SLC LANDSCAPE BMPS FOR WATER RESOURCE EFFICIENCY AND PROTECTION

For Landscape Professionals, Architects, Contractors, and Homeowners

SALT LAKE CITY

October 2011

An Introduction:

SLC Landscape BMPs for Water Resource Efficiency and Protection: A Landscape Manual for Landscape Professionals, Architects, Contractors, and Homeowners

This manual came into being due to the natural confluence of two separate, though parallel projects: a revision of the Salt Lake City Landscape Code being directed by the Salt Lake City Planning Department, and the development of an interactive website intended to inform, inspire, and promote water-wise landscapes by the city's Public Utilities Water Conservation Office. During the processes for each of these projects, it was frequently noted that there was no single resource identifying and outlining efficiency standards or best management practices (BMPs) to enhance water efficiency, reduce landscape chemical dependence, and eliminate water waste for landscapers or contractors working within the Salt Lake City area. While meeting with contractors and photographing landscapes for the interactive website, a frequent question was where does someone get informative, concise information to share with employees, homeowners, and property managers? It was through those conversations that both the need and the character of this manual was conceived.

The first steps were to construct an outline, essentially the table of contents, to identify and reach out to subject experts, and to create a process for peer review. It was during this stage that we came across the Green Industries of Colorado (GreenCo) *Water Conservation Best Management Practices for the Conservation and Protection of Water Resources in Colorado*. Prepared by Wright Engineering and funded with support from the Colorado Water Conservation Board, Headwaters Consulting, and the Colorado Department of Public Health and Environment-Water Quality control Division, under a grant from the US Environmental Protection Agency. The Water Conservation Office contacted Wright Engineering and GreenCo, at which time permission was given to use GreenCo's bmps as a starting point.

A group of subject experts and stakeholders was developed, and over the next year, the GreenCo bmps were reviewed and updated and revised to suit our region's climate and landscape practices. During this time, topics were identified by the stakeholders that were either not included or needed expanding, and experts were identified and tasked with preparing initial drafts of these new sections. In particular, topics pertaining to trees, stormwater pollution prevention practices, and backflow prevention were either expanded or added to the growing manual.

The end result of those labors is this manual. Many Salt Lake City Departments or Divisions participated, including Urban Forestry, Parks, Open Space, Golf, Cemeteries, Stormwater, Backflow Prevention, Engineering, Utility Development Review, and Planning, with the process lead by the Water Conservation Office. Other agencies outside of the City also participated, including the Utah State Division of Water Quality, Utah State University, Salt Lake County Cooperative Extension, the American Society of Landscape Architects-Utah Chapter, the Utah Landscape and Nursery Association, and the Bureau of Reclamation/Upper Colorado Basin Office.

And finally, there were a handful of individuals, landscape and irrigation professionals, and USU faculty members that assisted by not only generously and repeatedly offering their extensive expertise, but also their support, encouragement, and candor. From USU, Kelly Kopp and Larry Rupp were instrumental in developing the bmps on turf and landscape plant installation and maintenance; Russ Jacobsen and Fred Liljegren for their assistance in developing the irrigation segments; Jamie Tsandes, ASLA and Greg Graves, ASLA for their guidance on landscape design practices; and Janet Simonich of Progressive Plants for lending her plant expertise. The wisdom in these pages belongs to so many; any error, typos, or other shortcomings belong solely to the office of Water Conservation.

Salt Lake City Landscape Best Management Practices for
Water Resource Efficiency and Protection

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01 Sustainability
General Principles, Relationship to SLC BMPs, and Energy Conservation

BMP Type			
Design			X
Installation			X
Maintenance/Operations			X
Green Industry Relevance			
AIA	X	L/I.UNLA	X
ASLA	X	UCFC	X
ISTMA	X	UNPGA	X
ITP.UNLA	X	UWCF	X

Description

Both national and local efforts are underway to improve the sustainability of natural and built landscapes and to foster design, construction, and maintenance processes compatible to this goal. Definitions of sustainable landscaping vary, with the SLC Landscape BMP Working Group (SLC-MWG) offering the following:

"Irrigated landscapes support important functional, recreational, aesthetic, and economic interests for society, including erosion control, temperature modification, and the creation of recreational areas such as playing fields, parks, and golf courses." (Handbook of Water Use and Conservation 2001)

> "Sustainable landscaping should aim to create spaces that are enduring, adaptable, and attractive, in balance with the local climate and requiring resource input levels appropriate to a landscape's use, with an aim to reduce resource inputs, such as fertilizer, pesticides, and water on all sites. Sustainable landscaping includes thoughtful design, construction, plant selection, and maintenance practices to create functional, cost efficient, visually pleasing, environmentally friendly, and maintainable areas. The outcomes of these efforts are landscapes that meet the needs of the present without compromising the ability of future generations to meet their needs." (SLC-MWG 2011)

Sustainable landscaping has different meanings, depending on the audience, and may best be described along a continuum that progresses from conventional practices, which are often dependent on significant natural resource and energy inputs, to sustainable practices, which require less natural resource and energy use. The need for resources, such as water, to support a landscape should not necessarily preclude a site from being labeled as sustainable, but rather it should be the level of efficiencies that are achieved in the use of those resources. In our climate,

National Sustainability Initiatives

In 2007, the national "Sustainable Sites Initiative" was launched as an interdisciplinary partnership between the American Society of Landscape Architects (ASLA), the Lady Bird Johnson Wildflower Center, the United States Botanic Garden, and a diverse group of stakeholder organizations to develop guidelines and standards for landscape sustainability. The motivation behind this initiative stemmed from the desire to protect and enhance the ability of landscapes to provide services such as climate regulation, clean air and water, and improved quality of life. Sustainable Sites™ is a cooperative effort with the intention of supplementing existing green building and landscape guidelines, as well as becoming a stand-alone tool for site sustainability. For more information on this effort, see www.sustainablesites.org and www.frslc.wetpaint.com.

it would be difficult to support parks, golf courses, or our urban forest—valuable public assets—without providing supplemental irrigation; however, all landscapes can be operated and maintained such that those resources are optimally utilized. As stated by the U.S. Environmental Protection Agency, "sustainable development marries two important themes: that environmental protection does not preclude economic development and that economic development must be ecologically viable now and in the long run." Implementing practices that create and support sustainable landscapes creates many opportunities for the commercial landscape industry to both thrive economically and protect and restore the environment.

