow	S	M	12	L	1	L	1	L	14
Buxus microphylla	Boxwood, Littleleaf	S	M	23	M	2	M	1	M	26
Buxus sempervirens	Boxwood, Common	S	M	23	M	3	M	2	M	28
Calamagrostis acutiflora	Grass, Feather Reed	P	L	27	M	6	M	1	L	34
Calamagrostis brachytricha	Grass, Korean Feather Reed	P	L	11	M	3	M	1	L	15
Calandrinia umbellata 'Ruby Tuesday'	Rock Purslane	P	L	6					L	6
Calendula officinalis	Calendula	A	M	19	M	1	L	2	M	22
Callicarpa japonica	Beautyberry, Japanese	S	M	11	M	2	M	2	M	15
Callirhoe alcaeoides 'Logan Calhoun'	Prairie Winecups, White	P	L	14	L	1			L	15
Callirhoe involucrata	Prairie Winecups	P	L	30	VL	5	L	1	L	36
Calocedrus decurrens	Cedar, Incense	T	M	7	L	2	L	2	M	11
Calochortus gunnisonii	Mariposa Lily	P	VL	9	VL	1	L	2	L	12
Caltha leptosepala	Marsh Marigold, White	P	H	7	H	2	H	2	H	11
Caltha palustris	Marsh Marigold, Yellow	P	H	8	H	2	H	1	H	11
Calycanthus floridus	Carolina Allspice	S	H	4	H	1	H	1	H	6
Calylophus hartwegii fendleri	Sundrops, Fendler's	P	L	18	VL	6	L	1	L	25
Calylophus serrulatus	Shrubby Evening Primrose	P	L	4					L	4
Campanula carpatica	Harebell, Carpathian	P	M	19	M	3	M	1	M	23
Campanula cochleariifolia	Bluebells, Little	P	M	15	M	3	M	1	M	19
Campanula garganica	Bellflower, Greek	P	M	14	M	3	M	1	M	18
Campanula glomerata	Bellflower, Clustered	P	M	21	M	3	M	1	M	25
Campanula lactiflora	Bellflower, Milky	P	M	10	L	2			M	12
Campanula medium	Canterbury Bells	A P	M	16	M	3	H	2	M	21
Campanula persicifolia	Bellflower, Peach-Leaved	P	M	22	M	3	M	1	M	26
Campanula portenschlagiana	Bellflower, Dalmatian	P	M	16	L	2	M	1	M	19
Campanula poscharskyana	Blue Bells, Adriatic	P	M	18	L	2	M	1	M	21
Campanula punctata 'Cherry Bells'	Bellflower, Cherry Bells	P	M	11	L	1			M	12
Campanula rotundifolia	Harebell, Blue Native	P	L	27	L	5	L	3	L	35
Campsis radicans	Trumpet Vine	P V	L	23					L	23
Campsis x tagliabuana	Trumpet Vine	P V	L	13					L	13
Canna x generalis	Canna	A	H	19	H	1	H	1	H	21
Caragana arborescens	Peashrub, Siberian	S	L	33	VL	8	L	7	L	48
Caragana frutex	Peashrub, Russian	S	L	19	VL	4	L	2	L	25
Caragana maximowicziana	Peashrub, Maximowics	S	VL	12	L	2	L	1	VL	15
Caragana microphylla	Peashrub, Littleleaf	S	VL	12	VL	3	L	1	VL	16
Caragana pygmaea	Peashrub, Pygmy	S	L	22	VL	6	VL	3	L	31
Carex aquatilis	Sedge, Water	P	H	8	H	2	H	1	H	11
Carex buchananii	Sedge, Leatherleaf	P	M	12	M	2			M	14
Carex comans	Sedge, New Zealand Hair	A	M	4					M	4
Carex conica	Sedge, Dwarf	P	M	4	M	1			M	5
Carex elata	Sedge, Tufted	P	M	5	M	1	H	1	M	7
Carex flacca	Sedge, Blue Green	P	M	5					M	5
Carex flagelifera	Sedge, Copperleaf	P	M	4	H	1			M	5
Carex glauca	Sedge, Blue	P	M	4	M	1			M	5
Carex lanuginosa	Sedge, Hairy	P	H	5	H	2	H	1	H	8

Appendix E
Plant Water Requirement Estimates (GreenCO-CSU Crop Coefficient Survey 2004)

Estimated Water Usage for Plant: VL=Very Low < 25%; ET_0 L=Low 25%-50%; ET_0 M=Medium 50%-75%; ET_0 H=High >75% ET_0
Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Carex morrowii	Sedge, Japanese	P	M	7	H	1			M	8
Carex muskingumensis	Sedge, Palm	P	M	4	H	1			M	5
Carex nebraskensis	Sedge, Nebraska	P	H	5	H	1	H	1	H	7
Carex rostrata	Sedge, Beaked	P	H	4	H	2	H	1	H	7
Carpinus betulus	Hornbeam, European	T	M	21	M	2	M	2	M	25
Carpinus caroliniana	Hornbeam, American	T	M	21	M	3	M	3	M	27
Carpinus japonica	Hornbeam, Japanese	T	M	5	M	1	M	1	M	7
Caryopteris incana	Spirea, Blue Mist	S	L	25	L	5	VL	3	L	33
Caryopteris x clandonensis	Spirea, Blue Mist	S	L	40	L	6	VL	5	L	51
Castilleja integra	Indian Paintbrush, Orange	P	L	20	VL	3	L	2	L	25
Castilleja linariaefolia	Indian Paintbrush, Wyoming	P	L	12	VL	1	L	2	L	15
Castilleja miniata	Indian Paintbrush, Scarlet	P	L	12	VL	1	M	1	L	14
Castilleja rhexifolia	Indian Paintbrush, Rose	P	L	10	VL	1	H	2	L	13
Catalpa ovata	Catalpa, Chinese	T	M	18	L	3	L	3	L	24
Catalpa speciosa	Catalpa, Western	T	L	44	L	6	L	3	L	53
Catananche caerulea	Cupid's Dart	P	L	14			L	1	L	15
Catharanthus roseus	Periwinkle, Madagascar	A	L	14	L	1	L	2	L	17
Ceanothus fendleri	Deerbrush	S	L	13	VL	4	L	5	L	22
Ceanothus gloriosus	Point Reyes Creeper	S	L	4	L	2	L	2	L	8
Ceanothus velutinus	Snowbrush	S	L	8	M	1	M	1	M	10
Cedrus deodora	Cedar, Deodar	T	M	11	M	3	L	2	L	16
Cedrus libani atlantica	Cedar, Blue Atlas	T	M	11	M	1	M	1	M	13
Celastrus scandens	American Bittersweet	S V	L	20	L	3	L	2	L	25
Celosia argentea plumosa	Cockscomb	A	M	19	M	1	L	2	M	22
Celtis laevigata	Sugarberry	T	L	8	L	2	L	2	L	12
Celtis occidentalis	Hackberry, Western	T	L	40	L	7	L	5	L	52
Celtis reticulata	Hackberry, Canyon	S T	L	22	L	4	L	4	L	30
Centaurea cyanus	Bachelor Button	A	L	25	L	3	L	3	L	31
Centaurea dealbata	Bachelor Button, Pink	P	L	15	L	1	L	1	L	17
Centaurea montana	Bachelor Button, Perennial	P	M	23	VL	1	M	1	L	25
Centranthus ruber	Valerian, Red	P	L	29	L	4	L	3	L	36
Cerastium alpinum lanatum	Wooly Cerastium	P	L	4	L	1			L	5
Cerastium arvense	Chickweed, Mouse-ear	P	L	9	L	1	L	1	L	11
Cerastium tomentosum	Snow-In-Summer	P	L	30	VL	4	VL	3	L	37
Ceratostigma plumbaginoides	Plumbago	P	L	21	M	1			L	22
Cercidiphyllum japonicum	Katsura Tree	T	M	11	H	2	H	2	M	15
Cercis canadensis	Redbud, Eastern	S T	M	42	M	7	L	4	M	53
Cercocarpus breviflorus	Mountain Mahogany, Little Flowere	S	VL	19	VL	5	VL	4	VL	28
Cercocarpus ledifolius	Mountain Mahogany, Curlleaf	S T	VL	40	VL	11	VL	7	VL	58
Cercocarpus montanus	Mountain Mahogany, Common	S T	VL	38	VL	11	VL	9	VL	58
Chaenomeles japonica	Quince, Japanese Flowering	S	M	28	L	4	L	3	L	35
Chaenomeles speciosa	Quince, Flowering	S	M	23	L	3	L	3	L	29
Chaenomeles x superba	Quince, Hybrid Flowering	S	L	15	L	1	L	1	L	17
Chamaebatiaria millefolium	Fernbush	S	VL	25	VL	4	VL	4	VL	33
Chamaecyparis obtusa	Cypress, Hinoki	S	M	13	M	1	M	1	M	15
Chamaecyparis pisifera	Cypress, Japanese False	T	M	10	L	2	L	2	M	14
Chamaemelum nobile	Chamomile	P	L	8	L	1	M	1	L	10
Chamerion angustifolium	Fireweed	P	L	9	L	1	L	3	L	13
Chasmanthium latifolium	Sea Oats, Northern	P	M	16	M	1			M	17
Chilopsis linearis	Desert Willow	S	L	12	VL	3	L	2	L	17
Chionanthus retusus	Fringe Tree, Chinese	S T	M	11	L	3	L	3	M	17
Chionanthus virginicus	Fringe Tree, White	S T	M	19	L	3	M	3	M	25
Chitalpa tashkentensis	Chitalpa	S	L	8	L	2	L	2	L	12
Chrysanthemum x morifolium	Garden Mum	P	M	28	M	3	M	2	M	33
Chrysothamnus nauseosus	Rabbitbrush	S	VL	36	VL	9	VL	5	VL	50
Chrysothamnus viscidiflorus	Rabbitbrush, Sticky	S	VL	24	VL	6	VL	2	VL	32
Cimicifuga racemosa	Black Snakeroot	P	M	16	M	1			M	17
Cimicifuga simplex 'White Pearl'	White Bottlebrush	P	M	10	M	1			M	11
Cladrastis lutea	Yellowwood	T	M	19	M	3	L	3	M	25
Clematis alpina	Clematis, Alpine	P V	M	13			M	1	M	14
Clematis columbiana	Clematis, Columbian Virgin's Bow	P V	M	7			M	2	M	9
Clematis cultivars	Clematis	P V	M	29	L	2	M	1	M	32
Clematis hirsutissima	Clematis, Woolly	P	L	10	VL	1	L	2	L	13
Clematis integrifolia	Clematis, Bush	P	M	13			L	1	M	14
Clematis ligusticifolia	Clematis, Western Virgin's Bower	P V	L	17	VL	2	L	3	L	22
Clematis montana rubens	Clematis, Pink Anemone	P V	M	11					M	11
Clematis paniculata	Clematis, Spring	P V	M	16	M	1	M	1	M	18
Clematis pitcheri	Clematis, Purple Leatherflower	P V	M	9					M	9
Clematis tangutica	Clematis, Yellow Lantern	P V	L	16			L	1	L	17
Clematis terniflora	Clematis, Sweet Autumn	P V	L	16	L	1	M	1	L	18
Clematis texensis	Clematis, Scarlet	P	M	9					M	9
Clematis virginiana	Clematis, Virgin's Bower	P V	L	8			H	1	M	9
Clematis viticella	Clematis, Italian	P V	M	9					M	9
Cleome hassleriana	Spiderflower	A	M	15	M	1	H	2	M	18
Cleome serrulata	Rocky Mountain Beeplant	A	L	10	L	1	L	3	L	14
Clethra alnifolia	Summersweet	S	H	8	H	2	H	1	H	11
Coleus spp.	Coleus	A	M	25			M	3	M	28
Colutea arborescens	Bladder Pod	S	L	8	L	2	M	1	L	11
Convallaria majalis	Lily-of-the-Valley	GCP	M	25	M	1	M	1	M	27
Coreopsis 'Limerock Ruby'	Coreopsis, Limerock Ruby	P	M	14					M	14
Coreopsis auriculata	Coreopsis, Eared	P	L	20	VL	1			L	21
Coreopsis grandiflora	Coreopsis, Large-flowered	P	L	23	L	2	L	1	L	26
Coreopsis lanceolata	Coreopsis, Lance-leaf	P	L	25	L	3	L	2	L	30
Coreopsis rosea	Coreopsis, Pink	P	M	18	L	2	L	1	M	21
Coreopsis tinctoria	Coreopsis, Plains	A	L	19	L	1	L	2	L	22

Appendix E
Plant Water Requirement Estimates (GreenCO-CSU Crop Coefficient Survey 2004)

Estimated Water Usage for Plant: VL=Very Low < 25%; ET_0 L=Low 25%-50%; ET_0 M=Medium 50%-75%; ET_0 H=High >75% ET_0
Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Coreopsis verticillata	Coreopsis, Thread Leaf	P	L	25	L	3	L	1	L	29
Cornus alba	Dogwood, Tatarian	S	M	21	M	2	M	2	M	25
Cornus alternifolia	Dogwood, Pagoda	S T	M	26	M	3	M	2	M	31
Cornus anomum	Dogwood, Silky	S	M	7	H	1	H	1	H	9
Cornus canadensis	Dogwood, Bunchberry	S	M	11	M	2	M	3	M	16
Cornus florida	Dogwood, Flowering	T	H	20	H	3	M	2	M	25
Cornus kousa	Dogwood, Kousa	S T	M	23	H	4	M	3	M	30
Cornus mas	Dogwood, Cornelian Cherry	S T	M	25	M	5	M	3	M	33
Cornus pumila	Dogwood, Dwarf Red Tipped	S	M	12	H	1	H	1	M	14
Cornus racemosa	Dogwood, Gray	S T	M	23	M	5	M	4	M	32
Cornus sericea (stolonifera)	Dogwood, Redosier	S	M	23	M	3	H	4	M	30
Cornus stolonifera 'Kelseyi'	Dogwood, Kelsey Dwarf	S	M	28	M	4	M	2	M	34
Cortaderia selloana	Grass, Pampas	P	L	11					L	11
Corylus americana	Filbert, American	T	M	19	M	3	M	3	M	25
Corylus avellana 'Contorta'	Harry Lauder's Walkingstick	S	M	21	M	3	M	2	M	26
Corylus colurna	Filbert, Turkish	T	L	20	M	3	L	3	L	26
Corylus cornuta	Filbert, Beaked	S	M	10	M	2	M	2	M	14
Cosmos bipinnatus	Cosmos	A	L	27	L	1	L	2	L	30
Cotinus coggygria	Smoke Tree	S	M	27	L	4	L	2	M	33
Cotoneaster adpressa praecox	Cotoneaster, Creeping	S	M	13	M	3	L	2	M	18
Cotoneaster apiculatus	Cotoneaster, Cranberry	S	L	33	M	5	L	3	L	41
Cotoneaster congestus	Cotoneaster, Pyrenees	S	L	8	L	1	L	1	L	10
Cotoneaster dammeri	Cotoneaster, Bearberry	S	M	24	M	3	L	2	M	29
Cotoneaster divaricatus	Cotoneaster, Spreading	S	L	27	L	5	L	5	L	37
Cotoneaster glaucophyllus	Cotoneaster, Grey	S	L	10	L	1	L	1	L	12
Cotoneaster horizontalis	Cotoneaster, Rock	S	M	27	L	2	L	2	M	31
Cotoneaster lacteus /parneyi	Cotoneaster, Parney's Red	S	M	10	L	2	L	2	M	14
Cotoneaster lucidus /acutifolius	Cotoneaster, Peking	S	L	33	L	5	L	4	L	42
Cotoneaster multiflorus	Cotoneaster, Many Flowered	S	L	18	L	2	L	2	L	22
Cotoneaster nanshan	Cotoneaster, Creeping	S	L	9	L	1	L	1	L	11
Cowania mexicana	Cliffrose	S	VL	28	VL	5	VL	5	VL	38
Crambe cordifolia	Colewort	P	M	11					M	11
Crataegus 'Skinner Dwarf'	Hawthorn, Skinner Dwarf	T	L	10	L	1	L	1	L	12
Crataegus ambigua	Hawthorn, Russian	S T	L	40	L	8	L	6	L	54
Crataegus arnoldiana	Hawthorn, Arnold	T	M	12	L	2	L	2	L	16
Crataegus chrysocarpa	Hawthorn, Fire Berry	S T	L	13	L	3	L	3	L	19
Crataegus crus-galli	Hawthorn, Cockspur	S T	L	40	L	7	L	5	L	52
Crataegus crus-galli 'Inermis'	Hawthorn, Thornless Cockspur	S T	L	37	L	6	L	5	L	48
Crataegus douglassii	Hawthorn, Douglas	S T	L	23	L	6	L	4	L	33
Crataegus laevigata	Hawthorn, English	T	M	24	L	3	L	3	L	30
Crataegus mollis	Hawthorn, Downy	S T	L	28	L	6	L	4	L	38
Crataegus phaenopyrum	Hawthorn, Washington	S T	L	40	L	7	L	4	L	51
Crataegus punctata	Hawthorn, Thicket	T	L	9	L	1			L	10
Crataegus rivularis	Hawthorn, River	S T	M	16	L	3	L	3	L	22
Crataegus succulenta	Hawthorn, Colorado	S T	L	17	L	3	L	3	L	23
Crataegus x mordenensis	Hawthorn, Morden	T	L	18	L	2	L	2	L	22
Cuphea spp.	Cigar Flower	A	M	7			M	1	M	8
Cupressocyparis leylandii	Cypress, Leyland	T	M	6	L	2	L	2	M	10
Cupressus arizonica	Cypress, Arizona	T	L	12	L	3	L	2	L	17
Cytisus purgans 'Spanish Gold'	Broom, Spanish Gold	S	L	31	VL	3	L	3	L	37
Cytisus scoparius	Broom, Scotch	S	L	23	L	2	L	3	L	28
Cytisus x praecox	Broom, Warminster	S	L	22	L	2	L	1	L	25
Dahlia pinnata	Dahlia	A	M	21			M	2	M	23
Dalea formosa	Indigo Bush	P	L	7					L	7
Dalea purpurea	Clover, Purple Prairie	P	L	14			M	1	L	15
Daphne cneorum	Daphne, Rose	S	M	15	L	3	M	3	M	21
Daphne x burkwoodi	Daphne, Burkwood	S	M	31	L	3	M	3	M	37
Dasylirion wheeleri	Sotol Yucca	S	L	10	L	2	M	1	L	13
Datura sp.	Angel's Trumpet	A	L	16			M	1	L	17
Davidia involucrata	Dove Tree	T	M	6	M	1	M	1	M	8
Delosperma Mesa Verde	Iceplant, Mesa Verde	P	L	21	L	2	L	2	L	25
Delosperma Table Mountain	Iceplant, Table Mountain	P	L	21	L	2	L	2	L	25
Delosperma cooperi	Iceplant, Purple	P	L	31	L	4	L	2	L	37
Delosperma floribundum 'Starburst'	Iceplant, Starburst	P	L	24	L	3	L	2	L	29
Delosperma nubigenum	Iceplant, Yellow Hardy	P	L	27	L	4	L	2	L	33
Delphinium grandiflorum	Larkspur, Chinese	P	M	21	M	4	L	4	M	29
Delphinium nelsonii	Larkspur, Nelson	P	L	8	M	1	M	1	L	10
Delphinium species	Larkspur,	P	M	18	M	4	M	5	M	27
Delphinium x Pacific Giant	Larkspur, Mixed	P	M	23	M	3	M	4	M	30
Dendranthema weyrichii 'Pink Bomb'	Daisy, Pink Bomb	P	M	8	M	1	M	1	M	10
Dendranthema x rubellum 'Clara Curtis'	Daisy, Rose Pink	P	M	13	M	1	M	1	M	15
Deschampsia cespitosa	Grass, Tufted Hair	P	M	15	M	2	H	2	M	19
Deutzia gracilis	Deutzia, Slender	S	M	10	M	2	M	2	M	14
Dianthus anatolicus	Pinks, Anatolian	P	L	9	L	1	L	2	L	12
Dianthus barbatus	Sweet William	P	M	24	L	2	M	3	M	29
Dianthus caryophyllus	Carnation, Hardy	P	M	18	L	1	L	2	M	21
Dianthus cultivars	Pinks	A P	M	24	L	2	L	3	M	29
Dianthus deltoides	Pinks, Maiden	P	M	20	L	2	L	2	M	24
Dianthus graniticus	Pinks, Granite	P	M	13	L	2	M	3	M	18
Dianthus gratianopolitanus	Pinks, Pincushion	P	M	17	L	2	L	2	M	21
Dianthus plumarius (lumnitzer)	Pinks, Cottage	P	M	13	L	1	L	2	M	16
Dianthus x chinensis	Border Pink	A	M	17			L	2	M	19
Diascia barberae	Twinspur	A	M	15	L	1			L	16
Diascia integerrima 'Coral Canyon'	Twinspur, Coral Canyon	A P	L	26	L	2	L	2	L	30
Dicentra eximia	Bleeding Heart, Fringed	P	M	22	H	2	H	2	M	26

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Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Dicentra formosa	Bleeding Heart, Fringed	P	M	21	M	3	M	4	M	28
Dicentra spectabilis	Bleeding Heart, Old Fashioned	P	M	24	M	3	M	4	M	31
Dictamnus albus	Gas Plant	P	M	6					M	6
Diervilla lonicera	Honeysuckle, Bush	S	L	20	L	4	L	2	L	26
Digitalis 'Mertonensis'	Foxglove, Perennial Pink	P	M	19	M	1	M	1	M	21
Digitalis grandiflora	Foxglove, Perennial Yellow	P	M	19	L	3	M	2	M	24
Digitalis purpurea	Foxglove, Common	P	M	23	M	1	M	2	M	26
Digitalis thapsi	Foxglove, Spanish	P	M	23	M	1	M	1	M	25
Dodecatheon pulchellum	Shooting Star	P	M	14			M	1	M	15
Doronicium grandiflorum	Leopard's Bane	P	M	9	L	1	L	1	M	11
Draba hispanica	Draba, Spanish	P	L	9					L	9
Dracocephalum botryoides	Dragonhead, Evergreen	P	L	5					L	5
Dryopteris dilatata	Fern, Broad Buckler	P	H	8					H	8
Dryopteris erythrosora	Fern, Autumn	P	M	10	M	1			M	11
Dryopteris filix-mas	Fern, Leatherwood Male	P	M	14			M	1	M	15
Dryopteris marginalis	Fern, Leatherwood	P	H	10					H	10
Duchesnea indica	Strawberry, Mock	P	L	18	L	1	L	2	L	21
Dyssodia tenuiloba	Daisy, Dahlberg	A	L	6					L	6
Echinacea angustifolia	Coneflower, Narrow Leaf Purple	P	L	22	L	1	L	1	L	24
Echinacea purpurea	Coneflower, Purple	P	L	35	L	4	M	2	L	41
Echinops ritro	Globe Thistle	P	L	21	L	2	L	1	L	24
Elaeagnus commutata	Silverberry	S	L	19	L	2	L	3	L	24
Eleagnus umbellata	Autumn Olive	S T	L	22	VL	5	L	4	L	31
Ephedra torreyana	Joint Fir, Torrey	S	VL	16	VL	4	VL	4	VL	24
Ephedra viridis	Mormon Tea	S	VL	22	VL	4	VL	4	VL	30
Epilobium fleischeri	Willowherb, Alpine	P	M	11	L	2	L	2	M	15
Epimedium x cantabrigiense	Bishop's Hat	P	M	9					M	9
Equisetum hyemale	Rush, Scouring	P	H	8			H	1	H	9
Eragrostis trichodes	Grass, Sand Love	P	L	6	L	1			L	7
Erica carnea (herbacea)	Heath, Winter	P	M	5					M	5
Erigeron compositus	Daisy, Cut-Leaf	P	L	17	VL	1	VL	3	L	21
Erigeron divergens	Daisy, Spreading	P	L	9	VL	1	L	1	L	11
Erigeron flagelleris	Daisy, Whiplash	P	L	13	VL	2	L	2	L	17
Erigeron speciosus	Fleabane, Showy	P	L	14	L	1	L	2	L	17
Erigeron subtrinervis	Fleabane, Three-nerved	P	L	9	L	1			L	10
Erigeron vetensis	Daisy, Early Bluetop	P	L	5	L	1			L	6
Eriogonum jamesii	Sulphur Flower, Creamy	P	L	13	L	3	L	4	L	20
Eriogonum umbellatum	Sulphur Flower	P	VL	25	L	4	VL	6	VL	35
Erodium reichardii	Heron's Bill	P	M	8			L	1	M	9
Eryngium alpinum 'Superbum'	Sea Holly	P	L	10	L	1	L	1	L	12
Eryngium amethystinum	Sea Holly, Amethyst	P	L	8	L	1	L	1	L	10
Eryngium planum 'Blaukappe'	Sea Holly, Blue Cap	P	L	11	L	1	L	1	L	13
Eryngium variifolium	Sea Holly, Moroccan	P	L	10	L	1	L	1	L	12
Eryngium yuccifolium	Button-Snakeroot	P	L	11	L	1	L	1	L	13
Erysimum asperum	Wallflower	P	L	14	M	1	L	2	L	17
Erysimum kotschyanum	Wallflower, Alpine	P	M	9	M	1	M	2	M	12
Eschscholzia californica	Poppy, California	P	L	28	VL	3	L	4	L	35
Euonymus alatus	Burning Bush	S	M	33	M	5	M	3	M	41
Euonymus europaeus	Spindle Tree	S T	M	28	M	5	M	3	M	36
Euonymus fortunei 'Coloratus'	Wintercreeper, Purpleleaf	GCP	L	21	L	2	M	1	L	24
Euonymus fortuneii	Euonymus	S	M	30	M	4	M	3	M	37
Euonymus kewensis	Eyonymus, Kew	GC	M	13	M	1			M	14
Euonymus kiautschovica 'Manhattan'	Euonymus, Manhattan	S	M	28	M	4	M	2	M	34
Eupatorium purpureum	Joe-Pye Weed	P	M	5					M	5
Euphorbia amygdaloides	Spurge, Wood	P	L	13	VL	1	L	1	L	15
Euphorbia polychroma	Spurge, Cushion	P	L	22			L	1	L	23
Eurotia lanata	Winterfat	S	VL	14	VL	5	VL	3	VL	22
Fagus sylvatica	Beech, European	T	M	27	H	3	M	3	M	33
Fallopia japonica compacta	Fleeceflower, Dwarf	P	L	12	VL	1	VL	1	L	14
Fallugia paradoxa	Apache Plume	S	VL	43	VL	6	VL	6	VL	55
Fendlera rupicola	Mockorange, False	S	VL	15	VL	3	VL	3	VL	21
Festuca arundinacea	Tall Fescue	TU	M	17	M	3	M	3	M	23
Festuca glauca	Fescue, Blue	P	L	25	L	3	L	2	L	30
Festuca idahoensis	Fescue, Idaho	P	L	7			M	1	L	8
Festuca ovina	Fescue, Sheep	P TU	L	18	M	3	M	3	L	24
Festuca ovina duriuscula	Hard Fescue	TU	M	8	H	1	H	1	M	10
Festuca rubra	Fescue, Red	TU	M	12	M	2	H	1	M	15
Festuca rubra commutata	Fescue, Chewings	P TU	L	9	H	1	H	1	M	11
Filipendula rubra	Meadowsweet	P	M	13					M	13
Filipendula ulmaria	Meadow Sweet	P	M	10					M	10
Forestiera neomexicana	Privet, New Mexico	S	L	30	VL	5	VL	5	L	40
Forsythia cultivars	Forsythia	S	M	32	M	4	M	3	M	39
Forsythia viridissima 'Broxensis'	Forsythia, Dwarf	S	M	20	M	3	L	2	M	25
Forsythia x intermedia	Forysthia	S	M	26	M	3	M	2	M	31
Fothergilla gardenii	Fothergilla, Dwarf	S	M	12	L	2	L	2	M	16
Fothergilla major	Fothergilla, Large	S	M	10	VL	1	L	2	M	13
Fragaria americana	Strawberry, Wild	GCP	L	21	L	2	L	2	L	25
Fragaria cultivars	Strawberry	GCP	M	22	M	1	M	1	M	24
Fragaria vesca	Strawberry, Runnerless	GCP	M	13			M	1	M	14
Fragaria virginiana glauca	Strawberry, Scarlet	P	L	6			M	1	M	7
Frasera speciosa	Gentian, Green	P	M	4			H	1	M	5
Fraxinus americana	Ash, White	T	M	36	M	4	M	3	M	43
Fraxinus angustifolia 'Raywood'	Ash, Raywood	T	M	8	M	2	M	1	M	11
Fraxinus anomala	Ash, Single-Leaf	S T	L	18	L	4	L	2	L	24
Fraxinus excelsior	Ash, European	T	M	16	M	2	M	1	M	19