It is inevitable that discussions of what constitutes a sustainable landscape would move beyond water conservation and fertilizing into other areas, some with connections to landscape practices less obvious than others. The title of the manual that contains these BMP's is an example of this broad scope, referencing not only water conservation but water protection. This BMP attempts to introduce the landscape professional and home gardener to the concepts of sustainability, touching not only on water conservation, but other areas such as water protection, energy conservation, and urban forestry, in the hopes that these concepts can be integrated into everyday landscape practices.

Basic Practice Guidelines

This BMP focuses primarily on 1) increasing familiarity of the landscape industry, contractors, and home gardeners with general sustainability concepts, and 2) opportunities related to landscaping which are not addressed in other included BMPs of the SLC BMP Manual.

In the past several years, Salt Lake City has undertaken a focused effort to identify important sustainability goals, divided into ten concepts, and to identify opportunities to implement practices and policies that move us towards achieving those goals. Towards this end, the 2009 Water Conservation Master Plan included a water conservation and sustainability matrix to identify linkages between broader sustainability issues and those issues focused in water, specifically, water conservation and use reduction. In addition to the ten topics identified by the City, Public Utilities added the concept of water security to that list, bringing the total number of sustainability concepts to eleven. Below is a listing of these sustainability topics; Table 1 demonstrates the linkages between the BMPs contained in this manual with these concepts. For more information on these concepts, visit www.slcsaveh2o.com and view the 2009 Water Conservation Master Plan, and visit www.slcgreen.com.

SLC Sustainability Topics

Table 1 Relationship of SLC BMPs to SLC Sustainability Topics

SUSTAINABILITY TOPIC	RELEVANT BMP
Water Quality and Supply	3, 4, 5, 6, 10, 11, 12, 13, 14, 15, 16, 21, 22, 23, 26, 28, 29, 31, 32, 35, 36, 37, 38, 40
Energy	4, 8, 15, 18, 18a, 20
Air Quality and Climate Change	5, 6, 7, 8, 18, 21, 22, 30, 31, 32, 37, 38
Open Space, Parks, and Trails	1, 4, 8, 20, 33, 36, 24, 25, 26, 40
Recycling and Waste Reduction	2, 6, 24, 25, 26, 27

Mobility and Transportation	7, 8, 9, 29
Urban Forestry	7, 8, 9, 26
Housing Accessibility and Diversity	2, 11, 12
Community Health and Safety	5, 18, 18a, 19, 21, 22, 23, 29, 30, 31, 32, 34, 37, 38, 40
Food Production and Nutrition	6, 25
Disaster and Emergency Resilience	28, 34, 35, 36

Note: Sustainability topics and description provided from the 2009 SLC Water Conservation Master Plan

Water Quality and Supply

Though water conservation itself is a main subtopic under Water Quality and Supply, it is not the only linkage between water and landscape. Landscape management practices, including site preparation, the use of chemical and organic fertilizers and pesticides, and mowing practices can have negative consequences on stormwater, groundwater, and stream health. Following the BMPs outlined in this manual can reduce potential negative impacts.

Energy

Water demand has a direct link to energy use and production. In defining this link it is important to recognize that it takes a lot of energy to treat and convey water and wastewater, and it takes a lot of water to manufacture fuel and electricity. Salt Lake City Public Utilities is mapping its own "energy-water nexus" and defining how we affect and are affected by water and energy resource decisions.

Air Quality and Climate Change

Climate change is the biggest challenge we face with respect to our water supplies and water quality. Climate models predict our region to become warmer with a shrinking snowpack; projected warmer summer temperatures will likely increase water demand, while reducing the amount of water stored in the snowpack. The type and nature of precipitation may also change in our region leading to water quality issues resulting from periodic heavy rain storms, as well as changing the timing and storage of our water supply. In short, from a water resource planning perspective, using the past as a guide to future planning (the assumption of stationarity) is no longer a good tool.

Water conservation measures play an important role as we face water supply challenges due to climate change. In particular, public education and the establishment of conservation habits across the community can help us better adapt to a future of warmer temperatures and a changing hydrologic regime.

Landscape practices may also affect air quality, be it the negative impacts of exhaust expelled by motorized landscape maintenance equipment or dust caused by poor erosion control measures in site preparation; or more positive impacts through the sustaining of our urban forest and the reduction of chemical use.

Open Space, Parks, and Trails

Open Spaces are places of natural beauty that provide important habitats, recreational or community building opportunities, and critical environmental functions. Floodplains, wetlands, farms, ranches, parks, golf courses, gardens and trails can all be a part of an Open Spaces system.

Protected Open Spaces help the environment by combating air and noise pollution, providing erosion and wind control, moderating temperatures, and protecting habitats. They are invaluable to people's health as it protects surface and ground water resources by filtering trash, debris, and chemical pollutants before they enter a water system.

The very nature of Salt Lake City's setting between the Wasatch Mountains and the Great Salt Lake brings both the mountain and wetland environments into urban areas. This makes open spaces, parks, and trails critical to quality of life. With continued population growth, threats to this natural setting will heighten; protecting open spaces helps mitigate this pressure by redirecting new growth to designated areas.