Appendix E
Plant Water Requirement Estimates (GreenCO-CSU Crop Coefficient Survey 2004)

Estimated Water Usage for Plant: VL=Very Low < 25%; ET_0 L=Low 25%-50%; ET_0 M=Medium 50%-75%; ET_0 H=High >75% ET_0
Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Fraxinus latifolia	Ash, Oregon	T	M	6	M	1	M	1	M	8
Fraxinus mandshurica 'Mancana'	Ash, Mancana Manchurian	T	M	20	M	2	M	2	M	24
Fraxinus nigra	Ash, Black	T	M	20	M	3	M	3	M	26
Fraxinus pennsylvanica	Ash, Green	T	M	43	M	5	M	4	M	52
Fraxinus quadrangulata	Ash, Blue	T	M	12	M	2	M	2	M	16
Fraxinus velutina	Ash, Arizona	T	M	10	M	3	L	2	M	15
Gaillardia aristata	Blanket Flower, Native	P	L	31	VL	3	L	2	L	36
Gaillardia x grandiflora	Blanket Flower	P	L	25	VL	1	L	2	L	28
Galium boreale	Northern Bedstraw	P	L	8					L	8
Galium odoratum	Sweet Woodruff	P	M	30	L	2	VL	1	M	33
Gaura lindheimeri	Whirling Butterflies	P	L	28	L	2			L	30
Gazania krebsiana Tanager	Gazania, Orange Hardy	A P	L	19			L	1	L	20
Gazania linearis 'Colorado Gold'	Gazania, Colorado Gold Hardy	P	L	21			L	1	L	22
Gazania rigens	Treasure Flower	A	L	12			L	1	L	13
Genista pilosa 'Vancouver Gold'	Broom, Vancouver Gold	S	L	11	L	1	L	1	L	13
Genista tinctoria 'RoyalGold'	Woadwaxen, Royal Gold	S	L	11	L	2	L	1	L	14
Gentiana affinis	Gentian, Northern Pleated	P	M	11			H	1	M	12
Gentiana cachemirica	Gentian, Himalayan	P	M	6					M	6
Gentiana calycosa	Gentian, Explorer's	P	M	5			L	1	L	6
Gentiana septemfida lagodechiana	Gentian, Crested	P	M	8			H	1	M	9
Geranium caespitosum	Cranesbill, Purple Wild	P	L	15			M	1	L	16
Geranium cinereum 'Ballerina'	Cranesbill, Ballerina Grayleaf	P	M	20			M	1	M	21
Geranium cultivars	Cranesbill	P	M	23	M	1	M	1	M	25
Geranium dalmaticum	Cranesbill, Compact Rose	P	M	13			M	1	M	14
Geranium endressii 'Wargrave Pink'	Cranesbill, Pink	P	M	15	M	1	M	1	M	17
Geranium himalayense	Cranesbill, Lilac	P	M	17			M	1	M	18
Geranium macrorrhizum	Cranesbill, Adriatic	P	L	14	VL	1	L	2	L	17
Geranium maculatum	Geranium, Wild	P	L	16			M	1	M	17
Geranium magniflorum La Veta Lace	Geranium, La Veta Lace	P	M	11					M	11
Geranium platypetalum	Cranesbill, Broad-petaled	P	M	10			M	1	M	11
Geranium psilostemon	Cranesbill, Armenian	P	M	9			M	1	M	10
Geranium sanguineum	Cranesbill, Bloody	P	M	23	L	3	M	1	M	27
Geranium viscosissimum	Geranium, Sticky	P	L	13	L	1	M	1	L	15
Geranium x cantabrigiense	Cranesbill, Cambridge	GCP	L	16	M	1	M	1	M	18
Geranium x magnificum	Cranesbill, Showy	P	M	13	M	1	M	1	M	15
Geranium x oxonianum 'Claridge Druce'	Cranesbill, Lilac Pink	P	M	18	L	2			M	20
Geum chiloense	Avens, Chilean	P	M	17	M	1	L	1	M	19
Geum coccineum 'Borisii'	Avens, Orange	P	M	15			L	1	M	16
Geum triflorum	Avens, Prairie Smoke	P	L	19	M	2	L	1	L	22
Ginkgo biloba	Maidenhair Tree	T	M	24	M	3	M	1	M	28
Glechoma hederacea	Ivy, Ground	GCP	M	11			L	1	M	12
Gleditsia triacanthos inermis	Honeylocust, Thornless	T	L	42	L	6	L	3	L	51
Globularia cordifolia	Daisy, Dwarf Globe	GCP	L	12			L	1	L	13
Gomphrene globosa	Globe Amaranth	A	L	15			L	2	L	17
Grindelia squarrosa	Gumweed, Curly-cupped	P	L	7			VL	1	L	8
Gutierrezia sarothrae	Snakeweed	P	VL	12	VL	2	L	1	VL	15
Gymnocarpium dryopteris	Fern, Oak	P	L	1					L	1
Gymnocladus dioica	Kentucky Coffeetree	T	L	38	L	5	L	3	L	46
Gypsophila paniculata	Baby's Breath	P	L	33	M	1	VL	1	L	35
Gypsophila repens	Baby's Breath, Creeping	P	L	24	M	1	L	2	M	27
Hakonechloa macra	Grass, Japanese Forest	P	H	6					H	6
Hamamelis vernalis	Witchhazel, Vernal	S T	M	16	M	3	M	3	M	22
Hamamelis virginiana	Witchhazel, Common	S T	M	18	M	4	M	4	M	26
Haplopappus glutinosus	Golden Star	P	L	8			VL	1	L	9
Hebe albicans	Hebe	P	M	3					M	3
Hedera helix	Ivy, English	V	M	25	L	2	M	1	M	28
Helenium autumnale	Sneezeweed	P	M	17	M	1	L	1	M	19
Helianthemum	Sunrose	P	L	25	M	1	L	1	L	27
Helianthus maximiliana	Sunflower, Maximilian	P	L	27	L	2	VL	1	L	30
Helianthus pumilus	Sunflower, Dwarf	P	L	7					L	7
Helichrysum bracteatum	Strawflower	A	L	11			L	1	L	12
Helichrysum sibthorpii	Everlasting	P	L	5					L	5
Helictotrichon sempervirens	Grass, Blue Avena	P	L	28	L	3	M	1	L	32
Heliopsis helianthoides	False Sunflower	P	M	19			L	1	M	20
Heliotropium arborscens	Heliotrope	A	M	13	M	2	M	1	M	16
Helleborus argutifolius	Hellebore	P	M	14					M	14
Helleborus orientalis	Lenten Rose	P	M	4	M	1			M	5
Hemerocallis	Daylily	P	L	36	L	3	M	3	L	42
Hesperaloe parviflora	Yucca, Red	S	VL	18	VL	3	VL	2	VL	23
Heterotheca horrida	Aster, Golden	P	L	8					L	8
Heterotheca villosa	Aster, Hairy Golden	P	L	12			VL	1	L	13
Heuchera americana	Coral Bells, American	P	M	21			M	1	M	22
Heuchera cultivars	Coral Bells	P	M	27	L	2	M	1	M	30
Heuchera micrantha	Coral Bells, Smallflowered	P	M	19			M	1	M	20
Heuchera sanguinea	Coral Bells	P	M	24	M	1	M	1	M	26
Heuchera x brizoides	Coral Bells, Hybrid	P	M	11					M	11
Heucherella alba	Heucherella, White	P	M	12	M	1			M	13
Hibiscus moscheutos	Rose Mallow	P	M	21					M	21
Hibiscus syriacus	Althea	S	M	29	M	5	M	2	M	36
Hieracium lanatum	Hawkweed, Felted	P	L	8	L	1			L	9
Hierochloe odorata	Grass, Indian Sweet	P	L	5					L	5
Hippophae rhamnoides	Sea Buckthorn	S T	L	28	VL	6	VL	5	L	39
Holodiscus discolor	Ocean-Spray	S	L	15	VL	2	VL	2	L	19
Holodiscus dumosus	Rock Spirea	S	L	23	VL	5	VL	5	L	33
Hosta cultivars	Hosta	P	M	31	L	2	M	1	M	34