An important nexus to explore will be the potential water use demand resulting from increased acreage of irrigated lands, and the need to balance the desire for more open space with long-term goals of resource use reduction. Thoughtfully planned parks and golf courses, when designed with sustainability principals in mind, can be a great community asset while still utilizing natural and manufactured resources with wisdom and discernment.

Recycling and Waste Reduction

Within the last 35 years, the amount of waste each person creates has almost doubled from 2.7 to 4.6 pounds per day[1]. In a sustainable community, waste is not a problem to be disposed of, but a resource to be used and reused. Responsible waste management involves:

- Reduction of waste
- Reuse of waste materials
- Recycling of goods
- Buying products made from recycled content

Implementing best practices in the landscape creates a positive nexus between the mutual goals of waste reduction and water protection and use reduction. Reducing water waste; reusing landscape debris such as grass clippings and leaves; using materials indigenous to a site, such as old concrete; and purchasing fewer chemicals are all actions that move us towards a healthier landscape and reduced waster.

Mobility and Transportation

Americans drive almost 35 percent more miles a year than in the early 1980's. Besides burning a lot more gas—a chief source of greenhouse gases—more driving leads to more air pollution, more traffic, more accidents, and more water use. Access to personal vehicles and inexpensive gas has helped fuel the growth of sprawling suburbs. Urban sprawl adds to the nation's health

[1] http://www.recycle.slco.org/topics/topics.html

problems because people are less connected by the pathways, trails, and sidewalks that could get them to destinations by foot or bike.

Besides the obvious relationship between cars and gasoline or biofuels manufacturing, there is another link between mobility and water: walkable city streets. Studies have shown that the most appealing streets and neighborhoods for walking are those streets that contain trees and other landscape features. Greenery softens the hard urban landscape, appeals to the senses, and can cool streets and storefronts. City sidewalks, however, are a harsh environment for plants to endure, and so good design, proper plant selection, and appropriate watering practices are necessary to ensure a healthy, attractive, walkable streetscape. Sustaining our water supplies is a critical, though maybe overlooked, component of designing and building a walkable community.

Urban Forestry

There can be no doubt or disagreement that in a climate such as we find ourselves, with hot, dry summers, and bracing winter winds, our urban forest, makes this environment livable and enjoyable. Salt Lake City has been blessed by the foresight of generations past in planting the trees that now provide shade, shelter, and even food for ourselves and abundant wildlife, and forward acting Urban Forestry Division to ensure the ongoing vitality and health of this dynamic resource.

Our urban forest also helps to mitigate the effects of urban heat-island effect, helps to moderate air and soil temperatures, and some in some instances, helps to combat certain types of air pollution.

In order to ensure that our urban forest continues to grow with us into our future, it is vital that we work with the Urban Forestry Division to identify practices that sustain both this valuable resource while respecting that other precious resource: water. Research into adaptive tree species, planning and design practices, and alternative water sources are areas to be explored.

Housing Accessibility and Diversity

A sustainable community allows people the opportunity to live in various types of affordable housing that is close to work, schools, and services. During the last few decades, the demographic makeup of U.S. households has changed. These households now require new sustainable options to meet their basic needs. For example, many elderly people, single people with children, childless couples, and young families fall into lower income tiers making government programs necessary to ensure housing options are available.

Salt Lake City's goal is to make housing as safe, water efficient, and energy efficient as possible. The Housing and Neighborhood Development Division oversees numerous housing programs including low-interest housing rehabilitation loans, first-time homebuyer programs, housing development gap financing for affordable and special needs projects and federal grant programs.

Addressing costs associated with landscape maintenance is another aspect of affordable housing that needs to be examined. From design to plant selection, and maintenance to watering

practices, these factors can affect not only the cost of a proposed landscape, but the costs associated with a landscape over its lifetime. And these costs may not only be the responsibility of a homeowner, but in the case of public housing, are costs shouldered by a community. Following the included best management practices in landscape and irrigation design, construction, and maintenance will help to ensure that all housing is attractive and sustainable.

Community Health and Safety

Salt Lake City actively promotes human and environmental health and safety in our community. Obesity and asthma are two predominant health issues in our community. From a land use regulatory perspective, the general goal for community health is to promote healthy lifestyles. This best relates to landscape practices through the support of walkable streets and the development of sustainable and enduring public landscapes.

Another aspect of community health relating to landscape practices are those actions centered on the storage, use, and disposal of landscape chemicals. Implementing best practices will not only enhance the health and safety of employees exposed to chemicals, but the community surrounding sites where chemicals are stored and used.

Food Production and Nutrition

The average food item in the U.S. travels 1,400 miles to get to the dinner table. As the cost of fuel sky rockets, so do food prices. Suburban sprawl consumes productive land and forces dependence on foreign food producers. For the first time, in 2005, the U.S. imported more farm products by value than it exported. As awareness about nutrition has risen and obesity has increased, the public pressure for nutritious, local, and sustainably grown food is on the rise.

Utah has 16,700 farms on 11 million acres, according to the Utah Department of Agriculture and Food. Many of these farms have been family-owned for several generations. In addition, a significant percentage of local food supply can be homegrown even in urbanized places such as Salt Lake City. Community gardens, urban farms, public lands, urban plots, and even roof tops are all innovative ways to address food security, environmental issues, and the need for green space in an urban setting. They also support Salt Lake City's goal of increasing direct access to fresh foods and promoting community-based food production to minimize the environmental impacts of transporting food long distances.

The sustained local production of plants, whether for commercially grown food crops, biofuel crops, or home food production will require a sustained supply of water, delivered during the growing cycle, when rainfall is less likely. Conservation and our continued exploration of future new water supplies will be a critical component in the success of these ventures. It will also be important that as we consider programs involving the growing of crops for biofuels, or production of food on public lands that we consider all the benefits and the impacts, and include water use and quality in that matrix.

On a global scale, increasing opportunities for enlarging local food production means that water supplies in other regions or countries, both in quantity and quality, are less affected by our consumptive habits and patterns.