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Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Hosta sieboldiana	Hosta, Sieboldiana	P	M	24	M	1	M	1	M	26
Hosta x fortunei	Hosta, Fortunei	P	M	20			M	1	M	21
Hosta x tardiana 'Halcyon'	Hosta, Halcyon	P	M	15					M	15
Hosta x undulata	Hosta, Wavy	P	M	20	M	1	M	2	M	23
Houttuynia cordata 'Chameleon'	Chameleon Plant	P	M	10					M	10
Humulus lupulus neomexicanus	Hop Vine, Native	P V	L	16	L	1	L	2	L	19
Hydrangea anomala	Hydrangea, Climbing	S	M	14	L	2	L	2	M	18
Hydrangea anomala petiolaris	Hydrangea, Climbing	V	M	11					M	11
Hydrangea arborescens 'Annabelle'	Hydrangea, Annabelle Smooth	S	M	25	M	3	M	2	M	30
Hydrangea macrophylla	Hydrangea, Bigleaf	S	M	13	M	2	M	2	M	17
Hydrangea paniculata	Hydrangea, Panicle	S	M	19	L	2	L	2	M	23
Hydrangea quercifolia	Hydrangea, Oakleaf	S	M	13	L	2	L	2	M	17
Hymenoxys acaulis	Daisy, Angelita	P	L	5			L	1	L	6
Hypericum 'Hidcote'	St. John's Wort, Hidcote	P S	M	27	L	4	L	2	M	33
Hypericum calycinum	St. John's Wort, Mounding	GCP	M	13	M	1			M	14
Hypericum kalmianum	St. John's Wort, Kalm	S	L	16	M	3	L	2	M	21
Hypericum patulum	St. John's Wort, Goldencup	P	M	12	M	1			M	13
Hypericum reptans	St. John's Wort, Creeping	GCP	L	14	M	1			L	15
Hyssopus officinalis	Hyssop	P	L	6					L	6
Iberis gibraltarica	Candytuft, Lilac	GCP	L	13			M	1	L	14
Iberis sempervirens	Candytuft, Evergreen	GCP	L	26	M	1	M	1	L	28
Ilex glabra 'Compacta'	Holly, Compact Inkberry	S	M	10	M	2	M	2	M	14
Ilex x meserveae	Holly, Blue	S	M	19	M	3	M	2	M	24
Ilex x verticillata 'Winter Red'	Holly, Winter Red	S	H	7	M	2	M	2	M	11
Impatiens wallerana	Impatiens	A	H	23	H	1	M	2	H	26
Imperata cylindrica 'Red Baron'	Grass, Japanese Blood	P	M	17					M	17
Incarvillea delavayi	Gloxinia, Hardy	P	M	11					M	11
Ipomea batatas	Sweet Potato Vine	A	M	17			L	1	M	18
Ipomopsis aggregata	Gilia, Scarlet	P	L	17	L	2	L	2	L	21
Ipomopsis candida	Fairy Trumpet, White	P	L	7			L	1	L	8
Iris ensata (kaempheri)	Iris, Japanese	P	M	19	M	1	M	1	M	21
Iris missouriensis	Iris, Western Blue Flag	P	M	21	L	2	L	2	L	25
Iris orientalis	Iris, Yellow Butterfly	P	L	8					L	8
Iris pallida 'Variegata'	Iris, Variegated Sweet	P	L	21			M	1	L	22
Iris pseudacorus	Iris, Yellow Flag	P	M	17			H	1	M	18
Iris setosa artica	Iris, Dwarf Blue Flag	P	M	14			M	1	M	15
Iris siberica	Iris, Siberian	P	M	27	L	1	L	2	M	30
Iris x germanica	Iris, Bearded	P	L	33	L	1	L	3	L	37
Iris x pumila	Iris, Dwarf Bearded	P	L	19	M	1	M	1	L	21
Itea virginica	Sweetspire	S	M	7	M	2	M	2	M	11
Jamesia americana	Waxflower	S	L	20	L	5	L	6	L	31
Jasminum fruticans	Jasmine, Evergreen Yellow	P	M	4					M	4
Juglans nigra	Walnut, Black	T	L	35	L	4	L	3	L	42
Juncus balticus	Rush, Baltic	P	H	5			H	1	H	6
Juncus compressus	Rush, Round-fruit	P	H	5			H	1	H	6
Juncus effusus	Rush, Corkscrew	P	H	5			H	1	H	6
Juncus torreyi	Rush, Torrey	P	H	5			H	1	H	6
Juniperus chinensis	Juniper, Chinese	S T	L	39	L	7	L	8	L	54
Juniperus communis	Juniper, Common	S	L	36	L	6	L	8	L	50
Juniperus horizontalis	Juniper, Creeping	S	L	30	L	6	L	5	L	41
Juniperus monosperma	Juniper, One Seed	S T	VL	37	VL	9	VL	9	VL	55
Juniperus procumbens	Juniper, Japanese Garden	S	L	24	L	4	L	3	L	31
Juniperus sabina	Juniper, Savin	S	L	26	L	5	L	5	L	36
Juniperus scopulorum	Juniper, Rocky Mountain	S T	VL	42	VL	9	VL	10	VL	61
Juniperus squamata	Juniper, Flaky	S	L	26	L	4	L	3	L	33
Juniperus utahensis	Juniper, Utah	S T	VL	28	VL	8	VL	6	VL	42
Juniperus virginiana	Juniper, Eastern Red Cedar	T	L	35	L	5	L	5	L	45
Juniperus x media	Juniper, Hybrid Spreading	S	L	16	L	3	L	4	L	23
Kerria japonica 'Pleniflora'	Kerria, Japanese	S	M	10	L	2	L	2	M	14
Knautia macedonica	Knautia, Purple	P	L	16			M	1	L	17
Kniphofia	Torch Lily	P	L	22			L	1	L	23
Koelreuteria paniculata	Golden Rain Tree	T	L	37	L	5	L	3	L	45
Kolkwitzia amabilis	Beauty Bush	S	L	29	L	2	L	2	L	33
Laburnum x watereri	Golden-Chain Tree	T	M	18	H	2	M	1	M	21
Lamiastrum galeobdolon	Yellow archangel	GCP	M	14	M	1	M	1	M	16
Lamium maculatum	Nettle, Spotted	GCP	M	20	M	1	M	1	M	22
Lantana spp.	Lantana	A	L	18			L	2	L	20
Larix decidua	Larch, European	T	M	23	M	3	M	4	M	30
Lathyrus latifolius	Sweet Pea, Perennial	P	L	15			L	1	L	16
Lathyrus odoratus	Sweet Pea, Annual	A	M	19			M	1	M	20
Lavandula angustifolia	Lavender, English	P	L	27	L	2	L	2	L	31
Lavandula dentata	Lavender, French	P	L	16					L	16
Lavandula x intermedia	Lavender, Hybrid	P	L	15					L	15
Lavatera thuringiaca	Shrub Mallow	P	L	20	M	1	M	1	L	22
Leontopodium alpinum	Edelweiss	P	L	13	M	1	L	2	L	16
Lespedeza thunbergii	Japanese Bush-clover	P	L	6					L	6
Leucanthemum x superbum	Daisy, Shasta	P	M	29	M	1	M	2	M	32
Lewisia cotelydon	Bitterroot	P	L	9	L	1	L	2	L	12
Leymus arenarius 'Glauca'	Grass, Blue Lyme	P	L	8					L	8
Liatris punctata	Gayfeather, Native	P	L	25	L	2	L	2	L	29
Liatris pycnostachya	Gayfeather, Thickspike	P	L	13					L	13
Liatris spicata	Gayfeather, Spike	P	L	26	L	3	L	2	L	31
Ligularia dentata 'Othello'	Groundsel, Golden	P	H	15					H	15
Ligularia przewalskii	Groundsel, Shavalski's	P	H	8					H	8
Ligularia stenocephala 'The Rocket'	Ragwort, The Rocket	P	H	19					H	19

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Ligustrum obtusifolium 'Regalianum'	Privet, Regal	S	L	11	L	2	L	2	L	15
Ligustrum vulgare	Privet, Common	S	L	30	L	5	L	3	L	38
Ligustrum x vicaryi	Privet, Golden Vicary	S	M	27	M	4	M	2	M	33
Lilium cultivars	Lily cultivars	P	M	24			M	1	M	25
Limonium latifolium	Sea Lavender, Wide-leaved	P	L	18					L	18
Limonium sinuatum	Statice	A	L	14	L	1	L	1	L	16
Linum flavum	Flax, Yellow	P	L	17	L	1			L	18
Linum perenne	Flax, Blue	P	L	33	VL	3	VL	4	L	40
Liquidambar styraciflua	Sweetgum, American	T	M	14	M	3	L	2	M	19
Liriodendron tulipifera	Tulip Tree	T	M	21	M	2	L	2	M	25
Liriope muscari	Lily Turf	A	M	9			M	1	M	10
Lithospermum incisum	Puccoon, Narrow-leaf	P	L	5					L	5
Lithospermum multiflorum	Puccoon, Many-flowered	P	L	5					L	5
Lobelia cardinalis	Cardinal Flower	P	H	17	L	1			H	18
Lobelia fulgens 'Queen Victoria'	Lobelia, Scarlet	P	M	12					M	12
Lobelia sp.	Lobelia	A	M	20			M	3	M	23
Lobularia martitma	Sweet Alyssum	A	M	16					M	16
Lolium perenne	Perennial Ryegrass	TU	M	12	M	2	H	1	M	15
Lonicera caerulea edulis	Honeysuckle, Bearberry	S	M	11	L	2	L	2	M	15
Lonicera fragrantissima	Honeysuckle, Winter	S	M	8	L	2	L	2	M	12
Lonicera involucrata	Honeysuckle, Twinberry	S	M	19	L	4	L	5	M	28
Lonicera japonica	Honeysuckle, Japanese	S V	L	23	M	3	L	3	L	29
Lonicera korolkowii v. floribunda 'Blue Velvet	Honeysuckle, Blue Velvet Blueleaf	S	L	24	L	3	L	4	L	31
Lonicera periclymenum	Woodbine, Yellow Flowering	V	M	7					M	7
Lonicera sempervirens 'Magnifica'	Honeysuckle, Scarlet Trumpet	V	M	18	L	1	L	1	M	20
Lonicera syringantha 'Wolfii'	Honeysuckle, Tiny Trumpet	S	M	16	L	2	L	3	M	21
Lonicera tartarica 'Arnold's Red'	Honeysuckle, Arnold's Red Tartaria	S	L	24	L	4	L	4	L	32
Lonicera x 'Honeyrose'	Honeysuckle, Honeyrose	S	M	14	M	3	L	4	M	21
Lonicera x brownii 'Dropmore Scarlet'	Honeysuckle, Dropmore Scarlet Br	V	M	15	L	1	L	1	M	17
Lonicera x heckrotti 'Goldflame'	Honeysuckle, Goldflame	P S V	M	24	L	2	L	2	M	28
Lonicera x xylosteoides	Honeysuckle, European Fly	S	L	19	L	4	L	3	L	26
Lunaria annua	Money Plant	A	L	9			L	1	L	10
Lupinus	Lupine	P	M	25	L	2	L	2	M	29
Lupinus argenteus	Lupine, Silvery	P	L	11			L	1	L	12
Lychnis chalcedonica	Maltese Cross	P	M	15	M	1	L	1	M	17
Lychnis coronaria	Rose Campion	P	L	20	M	1	VL	1	L	22
Lysimachia clethroides	Loosestrife, Gooseneck	P	M	13			H	1	M	14
Lysimachia nummularia	Moneywort	P	M	20	H	1	M	1	M	22
Lysimachia punctata	Loosestrife, Yellow	P	M	11			M	1	M	12
Maackia amurensis	Amur Maackia	T	M	20	M	3	L	4	M	27
Machaeranthera bigelovii	Aster, Santa Fe	P	L	9			L	1	L	10
Machaeranthera pattersoni	Aster, Patterson	P	L	7					L	7
Macleaya cordata	Poppy, Plume	P	M	10					M	10
Macleaya microcarpa	Poppy, Plume	P	M	6					M	6
Magnolia grandiflora	Magnolia, Large-flowered	S	M	6	M	1	M	1	M	8
Magnolia kobus	Magnolia, Kobus	S	M	8	M	2	M	1	M	11
Magnolia stellata	Magnolia, Star	S T	M	28	M	6	M	4	M	38
Magnolia virginiana	Magnolia, Sweetbay	S	M	7	M	3	M	2	M	12
Magnolia x loebneri	Magnolia, Loebner	S	M	11	M	1	M	1	M	13
Magnolia x soulangiana	Magnolia, Saucer	S T	M	28	M	6	M	4	M	38
Mahonia aquifolium	Oregon Grape Holly	S	L	34	L	5	L	2	L	41
Mahonia fremonti	Fremont Holly Grape	S	L	18	VL	5	L	2	VL	25
Mahonia repens	Creeping Colorado Holly	GCP S	L	36	L	5	L	5	L	46
Malus crabapple	Crabapple	T	M	41	M	5	L	4	M	50
Malus sylvestris	Apple, Orchard	T	M	27	L	3	L	2	M	32
Malus x zumi 'Calocarpa'	Crab, Zumi	T	M	10	L	2	L	2	M	14
Malva alcea 'Fastigiata'	Hollyhock, Miniature	P	M	16	M	1	L	1	M	18
Marrubium rotundifolium	Horehound, Silvery	GCP	VL	10					VL	10
Matteuccia struthiopteris	Fern, Ostrich	P	H	10			M	1	H	11
Mazus reptans	Mazus	GCP	M	5					M	5
Melampodium leucanthum	Daisy, Blackfoot	P	L	12			VL	1	VL	13
Melinis (Rhynchelytrum) nerviglumis	Grass, Ruby	A	M	10			M	1	M	11
Mentha requienii	Mint, Corsican	P	L	6					L	6
Mentha spicata	Spearmint	P	M	11			M	1	M	12
Mentzelia decapetala	Evening-star	P	VL	9					VL	9
Mertensia lanceolata	Chiming Bells	P	M	8					M	8
Mertensia virginica	Bluebells	P	M	10			H	1	M	11
Metasequoia glyptostroboides	Redwood, Dawn	T	M	14	M	4	M	3	M	21
Microbiota decussata	Cypress, Siberian	S	M	10	L	2	M	3	M	15
Mimulus cardinalis	Monkey Flower, Scarlet	P	H	9					H	9
Mimulus guttatus	Monkey Flower, Yellow	P	H	8			H	2	H	10
Mimulus lewisii	Monkey Flower, Pink	P	M	9			H	1	M	10
Mimulus spp.	Monkey Flower, Annual	A	H	7			H	2	H	9
Mirabilis jalapa	Four O'Clock, Annual	A	L	22	L	1	VL	1	L	24
Mirabilis multiflora	Four-O'-Clock, Desert	P	VL	26	VL	3	VL	3	VL	32
Miscanthus floridulus	Grass, Giant Chinese Silver	P	M	12					M	12
Miscanthus sinensis	Grass, Maiden	P	M	26	L	2	M	1	M	29
Molinia caerulea	Grass, Purple Moor	P	M	13	L	1			M	14
Molucella laevis	Bells of Ireland	A	M	9			M	1	M	10
Monarda didyma	Bee-Balm	P	M	28	L	2	L	2	M	32
Monarda fistulosa menthaefolia	Bee-Balm, Native Lavender	P	L	25	L	1	L	2	L	28
Moneses uniflora	One-Flowered Wintergreen	P	M	4			H	2	M	6
Morus alba	Mulberry	T	M	25	M	3	M	3	M	31
Muhlengergia capillaris	Grass, Muhly	P	L	3			M	1	L	4
Myosotis alpestris	Forget-Me-Not	P	M	18	M	1	M	1	M	20

Appendix E
Plant Water Requirement Estimates (GreenCO-CSU Crop Coefficient Survey 2004)

Estimated Water Usage for Plant: VL=Very Low < 25%; ET_0 L=Low 25%-50%; ET_0 M=Medium 50%-75%; ET_0 H=High >75% ET_0
Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Myrica pennsylvanica	Bayberry	S	M	7	L	2	L	2	M	11
Nandina domestica	Bamboo, Heavenly	S	M	20	M	1	M	2	M	23
Nepeta racemosa	Catmint	P	L	18	L	2			L	20
Nepeta x faassenii	Catmint, Faassen's	P	L	24	L	2	VL	1	L	27
Nicotiana spp.	Flowering Tobacco	A	M	21			M	2	M	23
Nierembergia hippomanica	Cup Flower	A	M	8			M	1	M	9
Nolina microcarpa	Grass, Bear	P	L	13			M	1	L	14
Nyssa sylvatica	Sourgum	T	H	11	H	2	M	2	M	15
Ocimum basilicum	Basil	A	M	21			M	2	M	23
Oenothera berlandieri 'Siskiyou'	Primrose, Siskiyou	P	L	19	VL	1	L	1	L	21
Oenothera brachycarpa	Primrose, Leatherleaf	P	L	11	VL	1	M	1	L	13
Oenothera caespitosa	Primrose, White Evening	P	VL	18	VL	4	L	2	VL	24
Oenothera fruticosa glauca	Sundrops	P	L	11	VL	1	M	1	L	13
Oenothera macrocarpa	Primrose, Missouri Evening	P	L	27	VL	2	M	1	L	30
Oenothera speciosa 'Rosea'	Primrose, New Mexico Evening	P	L	22	VL	1	L	1	L	24
Oenothera strigosa	Evening Primrose, Common	P	L	11	VL	1			L	12
Opuntia polyacantha	Cactus, Prickly Pear	P	VL	25	VL	2			VL	27
Origanum lavevigatum 'Herrenhausen'	Oregano, Purple	P	L	16					L	16
Origanum vulgare	Oregano, Common	P	L	15	M	1			L	16
Oryzopsis hymenoides	Grass, Indian Rice	P	L	10	VL	1	L	1	L	12
Osteospermum 'Lavender Mist'	Sun Daisy, Lavender Mist	P	L	22	VL	1			L	23
Osteospermum barberiae compactum 'Purpl	Sun Daisy, Purple Mountain	P	L	21	VL	1			L	22
Ostrya virginiana	American Hophornbeam	T	M	16	M	3	M	3	M	22
Oxytropis lambertii	Loco Weed, Lambert's	P	VL	9			L	2	L	11
Pachysandra terminalis	Spurge, Japanese	GCP	M	15	M	2	M	1	M	18
Paeonia lactiflora	Peony	P	M	23	M	1	M	1	M	25
Panicum virgatum	Grass, Switch	P	L	25	L	2	M	1	L	28
Papaver alpinum	Poppy, Alpine	P	M	19	L	2	L	3	L	24
Papaver miyabeanum	Poppy, Japanese Alpine	P	M	10			M	1	M	11
Papaver nudicaule	Poppy, Iceland	P	M	23	L	2	M	3	M	28
Papaver orientale	Poppy, Oriental	P	L	27	L	2	M	3	L	32
Parrotia persica	Persian Parrotia	T	M	7	M	2	L	2	M	11
Parthenocissus quinquefolia	Virginia Creeper	V	L	26	L	3	L	2	L	31
Parthenocissus tricuspidata	Ivy, Boston	P V	M	22	M	1			M	23
Paxistima canbyi	Mountain Lover	P	L	12	L	1	M	2	M	15
Paxistima myrtifolia	Mountain Lover	P	L	7			M	1	L	8
Pedicularis groenlandica	Elephant's Head	P	M	8			H	2	H	10
Pelargonium hybrids	Geranium	A	M	22			M	2	M	24
Pennisetum alopecuroides	Grass, Fountain	P	L	23	L	2			L	25
Pennisetum orientale	Grass, Oriental Fountain	P	L	11	L	1			L	12
Pennisetum setaceum	Grass, Annual Fountain	A	M	21			L	2	M	23
Penstemon 'Elfin Pink'	Penstemon, Pink	P	L	19	VL	1	L	2	L	22
Penstemon 'Hyacinth Flowered'	Penstemon, Hyacinth Flowered	P	M	7					M	7
Penstemon acuminatus	Penstemon, Sand Dune	P	L	7					L	7
Penstemon alpinus	Penstemon, Alpine	P	L	15	L	2	L	2	L	19
Penstemon ambiguus	Penstemon, Sand	P	VL	15	L	2			VL	17
Penstemon angustifolius	Penstemon, Narrowleaf	P	VL	11					VL	11
Penstemon attenuatus	Penstemon, Taper-leaved	P	L	6					L	6
Penstemon barbatus	Penstemon, Scarlet Bugler	P	L	22	VL	3	L	2	L	27
Penstemon caespitosus	Penstemon, Mat	P	L	15	L	3	L	2	L	20
Penstemon cardinalis	Penstemon, Crimson	P	L	11	VL	1	M	1	L	13
Penstemon clutei	Penstemon, Sunset	P	L	11	L	1			L	12
Penstemon cyananthus	Penstemon, Wasatch	P	L	12	L	1			L	13
Penstemon davidsonii	Penstemon, Davidson's	P	L	8					L	8
Penstemon deustus	Penstemon, Hotrock	P	VL	5			VL	1	VL	6
Penstemon digitalis 'HuskerRed'	Penstemon, Husker Red	P	L	29	VL	1	M	1	L	31
Penstemon eatonii	Penstemon, Firecracker	P	L	22	VL	1	M	1	L	24
Penstemon ellipticus	Penstemon, Rockvine	P	VL	3					VL	3
Penstemon fruticosus	Penstemon, Shrubby	P	L	9					L	9
Penstemon glaber	Penstemon, Saw-sepal	P	L	8					L	8
Penstemon gracilis	Penstemon, Slender	P	L	6					L	6
Penstemon grandiflorus	Penstemon, Shell Leaf	P	L	21	VL	1			L	22
Penstemon hirsutus 'Pygmaeus'	Penstemon, Pygmy Purple	P	L	13	L	1	L	2	L	16
Penstemon jamesii	Penstemon, James	P	VL	8	L	1			VL	9
Penstemon linarioides	Penstemon, Blue Mat	P	VL	14			L	1	VL	15
Penstemon neomexicanus	Penstemon, New Mexican Blue	P	L	7					L	7
Penstemon nitidus	Penstemon, Smooth Blue	P	VL	8					VL	8
Penstemon palmeri	Penstemon, Palmer	P	L	17	VL	3			L	20
Penstemon parryi	Penstemon, Parry	P	L	9					L	9
Penstemon pinifolius	Penstemon, Pineleaf	P	L	25	VL	3	L	2	L	30
Penstemon procerus	Penstemon, Small-Flowered	P	L	8	L	1			L	9
Penstemon pseudospectabilis	Penstemon, Desert	P	L	12	L	1			L	13
Penstemon rostriflorus	Bridge's Penstemon	P	L	4					L	4
Penstemon secundiflorus	Penstemon, One-sided	P	L	12					L	12
Penstemon strictus	Penstemon, Rocky Mountain	P	L	27	VL	3	L	3	L	33
Penstemon teucrioides	Penstemon, Grayleaf Creeping	P	L	7					L	7
Penstemon triphyllus	Penstemon, Whorled	P	VL	2					VL	2
Penstemon utahensis	Penstemon, Utah	P	L	8					L	8
Penstemon venustus	Penstemon, Blue Mountain	P	VL	5					VL	5
Penstemon virens	Penstemon, Blue Mist	P	L	15	VL	2	L	2	L	19
Penstemon virgatus asagrayi	Penstemon, Tall	P	VL	7					VL	7
Penstemon whippleanus	Penstemon, Whipple's	P	L	15			L	2	L	17
Penstemon wilcoxii	Penstemon, Wilcox	P	VL	2					VL	2
Penstemon x mexicali	Penstemon, Mexicali Hybrids	P	L	23	VL	2			L	25
Perovskia atriplicifolia	Sage, Russian	S	L	35	VL	6	VL	6	VL	47

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Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Persicaria affinis	Himalayan Border Jewel	P	L	17	L	1	L	2	L	20
Persicaria virginiana 'Painter's Palette	Border Jewel, Painter's Palette	P	L	9					L	9
Petrophytum caespitosum	Rock Spirea	P	L	4					L	4
Petunia x hybrida	Petunia	A	M	22	L	1	M	4	M	27
Phacelia campanularia	California Bluebell	A	L	6			L	1	L	7
Phalaris arundinacea	Grass, Ribbon	P	M	17	M	1	M	1	M	19
Philadelphus coronarius	Mockorange, Sweet	S	L	19	L	2	L	3	L	24
Philadelphus lewisii	Mockorange, Lewis	S	L	22	L	5	L	3	L	30
Philadelphus microphyllus	Mockorange, Littleleaf	S	L	20	VL	5	L	3	L	28
Philadelphus x 'Buckley's Quill'	Mockorange, Buckley's Quill	S	M	15	L	3	L	3	M	21
Philadelphus x 'Snowbelle'	Mockorange, Snowbelle	S	M	9	L	2	L	3	L	14
Philadelphus x cymosus 'Bouquet Blanc'	Mockorange, Bouquet Blanc	S	M	14	L	2	L	3	M	19
Philadelphus x virginalis	Mockorange, Virginal	S	M	19	L	4	L	3	M	26
Phlomis cashmeriana	Sage, Himalayan	P	M	11	M	1			M	12
Phlomis russeliana	Sage, Jerusalem	P	L	9			L	1	L	10
Phlox borealis	Phlox, Artic	P	M	4			M	1	M	5
Phlox divaricata	Phlox, Wild Sweet William	P	M	14					M	14
Phlox douglasii	Phlox, Cushion	GCP	L	9			L	1	L	10
Phlox paniculata	Phlox, Garden	P	M	22	M	1	M	1	M	24
Phlox procumbens	Phlox, Creeping	GCP	L	5	M	1	M	1	M	7
Phlox stolonifera	Phlox, Creeping	GCP	M	10					M	10
Phlox subulata	Phlox, Creeping	GCP	L	25	M	2	L	2	L	29
Phyllostachys aurea	Bamboo, Golden	P	M	7					M	7
Phyllostachys aureosulcata	Bamboo, Yellow Groove	P	M	8					M	8
Physocarpus monogynus	Ninebark, Native	S	L	24	VL	5	L	7	L	36
Physocarpus opulifolius	Ninebark	S	L	23	L	5	L	5	L	33
Physostegia virginiana	Obedient Plant	P	M	21			L	1	M	22
Picea abies	Spruce, Norway	S T	M	32	L	6	L	6	M	44
Picea engelmannii	Spruce, Engelmann	T	M	31	L	6	M	9	M	46
Picea glauca 'Conica'	Spruce, Dwarf Alberta	S T	M	35	M	7	M	6	M	48
Picea glauca 'Densata'	Spruce, Black Hills	T	M	29	M	5	M	7	M	41
Picea omorika	Spruce, Serbian	T	M	17	M	3	M	4	M	24
Picea orientalis	Spruce, Oriental	T	M	9	M	2	M	2	M	13
Picea pungens	Spruce, Colorado	S T	M	44	L	7	M	11	M	62
Pieris japonica	Pieris, Japanese	S	H	11	M	2	M	2	M	15
Pieris taiwanensis	Pieris, Taiwan	S	H	6	M	2	M	2	M	10
Pinus aristata	Pine, Bristlecone	S T	L	41	L	8	VL	11	L	60
Pinus bungeana	Pine, Lacebark	T	L	15	M	4	L	4	L	23
Pinus cembra	Pine, Compact Swiss Stone	S	L	15	L	5	L	4	L	24
Pinus contorta latifolia	Pine, Lodgepole	T	L	26	L	7	L	11	L	44
Pinus densiflora	Pine, Tanyosho	S T	L	21	L	6	L	5	L	32
Pinus edulis	Pine, Pinon	T	VL	41	VL	8	VL	8	VL	57
Pinus flexilis	Pine, Limber	T	L	36	L	6	L	10	L	52
Pinus heldreichii (leucodermis)	Pine, Bosnian	S T	L	28	L	6	L	4	L	38
Pinus mugo	Pine, Mugo	S	L	36	L	6	L	6	L	48
Pinus nigra	Pine, Austrian	T	L	40	L	7	L	6	L	53
Pinus parviflora	Pine, Lacebark	T	L	9	L	3	L	3	L	15
Pinus ponderosa	Pine, Ponderosa	T	L	41	L	8	L	10	L	59
Pinus resinosa	Pine, Red	T	M	11	L	2	L	2	M	15
Pinus strobiformis	Pine, Border	T	L	20	L	4	L	4	L	28
Pinus strobus	Pine, Eastern White	T	M	32	L	5	M	4	M	41
Pinus sylvestris	Pine, Scotch	T	L	34	L	7	L	7	L	48
Pinus thunbergii	Pine, Japanese Black	T	L	10	L	4	L	4	L	18
Pinus virginiana 'Wates Golden'	Pine, Wates Golden Virginia Scrub	T	M	5	M	2	M	2	M	9
Platanus occidentalis	Sycamore	T	M	22	M	4	M	3	M	29
Platanus x acerifolia	Planetree, London	T	M	16	M	6	M	3	M	25
Platycladus orientalis 'Aurea Nana'	Arborvitae, Dwarf Golden Oriental	S	M	16	M	3	M	2	M	21
Platycodon grandiflorus	Balloon Flower	P	M	23	M	1	M	1	M	25
Plectranthus argentatus	Silver Dollar Plant	A	L	10			VL	1	L	11
Poa praetensis	Bluegrass	TU	H	25	H	2	M	2	H	29
Polemonium caeruleum	Jacob's Ladder	P	M	15	M	1	M	1	M	17
Polemonium carneum	Jacob's Ladder, Salmon	P	M	6					M	6
Polemonium reptans	Jacob's Ladder, Creeping	P	M	7					M	7
Polemonium viscosum	Sky Pilot	P	L	5			M	1	L	6
Polygonum aubertii	Vine, Silver Lace	P V	L	22	L	2	L	2	L	26
Polystichum polyblepharum	Fern, Tassle	P	H	6					H	6
Polystichum setiferum	Fern, English Hedge	P	H	7					H	7
Populus alba	Poplar, Silver	T	M	27	M	6	L	4	M	37
Populus angustifolia	Cottonwood, Narrowleaf	T	M	42	M	7	M	8	M	57
Populus balsamifera	Poplar, Balsam	T	M	14	H	3	H	3	H	20
Populus deltoides 'Siouxland'	Cottonwood, Soiuxland	T	M	38	M	8	M	4	M	50
Populus fremontii	Cottonwood, Fremont	T	M	26	M	6	M	4	M	36
Populus nigra	Poplar, Lombardy Black	T	H	16	H	6	H	2	H	24
Populus sargentii	Cottonwood, Plains	T	M	40	M	7	M	4	M	51
Populus tremuloides	Aspen	T	M	45	M	8	M	11	M	64
Populus x acuminata	Cottonwood, Lanceleaf	T	M	35	M	8	M	6	M	49
Populus x canescens	Cottonwood, Gray	T	M	16	M	5	M	4	M	25
Portulaca grandiflora	Moss Rose, Portulaca	A	L	21	VL	1	L	3	L	25
Potentilla (Drymocallis) fissa	Cinquefoil, Leafy	P	L	8			L	1	L	9
Potentilla atrosanguinea	Cinquefoil, Red	P	L	15	M	1	L	1	L	17
Potentilla fruticosa	Potentilla, Shrub	S	L	36	L	6	L	8	L	50
Potentilla hippiana	Cinquefoil, Wooly	P	L	14	L	1	VL	1	L	16
Potentilla nepalensis 'Miss Willmott'	Cinquefoil, Miss Wilmott	P	M	20	M	1	L	1	M	22
Potentilla neumanniana	Cinquefoil, Creeping	GCP	L	13	L	1	L	2	L	16
Potentilla nevadensis	Cinquefoil, Native Silvery	GCP	L	18	L	2	L	2	L	22