Drops to Watts: Have You Made the Water Use—Energy Connection? (Excerpted from USEPA 2008)

"Although most people understand that heating water requires energy, they don't always consider the energy it takes to treat and deliver the water they use. In 2005, the nation's municipal water infrastructure consumed about 56 billion kilowatt hours of electricity—that's enough energy to power more than 5 million homes for an entire year. Plus, as the demand for water grows, water utilities must pump water from more distant and deeper sources, which, in turn, requires even more energy…That's why simple [water efficient devices and practices] can really make a difference when it comes to addressing global warming—the less water we use, the fewer greenhouse gases will be produced to generate electricity."

Disaster Resilience

Salt Lake City is committed to helping our community be resilient in the event we are affected by emergencies and disasters. This includes SLCDPU's participation in all phases of the emergency management cycle: planning, mitigation, response, and recovery. SLCDPU is also very active in numerous local, state, and federal emergency management and homeland security programs.

Water, wastewater, and stormwater are critical functions providing for the public's well-being. Each of these utilities can be affected by disasters and emergencies, resulting in disruption of services. Source water protection and water conservation programs have an important role in our community's disaster resiliency in each phase of the emergency management cycle.

Energy Conservation

1. In addition to sustainability practices related to water conservation and water quality protection, the Green Industry has many opportunities for energy conservation as it continues to encourage sustainability. In a general sense, the typical areas to seek energy conserving opportunities include: building envelopes, windows, lighting systems (including daylight), electrical systems, plug loads and HVAC systems. Although this BMP Manual does not go into detail on this topic, basic practices that can be implemented across the Green Industry include these first steps, identified by the National Renewable Energy Laboratory (NREL 2008):
    - Replace incandescent lights with more efficient models, which may use about 70 percent less electricity than incandescent lights.
    - If motors are used in the greenhouse, switching to variable speed equipment and using the lowest speed appropriate can decrease energy use.
    - Maintain all heating, water pumping, mowing, and irrigation equipment for optimum performance to reduce energy use.
    - Caulk and seal building shell leaks and penetrations in greenhouses.
    - Turn off equipment when not in use and reduce vehicle idling times during deliveries.
    - When replacing trucks and transportation fleets, consider gas mileage and alternative fuel sources.
2. Based on research completed by NREL, energy conservation in the greenhouse is an area of limited research and focus relative to some other industries. Alternative fuel sources for greenhouses include geothermal energy, solar energy, and wind energy. One area that has been developed to some extent includes basic principles of solar greenhouse design, including the following very general principles:

- Orient glazing to receive maximum solar heat during the winter.
- Use heat storing materials to retain solar heat.
- Have large amounts of insulation where there is little or no direct sunlight.
- Use glazing material and installation methods that minimize heat loss.
- Rely primarily on natural ventilation for summer cooling.
- When considering the use of heat pumps, refer to the SLC Sewer Heat Pump BMP (site BMP reference number)

3. For large landscapes, the following energy-saving tips are recommended by the U.S. Environmental Protection Agency under its "Greenscape" program:
    - Strategically plant vegetation outside and around buildings to reduce indoor heating and cooling needs.
    - Use hand or electric equipment where ever feasible to reduce emissions.
    - Use bio-based fuels and lubricants in place of petroleum.
    - Implement a regularly scheduled equipment maintenance program for increased efficiency and reduced emissions
    - Use compost to improve soils (it also makes an excellent air filter media for volatile organic compounds).
    - Specify Green Building requirements for building structures.
    - Plant trees to replace those removed or damaged during construction and to expand their functional services where available planting spaces exist.
    - Buy locally produced goods and services whenever possible to reduce transportation emissions and costs.
    - Purchase or rent fuel efficient vehicles for your fleet.
    - Use high efficiency lighting for roadways, parking lots, security, and landscaping.
    - Use solar powered lighting and signage wherever possible.
    - Utilize solar, wind, and other renewable energy sources. Purchase "green power" from renewable energy sources if available.
    - Control fugitive light and apply dark-sky standards http://www.darksky.org/.
    - Consider battery or solar powered irrigation controllers on sites, especially those without existing electrical hookups.

Greenscape Concepts: Reduce, Recycle, Reuse, and Rebuy ("The 4 Rs")

The U.S. Environmental Protection Agency is encouraging "Greenscape" concepts focused on environmentally beneficial landscaping, taking into consideration conservation opportunities associated with reducing waste, reusing materials, recycling materials, and rebuying recycled materials. Many of the Greenscape concepts are consistent with the SLC BMPs, whereas a few of the recommended practices such as recycling gray water are not regionally recommended. To download the USEPA Greenscapes Tip Sheet, cost calculator, and other brochures, go to www.epa.gov/greenscapes.

Note: Some national sustainability and recognition programs may not fully account for regional constraints for some practices. For example, rainwater harvesting, greywater, and blackwater recycling onsite are restricted under Utah Water Law and/or the Salt Lake Valley Health Department and Utah Department of Environmental Quality. For information regarding these practices, refer to the appropriate SLC BMP.

While the general concepts presented in the Sustainable Sites Initiative are consistent with SLC BMPs, SLC has not yet either endorsed or rejected the standards and practices proposed as part of the Sustainable Sites Initiative.

Resources

Alliance for Water Efficiency www.allianceforwaterefficiency.org
Center for Water Efficient Landscaping http://www.hort.usu.edu/cwel

SLC GardenWise www.slcgov.com/gardenwise

Salt Lake Valley Health Department www.slvhealth.org

Sustainable Sites http://www.sustainablesites.org/report/SSI_Guidelines_Draft_2008.pdf

Utah State Department of Environmental Quality www.deq.utah.gov

U.S. Environmental Protection Agency, Energy Star http://www.energystar.gov/htm

U.S. Environmental Protection Agency, WaterSense Program www.epa.gov/WaterSense

U.S. Environmental Protection Agency, Greenscapes Program www.epa.gov/greenscapes/

U.S. Green Building Council www.gbci.org/ or www.usgbc.org/.