Appendix E
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Estimated Water Usage for Plant: VL=Very Low < 25%; ET_0 L=Low 25%-50%; ET_0 M=Medium 50%-75%; ET_0 H=High >75% ET_0
Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Potentilla pensylvanica	Cinquefoil, Prairie	P	L	9					L	9
Potentilla species	Cinquefoil, Creeping	GCP S	L	25	L	5	L	4	L	34
Potentilla thurberi	Cinquefoil, Silver	P	L	5					L	5
Primula 'Colossea'	Primrose, Hardy English	P	M	11					M	11
Primula denticulata	Primrose, Drumstick	P	M	12					M	12
Primula elatior	Primrose, Oxlip	P	M	9					M	9
Primula parryi	Primrose, Rocky Mountain	P	H	8	M	1	H	3	H	12
Primula veris	Primrose, Cowslip	P	M	8					M	8
Primula vulgaris	Primrose, English	P	M	12					M	12
Prinsepia sinensis	Prinsepia, Cherry	S	M	4	M	1	M	1	M	6
Prunella grandiflora	Self-Heal	P	M	8					M	8
Prunella laciniata	Lacy Self-Heal	P	L	14	L	2	M	1	L	17
Prunus americana	Plum, American	S T	L	41	L	8	L	7	L	56
Prunus armeniaca	Apricot	T	M	28	L	7	L	4	M	39
Prunus avium	Cherry, Sweet	T	M	25	L	6	L	3	M	34
Prunus besseyi	Cherry, Western Sand	S	L	36	L	6	L	5	L	47
Prunus cerasifera	Plum, Cherry	T	M	30	L	6	L	4	M	40
Prunus cerasus	Cherry, Sour	T	M	23	L	4	L	2	M	29
Prunus fruticosa	Cherry, European Dwarf	S	M	11	L	2	L	2	L	15
Prunus glandulosa 'Rosea Plena'	Almond, Pink Flowering	S	M	23	L	3	L	2	M	28
Prunus maackii	Chokecherry, Amur	T	M	30	L	4	L	4	M	38
Prunus maritima	Plum, Beach	T	M	6	L	1	L	1	M	8
Prunus nigra 'Princess Kay'	Plum, Princess Kay Canadian	T	M	28	L	4	L	3	M	35
Prunus padus	Mayday Tree	T	M	28	L	5	L	5	M	38
Prunus pensylvanica saximontana	Cherry, Pin	S	M	11	L	1	L	1	M	13
Prunus pesica	Peach	T	M	23	M	4	L	2	M	29
Prunus sargentii	Cherry, Sargent	T	M	14	L	3	L	3	M	20
Prunus serrulata 'Kwanzan'	Cherry, Kwanzan Japanese Flowe	T	M	15	M	3	M	3	M	21
Prunus subhirtella 'Pendula'	Cherry, Weeping Spring	T	M	13	M	3	L	2	M	18
Prunus tenella	Almond, Dwarf Russian	S	L	14	L	4	L	3	L	21
Prunus tomentosa	Cherry, Nanking	S	L	29	L	4	L	3	L	36
Prunus triloba	Rose Tree of China	S	M	17	L	4	L	2	M	23
Prunus virginiana 'Shubert'	Chokecherry, Canada Red	S T	M	42	L	8	L	8	L	58
Prunus virginiana melanocarpa	Chokecherry	S	L	32	L	5	L	7	L	44
Prunus x 'Snow Fountains'	Cherry, Weeping White	S	M	10	L	2	L	2	M	14
Prunus x americana 'Toka'	Plum, Toka	T	M	16	M	3	L	4	M	23
Prunus x cistena	Plum, Purple-Leaf	S T	M	38	L	8	L	5	M	51
Prunus x domestica 'Stanley'	Plum, Stanley Prune	T	M	19	L	2	L	2	M	23
Pseudotsuga menziesii	Fir, Douglas	S T	M	35	L	6	L	10	M	51
Psilostrophe tagetina	New Mexico Paper Flower	P	VL	11	L	1	L	1	VL	13
Ptelea trifoliata	Ash, Wafer	T	L	27	L	5	L	4	L	36
Pulmonaria 'Roy Davidson'	Bethlehem Sage, Roy Davidson'	P	M	14					M	14
Pulmonaria rubra 'Redstart'	Lungwort, Redstart	P	M	11	M	1			M	12
Pulmonaria saccharata	Bethlehem Sage	P	M	13					M	13
Pulsatilla patens	Pasqueflower, Lavender	P	L	13			L	2	L	15
Pulsatilla vulgaris	Pasqueflower, European	P	L	18	L	2	L	3	L	23
Purshia tridentata	Bitterbrush Antelope	S	VL	22	VL	4	VL	6	VL	32
Pyracantha angustifolia	Firethorn, Narrowleaf	S	M	19	L	3	L	2	L	24
Pyracantha coccinea	Firethorn, Scarlet	S	L	22	L	4	L	2	L	28
Pyrus calleryana	Pear, Ornamental	T	M	32	L	3	L	3	M	38
Pyrus communis	Pear, Orchard	T	M	18	L	4	L	4	M	26
Pyrus fauriei	Pear, Korean Wild Pear	T	L	11	L	4	L	4	L	19
Pyrus ussuriensis	Pear, Ussurian	T	L	24	L	6	L	5	L	35
Quercus acutissima	Oak, Sawtooth	T	M	12	M	3	L	2	M	17
Quercus alba	Oak, White	T	M	25	L	5	L	2	M	32
Quercus bicolor	Oak, Swamp White	T	L	31	L	5	L	3	L	39
Quercus coccinea	Oak, Scarlet	T	M	23	L	4	L	2	M	29
Quercus ellipsoidalis	Oak, Northern Pin	T	M	17	L	4	L	2	M	23
Quercus gambelii	Oak, Gambel	S T	L	42	VL	9	VL	6	VL	57
Quercus imbricaria	Oak, Shingle	T	M	15	L	2	L	1	M	18
Quercus macrocarpa	Oak, Bur	T	L	39	L	6	L	4	L	49
Quercus muehlenbergii	Oak, Chinkapin	T	L	16	M	3	L	2	L	21
Quercus palustris	Oak, Pin	T	M	24	M	3	L	2	M	29
Quercus phellos	Oak, Willow	T	M	13	L	2	L	2	M	17
Quercus prinus	Oak, Chestnut	T	M	13	L	3	L	2	M	18
Quercus robur	Oak, English	T	M	30	L	5	L	3	M	38
Quercus rubra	Oak, Northern Red	T	M	30	L	5	L	3	M	38
Quercus shumardi	Oak, Shumard Oak	T	M	21	M	3	L	2	L	26
Quercus turbinella	Oak, Shrub Liveoak	S	VL	13	L	2	L	2	VL	17
Quercus undulata	Oak, Wavyleaf	T	L	16	L	2	L	2	L	20
Ranunculus gramineus	Buttercup, European	P	M	9			M	1	M	10
Ranunculus repens	Creeping Buttercup	P	M	15			H	1	M	16
Ratibida columnifera	Coneflower, Prairie	P	L	26	VL	3	L	2	VL	31
Rhamnus catharticus	Buckthorn, Common	S	L	29	L	3	L	2	L	34
Rhamnus frangula 'Asplenifolius'	Buckthorn, Glossy Cutleaf	S	M	19	L	4	L	3	L	26
Rhamnus frangula 'Columnaris'	Buckthorn, Tall Hedge	S	L	26	L	5	L	2	L	33
Rhamnus saxitile	Buckthorn, Rock	S	L	10	L	2	L	2	L	14
Rhamnus smithii	Buckthorn, Smith's Alder	S	L	16	VL	5	L	2	L	23
Rheum rhabarbarum	Rhubarb	P	M	20			M	1	M	21
Rhododendron	Rhododendron	S	H	19	M	4	H	2	H	25
Rhus aromatica	Sumac, Fragrant	S	L	24	L	5	L	4	L	33
Rhus glabra	Sumac, Smooth	S	L	28	L	6	L	4	L	38
Rhus lanceolata	Sumac, Flameleaf	S	L	8	L	4	L	3	L	15
Rhus microphylla	Sumac, Little Leaf Desert	S	VL	12	L	4	L	3	VL	19
Rhus trilobata	Sumac, Three-Leaf	S	VL	33	L	6	VL	7	VL	46