U.S. Green Building Council's (national) Leaders in Environmental Design (LEED) program http://www.gbci.org/ or http://www.usgbc.org/

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02 Water-wise Gardening or Xeriscape™

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Implement the seven basic landscape principles of Water-wise gardening, sometimes called 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 addressed in a number of individual SLC BMPs. Integration of these seven BMPs provides a comprehensive approach that can be very effective for conserving water. A common misconception of Xeriscape is that it is a plant palette mostly comprised of desert plants—this is not the case. Instead, Xeriscape is a combination of multiple practices that, when properly implemented, results in landscape water conservation that meets the seasonal needs of plants.

A well designed and maintained landscape not only conserves water, but is pleasing aesthetically and functionally. Source: SLCDPU Gardenwise

Seven Principles of Xeriscaping™

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 and ventilation of gases from the soil produced by flora and fauna. See *6 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 as no one grass is ideal for all locations. Grasses to consider, depending on the area's purpose, may include improved varieties of Kentucky bluegrass, tall fescue, buffalograss, blue grama grass, or other grasses. 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 low-water native or non-native adaptive species 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. Also, spacing plants farther apart can also reduce water demand by reducing competition for water. Regardless of the plant palette, grouping plants into "zones" based on their water requirements allows them to be irrigated efficiently. See the *Plant Selection and Placement BMP,* and the *SLC Plant List* for more information.

5. **Water efficiently with a properly designed irrigation system**. Water according to the condition of the plants and their needs, current soil moisture conditions, and seasonal requirements, rather than on a fixed schedule. Adjust controllers, or alter manual watering schedules, with the changing seasons and changes in weather. Well-planned sprinkler systems can save water when properly installed and operated. Turf areas should be watered separately from beds of perennials, annuals, and shrubs, and separately from 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 emitters. To promote deep rooting in clay soils, water infrequently, but deeply. Keep in mind that recently planted trees, shrubs, and perennials will need more frequent watering to assist in successful establishment. Remember that, with the exception of very sandy soils, frequent, shallow watering promotes shallow roots, which then may cause plants to require more frequent watering, which defeats the purpose of a water-wise or Xeriscape landscape. . 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, improve conditions for soil microorganisms that foster root health and growth, minimize evaporation, reduce weed growth, reduce dust, 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, mulching, mowing, and fertilization, plus attention to the irrigation system enhance plant health, and good plant health is needed to maximize water savings. Regular maintenance preserves the intended beauty of the landscape, saves water, and reduces maintenance costs. See the *Landscape Maintenance BMP* for more information.

This front yard in an older neighborhood incorporates non-traditional plants in a manner that mirrors more conventional neighboring landscapes. The use of a low-growing, non-turf groundcover in place of turf gives the same impression curbside as would the more traditional turf. Source: SLCDPU Gardenwise

Existing Landscapes

Ideally, landscapes are conceived, designed, and installed with these principles in mind. However, existing landscape can also become more water efficient by implementing the principles to the extent possible. Here are some suggestions for retrofitting or altering a landscape to make it more water efficient and sustainable:

- Assess the site to determine if there are areas of the landscape that require extra attention or more water than other areas. These might be areas of difficult-to-maintain turf, or for

shrub or flower borders that seem to continually dry out. Consider altering the function of those areas, or a different plant palette.

- Existing landscapes benefit from improvements to the soil. Adding and maintaining three to four (3 to 4) inches of mulch can improve soil health, as the mulch breaks down and integrates with the native soil. Perennial borders can be dug up during appropriate times, and the soil amended, and the perennials divided and replanted. Aerate lawns in the spring and/or the fall, leaving the plugs in place to improve soil.

- Evaluate existing turf areas, paying particular attention to areas that are under-utilized, or that require comparatively more water than other turf areas. Side yards, park strips, and west and south facing sloped areas are good places to start. Consider replacing those turf areas with plants having lower water demands; or changing the turf species to a lower water-demanding turf.

  Note, however, that if turf is removed and replaced with plants with lower water demands, the irrigation system may need to be modified to accommodate the change in plants. It doesn't help to replace turf with low-water plants if the newly planted area has to be watered at the same time as the turf because they share a sprinkler zone.

- Examine the sprinkler system at least monthly to determine that all the sprinkler heads are properly functioning and in the correct position, and that there are no broken, cracked, or damaged heads. Consider conducting a sprinkler audit; see *14 Irrigation Efficiency Audits* for more information.

- Mature trees particularly in locations that predispose them to moisture stress due to limited soil volume, elevated temperatures due to convective heat from adjoining impervious surfaces, and increased exposure due to isolation from other trees in group settings, are not well-suited to significant changes to their irrigation regiment and need careful attention to their water requirements to protect their health and the many functional values they provide.

Resources

Center for Water Efficient Landscaping www.

Denver Xeriscape http://www.denverwater.org/cons_xeriscape/cons_xeriscapeframe.html

Salt Lake City Water Conservation Website www.slcsaveh2o.com

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03 Water Budgeting

BMP Type			
Design			X
Installation			X
Maintenance/Operations			X
Green Industry Relevance			
AIA	X	L/I.UNLA	X
ASLA	X	UCFC	X
ISTMA	X	UNPGA	X
ITP.UNLA	X	UWCF	X

Description

Calculate the water needs of irrigated landscapes based on plant types, land area, and irrigation system efficiency. Site features including soil attributes; amount of solar radiation, wind exposure; and size, species and density of plants are a few variables that influence water requirements of landscapes. Use the calculated water budget in association with knowledge of these factors to apply water according to the needs of the plants and manage irrigation.

Basic Practice Guidelines

A water budget is a general term that can have varied meanings, depending on the context in which the term is used. Two of the more common definitions that landscape professionals may encounter include: 1) a "water allotment" by a water utility or 2) a landscape water budget based on the plant water requirements, as described below.

1. A water budget in the context of a "water allotment" or "water allocation," is typically assigned by a local government in the context of water rate structures designed to encourage water conservation and help the utility stretch existing water supplies. Salt Lake City Department of Public Utilities (SLCDPU) has established monthly water budgets for each water utility customer that utilizes a dedicated irrigation meter. The allocation is calculated based on reasonable and necessary outdoor use, water conservation, and other relevant factors associated with water use in the city. The typical approach to water budgeting in the context of a water allocation is as follows:

Total Irrigation Water Allotment (gal/yr) =

Landscaped Area (sq. ft.) x Allotment (gal/sq. ft./yr)

Example 1. Designing a landscape to meet a water allocation.

A local water provider's rate structure is based on a water budgeting approach. The landscape water allotment is 15 gallons/sq. ft./year. Design a 5,000 sq. ft. landscape to meet this allotment of (15 gal/sq. ft./ yr x 5,000 sq. ft. = 75,000 gal/yr). The designer can experiment with various plant types grouped in hydrozones with comparable water needs until the target water allocation is met. One possible design could include 3,500 sq. ft. of bluegrass, which would use about 18-20 gal/sq. ft./yr, and 1,500 sq. ft. of very low water plants, which would require about 0-5 gal/sq. ft./yr based on data from Appendix D. Simplified calculations would be:

19 gal/sq. ft. * 3,500 sq. ft. = 66,500 gal/yr
+ 2.5 gal/sq. ft. * 1,500 sq. ft. = 3,750 gal/yr
Total Landscape Water Requirement = 70,250 gal/yr (about 14.1 gallons/sq. ft.)

2. A water budget can also mean: 1) the total amount of water that a landscape needs to remain healthy (for example, large trees will need more water than small trees regardless of the source or availability of water); or 2) the amount of irrigation that a landscape needs in order to remain healthy after accounting for effective precipitation. A property manager can use this type of water budget to determine how much water a landscape needs and compare it to how much irrigation is being applied in order to better manage irrigation practices and control costs. This type of water budgeting can be conducted much like balancing a checkbook. To calculate the site landscape water budget (gallons of water required for the landscape for either the year or month) and the irrigation water requirement, the following methods can be used:

Method 1. Determine Plant Water Requirement for a Landscape

Plant Water Requirement = $\frac{(ETo)(Kp)(LA)(0.623)}{}$ = gallons of water

Where:

Plant Water Requirement = Water Needed for Plants (gallons per year)
ETo = Reference evapotranspiration (inches per year during the growing season or month or billing cycle) (See Appendix F for more information.)
Kp = Plant coefficient for plant type (See Appendix E for more information.)
LA = Landscaped Area (square feet)
0.623 = Conversion Factor (to gallons per square foot)

Method 2. Determine Landscape Water Requirement, incorporating the irrigation system and assuming all water is supplied by irrigation. In this step, the plant water requirement is adjusted by the efficiency of the irrigation system (IE). Irrigation efficiency varies for each site. For calculation purposes, a properly designed irrigation system can be assigned an irrigation efficiency of 0.75 to 0.80. Where drip irrigation is used, a factor of 0.9 may be used (the irrigation contractor can provide site-specific estimates of efficiency to replace these rules of thumb). This term recognizes that inefficient irrigation systems require additional irrigation application in order to meet plant water requirements.

Landscape Water Budget = $\frac{(ETo)(Kp)(LA)(0.623)}{}$ = gallons of water

Method 3. Determine irrigation water requirements for a closely managed irrigation system, utilizing technologies that incorporate effective rainfall. This step in the water budget can be used by landscape or irrigation managers who are adjusting irrigation based on rainfall at their particular site. At the planning level, this step is often **not** included in water budgets because of uncertainty regarding when rainfall will occur and how much rainfall will occur at a given site during a given growing season. However, for those using rain sensors or other smart controllers, irrigation application can be reduced by accounting for effective precipitation. As a general rule of thumb, effective rainfall (Re) can be estimated as approximately 70 percent of measured rainfall.

Irrigation Water Budget = $[\frac{(ETo*Kp)-Re](LA)(0.623)}{}$ = gallons of water

Example 2. Developing a water budget based on plant water requirements.

For purposes of a simple example, assume that 70% of a 5,000 sq. ft. Salt Lake Service Area landscape is Kentucky bluegrass, irrigated with a properly designed automatic irrigation system using an 80% irrigation efficiency rule of thumb. The remaining 30% of the landscape are "low to very low" water use plants, irrigated with a drip irrigation system with a 90% irrigation efficiency. The seasonal grass reference ETo value for this area is 34.53 inches for cool season grass mowed at 5 inches. *Effective* precipitation is estimated at 5.94 inches for the growing season. 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 grass reference ETo. Water budget and irrigation management calculations are as follows:

Step 1. Calculate total plant water requirement.

Water for Turf Area = (34.53"*0.9)*3500 sq. ft.*0.623 = 67,763 gal/yr
+ Water for Other Area = (34.53"*0.25)*1500 sq. ft.*0.623 = 8,067 gal/yr
Total Plant Water Requirement = 75,830 gal/yr (15.2 gal/sq. ft.)

Step 2. Determine the landscape water requirement incorporating irrigation system efficiency, without precipitation.

Water for Turf Area = [(34.53"*0.9)*3500 sq. ft.*0.623]/0.8= 84,705 gal/yr
+ Water for Other Area = [(34.53"*0.25)*1500 sq. ft.*0.623]/0.9 = 8,963 gal/yr
Total Landscape Water Requirement = 93,668 gal/yr (18.7 gal/sq. ft.)