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Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Rhus typhina	Sumac, Staghorn	S	L	28	L	6	L	4	L	38
Ribes alpinum	Currant, Alpine	S	L	33	L	7	L	6	L	46
Ribes aureum	Currant, Yellow Flowering	S	L	26	L	6	L	6	L	38
Ribes cereum	Currant, Squaw	S	L	22	L	6	L	7	L	35
Ribes hirtellum 'Pixwell'	Gooseberry, Pixwell	S	L	20	L	5	L	6	L	31
Ribes inerme	Gooseberry, Whitestem	S	L	10	L	5	L	6	L	21
Ribes leptanthum	Currant, Black	S	L	12	L	3	L	4	L	19
Ribes nigrum	Currant, Black	S	L	9	L	3	L	3	L	15
Ribes odoratum	Currant, Clove	S	L	19	L	5	L	4	L	28
Ribes sanguineum	Currant, Red Flowering	S	L	7	L	1	L	1	L	9
Ribes silvestre 'Red Lake'	Currant, Red Lake	S	L	19	L	3	L	4	L	26
Ribes uva-crispa 'Red Jacket'	Gooseberry, Red Jacket	S	L	14	L	3	L	3	L	20
Ricinus communis	Castor Bean	A	M	9					M	9
Robinia neomexicana	Locust, New Mexico	S T	L	35	VL	9	VL	5	L	49
Robinia pseudoacacia	Locust, Black	T	L	35	L	6	L	4	L	45
Rosa	Rose, Shrub	S	M	21	L	3	L	4	M	28
Rosa foetida 'Bicolor'	Rose, Austrian Copper	S	L	23	L	4	L	4	L	31
Rosa foetida 'Persiana'	Rose, Persian Yellow	S	L	21	L	4	L	4	L	29
Rosa glauca	Rose, Red-Leaved	S	L	22	L	4	L	5	L	31
Rosa pomifera	Rose, Apple	S	L	9	L	3	L	3	L	15
Rosa rugosa	Rose, Rugosa	S	L	23	L	3	L	5	L	31
Rosa woodsii	Rose, Native Pink	S	L	25	L	4	L	5	L	34
Rosa xanthina hugonis	Rose, Yellow Shrub	S	L	16	L	3	L	3	L	22
Rosmarinus officinalis	Rosemary	A P	L	16			L	1	L	17
Rosularia globulariifolia	Rosularia, Roundleaf	P	L	5					L	5
Rubus deliciosus	Boulder Raspberry	S	L	28	L	4	L	6	L	38
Rubus idaeus	Raspberry	S	M	16	L	1	L	2	M	19
Rubus odoratus	Raspberry, Purple-flowering	S	L	12	L	2	L	2	L	16
Rubus parviflorus	Thimbleberry	S	M	15	L	4	L	5	L	24
Rudbeckia fulgida	Black-Eyed Susan	P	L	28	L	2	L	1	L	31
Rudbeckia hirta	Black-Eyed Susan	P	M	25	L	2	M	2	M	29
Rudbeckia laciniata 'Double Gold'	Black Eyed Susan, Double Gold	P	M	18			H	1	M	19
Saccharum ravennae	Grass, Plume	P	M	13					M	13
Sagina subulata	Pearlwort	GCP	M	10			M	1	M	11
Sagittaria latifolia	Arrowhead, Broadleaf	P	H	8			H	1	H	9
Salix 'Prairie Cascade'	Willow, Prairie Cascade Weeping	T	H	25	H	3	H	2	H	30
Salix alba 'Tristis'	Willow, Golden Weeping	S T	H	32	H	6	M	4	H	42
Salix alba vitellina	Willow, Russian Golden	S T	H	23	M	5	M	6	H	34
Salix amygdaloides	Willow, Peach Leaf	S T	M	26	M	6	M	7	M	39
Salix arenaria	Willow, Silver Creeping	S	M	11	M	3	M	3	M	17
Salix bebbiana	Willow, Bebb's	S	M	9	M	2	M	3	M	14
Salix caprea	Willow, Goat	S	H	10	H	1	H	1	H	12
Salix discolor	Willow, Pussy	S	H	21	H	3	M	3	H	27
Salix drummondiana	Willow, Drummond	S	H	8	M	2	M	3	M	13
Salix exigua	Willow, Coyote	S	M	19	M	3	H	4	M	26
Salix fragilis	Willow, Crack	S	H	10	M	3	H	4	H	17
Salix geyeriana	Willow, Geyer's	S	H	8	M	2	M	3	M	13
Salix integra 'Hakuro Nishiki'	Willow, Dappled	S	H	11	H	2	H	2	H	15
Salix irrorata	Willow, Blue Stem	S	M	20	M	3	M	5	M	28
Salix lutea ligulifolia	Willow, Strapleaf Yellow	S	M	9	M	2	M	2	M	13
Salix matsudana 'Umbraculifera'	Willow, Globe	S T	H	29	H	6	M	3	H	38
Salix monticola	Willow, Yellow Mountain	S	H	11	M	4	M	5	M	20
Salix pentandra	Willow, Laurel Leaf	T	H	16	M	3	M	2	M	21
Salix purpurea	Willow, Basket	S	H	18	M	4	M	3	M	25
Salix repens	Willow, Creeping	S	M	13	M	3	M	3	M	19
Salix scouleriana	Willow, Scoulers	S	M	7	M	2	M	2	M	11
Salix x sepulcralis chrysocoma	Willow, Niobe Weeping	T	H	17	M	3	M	2	H	22
Salvia argentea	Salvia, Silver	P	L	18	L	2	L	2	L	22
Salvia azurea grandiflora	Salvia, Blue	P	L	15	L	2			L	17
Salvia farinacea	Mealycup sage	A	M	10			L	1	M	11
Salvia greggii	Sage, Autumn	P	L	15	L	1			L	16
Salvia jurisicii	Salvia, Cutleaf	P	L	13					L	13
Salvia leucantha	Sage, Mexican Bush	P	L	7					L	7
Salvia lyrata	Sage, Lyre-leaf	P	L	5					L	5
Salvia microphylla	Salvia, Red Baby	P	L	8					L	8
Salvia nemorosa	Salvia, Blue	P	L	19	L	2	M	1	L	22
Salvia officinalis	Sage, Garden	P	L	21	L	2			L	23
Salvia pitcheri	Sage, Pitcher	P	L	9					L	9
Salvia sclarea	Clary Sage	A P	L	21	VL	1	M	1	L	23
Salvia splendens	Scarlet Salvia	A	M	11			L	2	M	13
Salvia superba	Salvia, Hybrid	P	L	13			M	1	L	14
Sambucus canadensis	Elder, American	S	M	26	M	5	M	5	M	36
Sambucus nigra 'Marginata'	Elder, Variegated	S	M	16	M	3	M	4	M	23
Sambucus pubens	Elder, Native Red Berried	S	M	18	L	4	L	6	M	28
Sambucus racemosa	Elder, European Red	S	M	15	M	4	M	4	M	23
Santolina chamaecyparissus	Lavender Cotton	P	L	24	L	2	VL	1	L	27
Santolina rosmarinifolia	Lavender Cotton, Green	P	L	18	VL	1	VL	1	L	20
Sanvitalia procumbens	Creeping Zinnia	A	L	11			L	2	L	13
Sapindus drummondii	Soapberry, Western	S T	L	8	L	3	L	2	L	13
Saponaria ocymoides	Rock Soapwort	P	L	20	L	2	M	1	L	23
Saxifraga oppositifolia 'Purple Robe'	Saxifrage, Purple Robe	P	M	12	M	1	H	2	M	15
Saxifraga x arendsii	Saxifrage, Rose Mound	P	M	10			H	1	M	11
Scabiosa caucasica	Pincushion Flower	P	M	19	M	1	L	1	M	21
Scabiosa columbaria	Pincushion Flower	P	L	16			L	1	L	17
Scabiosa lucida	Pincushion Flower, Dwarf	P	L	15	M	1	L	1	L	17

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Scabiosa ochroleuca	Pincushion, Yellow	P	L	12					L	12
Scaevola aemula	Fan Flower	A	M	11			M	2	M	13
Schizachyrium scoparium	Bluestem, Little	P	L	22	VL	3	L	2	L	27
Schizophragma hydrangeoides	Vine, Japanese Hydrangea	P	M	4					M	4
Schoenoplectus lacustris	Bulrush, Common	P	H	6					H	6
Schoenoplectus validus	Bulrush, Softstem Great	P	H	6					H	6
Scirpus acutus	Bulrush, Hardstem	P	H	7			H	1	H	8
Scirpus americanus	Bulrush, Three-square	P	H	7			H	1	H	8
Scirpus microcarpus	Bulrush, Small-fruited	P	H	7			H	1	H	8
Scutellaria alpina 'Arcobaleno'	Skull Cap, Rainbow	P	M	8			M	1	M	9
Scutellaria resinosa	Skull Cap, Prairie	P	L	8					L	8
Sedum 'Autumn Joy'	Stonecrop, Autumn Joy	P	L	28	L	1	L	1	L	30
Sedum 'Blue Spruce'	Stonecrop, Blue Creeping	GCP	L	14	L	2	L	2	L	18
Sedum 'Robustum'	Stonecrop, Red-leaf Showy	P	L	11			L	1	L	12
Sedum 'Vera Jameson'	Stonecrop, Vera Jameson	P	L	17	L	1	M	1	L	19
Sedum acre evergreen	Stonecrop, Goldmoss-Utah	GCP	L	16	L	2	VL	3	L	21
Sedum hybridum	Stonecrop, Oak-leaf	GCP	L	12	VL	1	L	2	L	15
Sedum kamtschaticum	Stonecrop, Russian	P	L	13	L	1	VL	1	L	15
Sedum lanceolatum	Stonecrop, Native	P	VL	11			VL	2	VL	13
Sedum populifolium	Stonecrop, Herbacious	P	L	8					L	8
Sedum sieboldii 'October Daphne '	Stonecrop, October Daphne	P	L	8					L	8
Sedum spectabile 'Indian Chief'	Stonecrop, Russet Showy	P	L	15	L	1	L	1	L	17
Sedum spurium	Stonecrop, Two-row	GCP	L	17	L	2	VL	2	L	21
Sempervivum species	Hens and Chicks	GCP	VL	32	VL	4	L	4	VL	40
Senecio cineraria	Dusty Miller	A	L	22	L	1	L	2	L	25
Senecio longilobus	Groundsel, Threadleaf	P	L	8			L	1	L	9
Senecio spartioides	Groundsel, Broom	P	L	5			L	1	L	6
Sequoiadendron giganteum	Giant Sequoia	T	M	10	M	2	L	2	M	14
Shepherdia argentea	Buffaloberry	S T	L	35	VL	8	VL	7	VL	50
Shepherdia canadensis	Buffaloberry, Russet	S	L	19	VL	5	L	6	L	30
Shepherdia rotundifolia	Buffaloberry, Roundleaf	S	VL	15	VL	5	VL	4	VL	24
Sibiraea laevigata	Sibiraea	S	L	11	L	3	L	3	L	17
Sidalcea malviflora	Mallow, Prairie	P	M	17			M	1	M	18
Silene acaulis	Moss Campion	P	M	8			M	1	M	9
Silene alpestris	Alpine Catchfly	P	M	10			M	1	M	11
Silphium perfoliatum	Cup Flower	P	M	5					M	5
Sisyrinchium angustifolium	Grass, Blue-Eyed	P	M	15			M	1	M	16
Sisyrinchium macrocephalum	Grass, Yellow-Eyed	P	M	9					M	9
Sisyrinchium montanum	Grass, Blue-Eyed	P	M	10			M	1	M	11
Solidago 'Golden Baby'	Goldenrod, Golden Baby	P	L	15			L	1	L	16
Solidago decumbens	Goldenrod, Dwarf	P	L	13			H	1	L	14
Solidago missouriensis	Goldenrod, Prairie	P	L	9			M	1	L	10
Sophora japonica	Japanese Pagoda Tree	T	M	26	L	6	M	3	M	35
Sorbaria sorbifolia	Spirea, Ural False	S	L	22	M	3	M	4	M	29
Sorbus alnifolia	Mountain Ash, Korean	T	M	15	L	2	L	2	M	19
Sorbus aucuparia	Mountain Ash, European	S T	M	35	M	6	L	5	M	46
Sorbus decora	Mountain Ash, Showy	T	M	12	L	2	L	2	M	16
Sorbus hybrida	Mountain Ash, Oak Leaf	S	M	9	L	2	L	2	M	13
Sorbus intermedia	Whitebeam, Swedish	T	M	8	M	1	M	1	M	10
Sorbus mougeotii	Whitebeam, Austrian	T	M	6	M	1	M	1	M	8
Sorbus scopulina	Mountain Ash, Native	S T	M	24	M	3	M	4	M	31
Sorghastrum nutans	Grass, Indian	P	L	19	L	2			L	21
Spartina pectinata	Grass, Prairie Cordgrass	P	M	12	L	1	H	1	M	14
Sphaeralcea coccinea	Prairie Mallow	P	VL	17	VL	2	VL	1	VL	20
Sphaeralcea munroana	Globe Mallow, Orange	P	VL	12					VL	12
Spiraea albiflora	Spirea, Japanese White	S	M	15	M	3	M	2	M	20
Spiraea argunta 'Compacta'	Spirea, Compact Garland	S	L	9	M	2	M	2	M	13
Spiraea decumbens	Spirea, White Lace	S	L	6	M	2	M	2	L	10
Spiraea fritschiana	Spirea, Fritschiana	S	L	10	M	3	M	2	M	15
Spiraea japonica	Spirea, Japanese	S	M	21	L	4	M	3	M	28
Spiraea nipponica	Spirea, Snowmound	S	L	23	M	5	M	3	M	31
Spiraea prunifolia	Spirea, Bridalwreath	S	L	23	M	4	M	3	L	30
Spiraea thunbergii	Spirea, Thunberg	S	L	5	M	1	M	1	L	7
Spiraea trilobata	Spirea, Threelobe	S	L	9	M	3	M	3	M	15
Spiraea x 'Goldmound'	Spirea, Goldmound	S	M	22	M	4	M	3	M	29
Spiraea x billardii	Spirea, Billard	S	M	9	M	3	M	3	M	15
Spiraea x bumalda	Spirea, Bumald	S	M	17	M	3	M	2	M	22
Spiraea x cineria 'Grefsheim'	Spirea, Grefsheim	S	M	11	M	2	M	3	M	16
Spiraea x vanhouttei	Spirea, Vanhoutte	S	M	25	M	4	M	3	M	32
Sporobolus wrightii	Grass, Giant Sacaton	P	VL	5	L	1			L	6
Stachys byzantina	Lamb's Ears	GCP	L	25	VL	1	VL	2	L	28
Stachys coccinea	Nettle, Scarlet Hedge	P	L	10					L	10
Stanleya pinnata	Prince's Plume	P	VL	11	VL	1	L	2	VL	14
Stewartia koreana	Korean Stewartia	S	M	5	H	1	H	1	M	7
Stipa comata	Grass, Needle-and-Thread	P	L	10	L	2			L	12
Stipa gigantea	Needlegrass, Giant	P	L	4					L	4
Stipa lettermani	Grass, Needle	P	L	7					L	7
Stipa neomexicana	Needlegrass, New Mexico	P	L	8					L	8
Stipa tenuissima	Grass, Mexican Feather	P	L	16	L	2	L	2	L	20
Stokesia laevis	Aster, Stokes'	P	M	10			L	1	M	11
Styrax japonicus	Snowbell, Japanese	T	H	6	H	2	H	2	H	10
Sutera cordata	Bacopa	A	L	9			M	2	M	11
Symphoricarpos albus	Snowberry, White	S	L	24	L	4	L	3	L	31
Symphoricarpos occidentalis	Wolfberry	S	L	13	L	3	L	4	L	20
Symphoricarpos orbiculatus	Coralberry, Red	S	L	20	L	3	M	3	L	26

Appendix E
Plant Water Requirement Estimates (GreenCO-CSU Crop Coefficient Survey 2004)

Estimated Water Usage for Plant: VL=Very Low < 25%; ET_0 L=Low 25%-50%; ET_0 M=Medium 50%-75%; ET_0 H=High >75% ET_0
Plant Type: A=Annual ; P=Perennial; T=Tree; V=Vine; GC=Ground Cover; S=Shrub; TU=Turf

Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Symphoricarpos oreophilus	Snowberry, Mountain	S	L	15	L	5	L	5	L	25
Symphoricarpos x chenaultii	Coralberry, Chenault	S	L	18	L	3	M	1	L	22
Symphoricarpos x doorenbosii	Snowberry	S	L	13	L	3	L	2	L	18
Symphytum grandiflorum	Comfrey	P	M	12			M	1	M	13
Syringa laciniata	Lilac, Cutleaf	S	L	14	L	3	L	3	L	20
Syringa meyeri 'Palibin'	Lilac, Dwarf Korean	S	L	27	L	5	L	4	L	36
Syringa microphylla	Lilac, Littleleaf	S	L	14	L	3	L	3	L	20
Syringa oblata 'Cheyenne'	Lilac, Cheyenne Early	S	L	15	L	4	L	4	L	23
Syringa patula 'Miss Kim'	Lilac, Miss Kim Dwarf	S	L	27	L	5	L	4	L	36
Syringa pekinensis	Lilac, Peking	S T	L	28	L	6	L	5	L	39
Syringa reflexa	Lilac, Nodding	S	L	8	L	3	L	2	L	13
Syringa reticulata	Lilac, Japanese Tree	S T	M	34	L	7	L	5	L	46
Syringa vulgaris	Lilac, Common Purple	S	L	35	L	6	L	6	L	47
Syringa x chinensis	Lilac, Chinese	S	L	21	L	4	L	4	L	29
Syringa x hyacinthiflora	Lilac, Hybrid	S	L	18	L	4	L	4	L	26
Syringa x josiflexa 'Royalty'	Lilac, Hybrid Purple Singl	S	L	13	M	3	M	3	L	19
Syringa x persica	Lilac, Persian	S	L	15	L	5	L	3	L	23
Syringa x prestoniae	Lilac, Canadian	S	L	22	M	5	L	4	L	31
Tagetes spp.	Marigold	A	L	23	L	1	L	3	L	27
Tanacetum densum amani	Partridge Feather	GCP	VL	19	VL	1	VL	1	VL	21
Tanacetum niveum	Tansy, Snow Daisy	P	L	15	L	1	VL	1	L	17
Tanacetum parthenium 'White Star'	Feverfew, White	P	L	16	M	1			L	17
Tanacetum x coccineum	Painted Daisy	P	L	17			M	1	L	18
Taxodium distichum	Bald Cypress	T	M	23	H	2	H	2	M	27
Taxus cuspidata	Yew, Spreading Japanese	S	M	21	H	4	H	2	M	27
Taxus x media	Yew, Anglojap	S	M	25	H	4	H	2	M	31
Teucrium canadensis	Germander, Creeping	P	L	10					L	10
Teucrium chamaedrys	Germander, Wall	GCP	L	14			L	1	L	15
Thalictrum aquilegifolium	Meadowrue, Columbine	P	M	17	M	1	M	1	M	19
Thalictrum delavayi 'Hewitt's Double'	Meadowrue, Hewitt's Double	P	M	9			M	1	M	10
Thalictrum dipterocarpum	Meadowrue, Yunnan	P	M	9			M	1	M	10
Thalictrum fendleri	Meadowrue, Fendler's	P	M	7	M	1	M	1	M	9
Thalictrum flavum glaucum	Meadowrue, Yellow	P	M	11					M	11
Thalictrum rochebrunianum	Meadowrue, Lavender Mist	P	M	10			M	1	M	11
Thelesperma ambiguus	Navajo Tea	P	L	6	VL	1			VL	7
Thelesperma filifolium	Threadleaf Thelesperma	P	L	10			VL	2	L	12
Thermopsis divaricarpa	Golden Banner	P	L	10	L	2	M	3	M	15
Thermopsis rhombifolia	Golden Banner, Arroyo	P	L	6	L	1	L	2	L	9
Thuja occidentalis	Arborvitae, American	T	M	32	M	4	M	3	M	39
Thuja orientalis	Arborvitae, Oriental	T	M	23	H	3	M	3	M	29
Thuja plicata	Arborvitae, Giant	T	M	15	H	1	H	1	M	17
Thymus 'Elfin'	Thyme, Elfin	GCP	L	15	L	1	VL	1	L	17
Thymus argentia	Thyme, Silver Posy	P	L	7			VL	1	L	8
Thymus praecox 'Pseudolanuginosus'	Thyme, Woolly	GC	L	6	L	1	VL	1	L	8
Thymus praecox arcticus	Thyme, Mother of	GCP	L	19	L	2	L	4	L	25
Thymus serphyllum	Thyme, Wild	GCP	L	16	L	2	L	2	L	20
Thymus vulgaris	Thyme, Garden	P	L	15			VL	1	L	16
Thymus x citriodorus	Thyme, Lemon	P	L	19	L	1	L	1	L	21
Tiarella cordifolia	Foamflower	P	M	11			M	1	M	12
Tiarella wherryi	Foamflower, Wherry's	P	M	11			M	1	M	12
Tilia 'Euchlora'	Linden, Crimean	T	M	17	M	3	M	3	M	23
Tilia americana	Linden, American	T	M	33	M	6	L	4	M	43
Tilia cordata	Linden, Littleleaf	T	M	36	M	5	M	3	M	44
Tilia mongolica	Linden, Mongolian	T	M	11	M	2	L	2	M	15
Tilia tomentosa	Linden, Silver	T	M	16	M	3	M	2	M	21
Tithonia rotundifolia	Sunflower, Mexican	A	L	15			L	1	L	16
Townsendia exscapa	Easter Daisy, White	P	L	10			L	2	L	12
Townsendia grandiflora	Easter Daisy, Large-flower	P	L	7			L	1	L	8
Townsendia parryi	Easter Daisy, Violet-Blue	P	L	4			L	1	L	5
Tradescantia andersoniana	Spiderwort	P	M	20	M	1	M	1	M	22
Tradescantia occidentalis	Spiderwort, Western Blue	P	L	16	VL	1	M	1	L	18
Tricyrtis hirta	Toad Lily	P	M	6					M	6
Trollius chinensis	Globeflower	P	M	16	M	1	M	1	M	18
Trollius pumilus	Globeflower, Dwarf	P	M	8					M	8
Tropaeolum majus	Nasturtium	A	L	21			L	2	L	23
Tsuga canadensis 'Cole's Prostrata'	Hemlock, Canadian Creeping	S	H	10	H	2	H	2	H	14
Tsuga canadensis 'Gracilis'	Hemlock, Dwarf Spreading Canad	S	H	10	H	2	H	2	H	14
Typha angustifolia	Cattail, Narrowleaf	P	H	10			H	1	H	11
Typha latifolia	Cattail, Common	P	H	10			H	1	H	11
Ulmus americana	Elm, American	T	M	30	M	4	M	3	M	37
Ulmus cultivars	Elm	T	M	23	L	2	L	2	M	27
Ulmus glabra	Elm, Scotch	T	L	12	L	3	L	2	L	17
Ulmus parvifolia	Elm, Lacebark	T	L	19	M	3	L	4	M	26
Ulmus wilsoniana	Elm, Wilson	T	M	8	M	3	M	3	M	14
Vaccinium	Blueberry	S	M	8	H	2	H	2	M	12
Valeriana officinalis	Garden Heliotrope	P	M	8					M	8
Verbascum 'Helen Johnson'	Mullein, Peach	P	L	4					L	4
Verbascum bombyciferum	Mullein, Wooly	P	L	16			VL	1	L	17
Verbascum undulatum	Mullein, Wavy-leafed	P	L	4					L	4
Verbena bipinnatifida	Verbena, Native	P	L	19					L	19
Verbena bonariensis	Verbena, Tall	A	L	16	VL	1			L	17
Verbena canadensis	Verbena, Rose	P	L	12	M	1			M	13
Verbena hastata	Vervain, Blue	P	M	5					M	5
Verbena x hybrida	Verbena, Garden	A	L	16	L	1	L	3	L	20
Veronica 'Royal Candles'	Speedwell, Royal Candles	P	L	4					L	4

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Botanic Name	Common Name	Plant Type	East Slope	East Slope Votes	West Slope	West Slope Votes	Mountain	Mountain Votes	All Regions	Total Votes
Veronica 'Sunny Border Blue'	Speedwell, Sunny Border Blue	P	L	18	L	2	M	1	L	21
Veronica Crystal River	Speedwell, Crystal River	GCP	L	10	L	2	L	2	L	14
Veronica allionii	Speedwell, Allioni	GCP	L	15	L	2	L	2	L	19
Veronica austriaca	Speedwell, Hungarian	P	L	12	L	1	M	1	L	14
Veronica filiformis	Speedwell, Birdseye	GCP	L	11	VL	1	L	2	L	14
Veronica gentianoides	Speedwell, Gentian	P	L	8					L	8
Veronica liwanensis	Speedwell, Turkish	GCP	L	21	L	3	L	2	L	26
Veronica longifolia	Speedwell, Long Leaf	P	L	5					L	5
Veronica orientalis	Speedwell, Oriental	P	L	6					L	6
Veronica pectinata	Speedwell, Wooly Creeping	GCP	L	20	L	4	L	2	L	26
Veronica peduncularis 'Georgia Blue'	Speedwell, Georgia Blue	P	L	10	L	1			L	11
Veronica prostrata	Speedwell, Prostrate	GCP	L	12	L	2	L	2	L	16
Veronica repens	Speedwell, Creeping	GCP	L	17	L	3	L	2	L	22
Veronica spicata	Speedwell, Spike	P	M	18	L	1	L	1	M	20
Veronica spicata incana	Speedwell, Wooly	P	L	16			L	1	L	17
Veronicastrum virginicum	Bowman's Root	P	M	11					M	11
Viburnum carlesii	Viburnum, Koreanspice	S	M	30	M	3	L	2	M	35
Viburnum dentatum	Viburnum, Arrowwood	S	M	24	M	4	L	2	M	30
Viburnum dilatatum	Viburnum, Linden	S	L	6	M	1	M	1	M	8
Viburnum lantana	Wayfaringtree	S T	L	34	L	7	L	4	L	45
Viburnum lentago	Viburnum, Nannyberry	S	L	26	L	5	M	3	L	34
Viburnum opulus	Viburnum, European	S	M	26	M	5	L	2	M	33
Viburnum plicatum tomentosum	Viburnum, Doublefile	S	M	18	M	3	M	2	M	23
Viburnum prunifolium	Viburnum, Blackhaw	S	M	16	L	4	L	2	M	22
Viburnum rufidulum	Viburnum, Rusty Blackhaw	S	M	5	M	1	M	1	M	7
Viburnum sargentii	Viburnum Sargent	S	M	13	L	3	L	2	L	18
Viburnum trilobum	Viburnum, American Cranberrybus	S	M	24	L	5	L	2	M	31
Viburnum x bodnantense 'Pink Dawn'	Viburnum, Pink Dawn	S	M	15	M	2	M	2	M	19
Viburnum x burkwoodii	Viburnum, Burkwood	S	M	27	L	4	L	1	M	32
Viburnum x carlcephalum	Viburnum, Fragrant Snowball	S	M	16	L	3	L	2	M	21
Viburnum x juddii	Viburnum, Judd	S	M	18	M	3	L	2	M	23
Viburnum x rhytidophylloides 'Alleghany'	Viburnum, Alleghany	S	L	23	L	4	L	2	L	29
Viguiera multiflora	Showy Goldeneye	P	L	5					L	5
Vinca major	Periwinkle, Big-Leaf	GCP	M	16	M	2	M	2	M	20
Vinca minor	Periwinkle	GCP	L	24	L	3	M	2	L	29
Viola canadensis	Violet, Canadian	P	M	6			M	1	M	7
Viola cornuta	Pansy, Tufted	P	M	15	M	1	M	1	M	17
Viola corsica	Violet, Corsican	P	M	16	M	1	M	1	M	18
Viola odorata	Violet, English	P	M	13			M	1	M	14
Viola tricolor	Viola, Johnny-jump-up	A	M	22			M	2	M	24
Viola x wittrockiana	Pansy	A	M	21			M	3	M	24
Vitis cultivars	Grape cultivars	S V	M	22	M	4	M	1	M	27
Vitis riparia	Grape, Frost	S V	M	11	M	3	M	1	M	15
Waldsteinia ternata	Strawberry, Barren	GCP	L	20	L	3	L	2	L	25
Weigela florida	Weigela	S	M	22	M	4	M	2	M	28
Wisteria floribunda	Japanese Wisteria	V	L	2					L	2
Wisteria sinensis	Wisteria, Chinese	V	M	16					M	16
Xanthoceras sorbifolium	Yellowhorn	T	L	10	L	2	H	1	M	13
Yucca baccata	Yucca, Banana	S	VL	26	VL	6	VL	4	VL	36
Yucca elata	Soap Tree	S	VL	23	VL	5	VL	4	VL	32
Yucca filamentosa	Adam's Needle	S	L	27	VL	5	VL	3	L	35
Yucca glauca	Soapweed	S	VL	28	VL	6	VL	6	VL	40
Yucca recurvifolia	Yucca, Spineless	S	VL	15	VL	4	VL	3	VL	22
Zauschneria californica latifolia	Hummingbird Flower	P	L	19	VL	1			L	20
Zauschneria garrettii 'Orange Carpet'	California Fuchsia, Orange	P	L	23	VL	2			L	25
Zelkova serrata	Zelkova, Japanese	T	M	11	M	3	M	2	M	16
Zinnia elegans	Zinnia	A	L	23	L	1	L	2	L	26
Zinnia grandiflora	Paper Flower	P	VL	23	VL	3	VL	1	VL	27