Step 3. Determine estimated irrigation water requirement for a closely managed system, adjusting irrigation based on effective precipitation.

Water for Turf Area = [((34.53"*0.9)-5.94")*3500 sq.ft.*0.623]/0.8= 68,514 gal/yr
+ Water for Other Area =[((34.53"*0.25)-5.94")*1500 sq.ft.*0.623]/0.9 = 2,796 gal/yr
Total Irrigation Water Requirement = 71,310 gal/yr (14.3 gal/sq. ft.)

The irrigation water needed for this landscape would likely range between 14.3 and 18.7 gal/sq. ft. depending on how the irrigation requirement is managed. If a water allocation of 15 gal/sq. ft. were assigned by a water provider, a reasonably healthy landscape should be able to be maintained, when properly managed.

Regardless of the water budgeting approach used, 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, recognizing and accommodating changes in water demand based on plant growth. 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.).

3. Irrigation scheduling should be based on calculation of a monthly and annual water budget for existing sites.

4. The water budget (landscape water requirement) provides the total gallons per year that the site needs to thrive under average conditions. In either wetter or drier years, the water budget will need to be adjusted. The irrigation water requirement can be calculated after reducing the landscape water requirement by effective precipitation.

5. Evapotranspiration (ET) is the rate at which water is transpired from vegetation and evaporated from soil and plant surfaces. Temperature, humidity, wind, and light all influence the ET rate. For these reasons plants, including trees, that are located next streets, within parking lots, or surrounded by concrete are vulnerable to higher rates of Evapotranspiration. In order for water budgets to be reasonably accurate, it is necessary to provide accurate information on factors such as crop coefficients. See the SLC Conservation web site (www.slcsaveh2o.com) and Appendix E for recommended crop coefficients to be used in calculating water budgets.

6. It should be noted that the grass reference ET (ETo) in the water budget equation is for a theoretical cool season grass that is well-maintained and never lacking for water or nutrients. Turf grasses used in the landscape such as 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 and horticultural practices. See the SLC Plant List for specific turf ETo recommendations.

7. 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.

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

9. 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.

10. Weather-based or soil moisture based controllers (also called "smart" controllers) are one tool that can facilitate landscape irrigation according to the needs of the plants (and therefore the water budget). It is important to remember that:

    a. Low water use plants don't automatically save water (they are easily and often over-watered). Using a "smart" controller can ensure that 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 ensure that the proper irrigation is applied to higher water use plants.

11. Often the retrofitting of poor performing irrigation systems and the use of "smart" controllers will provide a payback in saved water, particularly on north and east facing slopes, and in shaded areas. 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. Additionally, retrofitting spray heads to multi-spray/multi-trajectory heads will also conserve water.

12. SLCDPU provides a simple water budget calculator on its website at

www.slcgov.com/gardenwise 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.

13. Requests for meters 4 inches and larger are required to submit to SLCDPU an estimated daily and annual water use budget.

Values of Water Budgeting

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 SLCDPU 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. To view current water rates and tier levels, visit www.slch2o.com.

4. Salt Lake City's *Water Efficient Landscape Ordinance* (see www.slcgov.com) is based on a variety of methodologies and strategies that reduce water use in landscaped areas while still protecting and sustaining our urban forest and landscape aesthetics. .

5. Check the SLCDPU Conservation website (www.slcsaveh2o.com) for more information on water budgeting techniques.

Resources

Utah Climate Center http://climate.usurf.usu.edu/

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04 Landscape Design

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Plan and design landscapes comprehensively to enhance water conservation opportunities and protect water quality, with a focus given to site conditions, and the plants and trees proposed for use through all stages of their lives from youth to maturity. This BMP includes plant selection and placement guidance, as well as other design features.

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.

Basic Practice Guidelines

Design and Construction Principles

1. Consider existing grade (slope), existing plants to preserve/protect, exposure to natural (e.g., wind, sun) and human elements (e.g., pedestrian traffic), 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.

3. Use organic or inorganic (e.g., mulch, compost, gravel, rock) materials to reduce weeds while still allowing water and air to penetrate the soil. Do not use black plastic because it prohibits water and air penetration into the soil. While use of weed barrier fabrics is allowed, first consider and weigh its impacts on other environmental areas such as energy demand (in manufacturing), and on landfills. Weed barriers are to be maintained with a layer of mulch, either organic or inorganic (see SLC Ord 21A.41.050). See *Mulch BMP* for more information.

4. Landscape bare areas to reduce soil erosion. Good 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 or contiguous to open waterways or known recharge areas to provide extra filtering of runoff. Except for areas defined in the Riparian Corridor Overlay SLC Code 21A.34.130. Discourage use of fertilizers, pesticides, and herbicides within 25 feet of waterway.

5. 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 relevant regulatory agencies or local government staff when these facilities are necessary.

6. Large landscaped areas such as parks, golf courses, business or school campuses, and church grounds 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. New development that falls under the SLC Water Efficiency Landscape Ordinance is required to prepare and submit these and other plan documents (see SLC Ord 21A.48.055: Water Efficient Landscape).

7. Ultra-urban landscapes also have special design considerations, particularly with regard to soil space allocated to trees. See the *Tree Placement in Urban Landscapes* BMP for more information.

Irrigation and Drainage

8. 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.)*

9. Develop plant lists for landscape components based on hydrozones. For example, identify zones of high, moderate and low water usage and then identify water requirements and appropriate plants for each zone. See the *SLC Plant List* for plant hydrozone recommendations.

10. Design landscapes to take advantage of rainfall by capturing site runoff, enabling plants to benefit from natural precipitation, while minimizing runoff into stormwater drainage systems. Such site designs break up impervious areas with landscape areas to enable infiltration of runoff into the soil. This practice should be implemented in a manner that does not compromise the building foundations from water damage or endangers or effects adjacent properties (see *Stormwater BMP).* Vegetated swales and buffers can be used to direct water flow to cultivated areas. Also see the *Landscape Features in Low Impact Development BMP* for more information on practices such as porous landscape detention, which can be implemented in parking medians, residential lots, and other locations.

11. 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.

12. Consider installing terraced gardens on slopes to allow heavy rains to soak in rather than to runoff and cause erosion, while maintaining compliance with SLC Zoning ordinances regarding re-grading.

13. Use porous hardscape materials (e.g., brick, gravel, flagstone, porous pavement) for patios and walkways to keep water in the garden rather than in the gutter. See the EPA Fact Sheet on Porous Pavement for more information (web address in reference section). While porous pavement has useful and appropriate applications, its use in Salt Lake City Water Service Area is discouraged in areas of vehicular traffic or parking due to groundwater and soil contamination from car discharges. See *Landscape Features in Low Impact Development BMP* for more information.

Soils

14. Take soil samples prior to making decisions regarding soil amending and fertilizer application. See the *Soil Amendment BMP* for more detail, including resources for soil testing, recommended tests for soils, and soil amendment classifications.

15. For already developed sites with existing landscaping, conducting periodic soil tests will assist in making good on-going decisions regarding fertilizer application. See the *Soil Amendment BMP* for more information.

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

17. Low Impact Development design approaches also encourage early review of Natural Resources Conservation Service (NRCS) soil mapping for the site to identify areas with soils with higher infiltration capacities (e.g., NRCS Type A or B soils) that may be suitable to be left undisturbed as part of a natural area in a development. Urban development areas are assumed to be a C Group in the NRCS Soils Survey www.nrcs.usda.gov.

18. For trees growing in urban areas, such as within cutouts in paving or sidewalks, provide a minimum of 60 cubic feet of soil for every anticipated inch of diameter at breast height (DBH) at full growth. Strategies to provide the proper amount of soil include root paths, structural soils, and Silva Cells. These strategies will help ensure optimum growth and tree survival while minimizing root/hardscape conflicts. Also see the *Tree Placement in Urban Landscapes* BMP.

Plant Selection and Placement

19. Select plants that are well adapted to the climate, topographic and soil conditions at the site, considering microclimates that may be present within a site. Native plants and plants with documented lower water requirements should be given priority in landscape design. Keep in

mind that some native plants may have relatively high water requirements and high biogenic volatile organic compound emissions, such as those associated with riparian or wetland areas. Avoid plants with high susceptibility to pests and disease.

20. Consider using plants with low water requirements. Information on water requirements for various plants can be obtained from many sources, including the *Salt Lake City Plant List* www.slcgov.com/plantlist; *Water-wise Plants for Utah Landscapes* www.waterwiseplants.utah.gov; and *Water Wise Native Plants for the Intermountain West* (USU Press).

21. When selecting plants for areas near or adjacent to riparian corridor areas, see the Riparian Corridor Plant List.

22. When selecting plants, consider site factors such as the dimensions 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. Also consider the potential habitat-related benefits (e.g., attract butterflies, birds, etc.) when selecting and placing plants.

23. When selecting plants, accommodate their mature size, form, and growth rate so as to best match plants with a space to minimize maintenance and the need to shape, shear, or otherwise control the size of the selected plants.

24. Group plants together that have the same water requirements; see *SLC Plant List* for hydrozone recommendations. Plants located within the drip line for large trees and shrubs should have water requirements similar to the trees and shrubs.

25. Choose plants with lower water requirements for areas with southern and western exposures.

26. Where possible, retain significant native or acclimated vegetation that is already adapted to the site. 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. *(See the Tree Preservation BMP for more information.)*

27. Remove species that are designated state noxious weeds, invasive plants, and un-desirable ornamental species such as purple loosestrife, oxeye daisy, tamarisk, myrtle spurge, and yellow toadflax. See http://www.utahweed.org/weeds.htm for a complete listing of such weeds. Also visit www.slcgov/com/gardenwise for more information on identifying and managing weeds in the landscape.

28. On steep slopes (those with a 1-foot rise and a 3-foot or less run) 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.

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

30. 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.

31. Consider using groundcovers with lower water requirements or naturally low-growing turfs such as buffalo grass or grama grass for slopes and hard-to-mow locations.

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

32. A temporary "nurse crop" of grasses and legumes may be required to provide immediate soil stabilization on steep slopes. Consult with the Salt Lake County Extension Services or the Natural Resources Conservation Service for information to avoid planting overly aggressive species that may compete with permanent ground cover.

33. 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 Salt Lake area communities is ideal. See the Tree Selection and Placement BMP for information recommendations of tree species for specific conditions, including below or above ground utilities.

34. In mountain areas, consider length of growing season, soil, and exposure before selecting plants. Select 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 SLC Plant List for guidance on selecting ground covers for higher elevation areas.

Turf

35. Many turfgrass species are commercially available, so select the appropriate grass for the intended use, expected maintenance effort, water availability, and site conditions. Consider using improved blends and mixes with lower water requirements. See the *Turf Management BMP* or visit CWEL Turfgrass Research page for more information http://www.hort.usu.edu/turfgrass/index.htm.

36. In areas where irrigation is not planned, a mix of mainly native bunch and sod-forming grasses can be used. Avoid the use of noxious grasses including Bermudagrass, quackgrass, Johnson grass, and seaside arrowgrass.

37. Avoid using turf in areas less than 10 feet wide and on slopes with a rise of one (1) foot and a three (3) or less foot run. Although turf provides effective erosion-control, maintaining regularly mowed turf on a steep slope can be difficult and/or dangerous.

38. Assess the actual need and planned use for turf, and design accordingly. Many landscapes can benefit greatly from smaller turf areas, both as a design and functional feature, and for reduced turf maintenance time.

The combination of a small turf area and small patio meet the varied needs of the garden users. Source: SLCDPU Gardenwise

Buffers and Wetlands

39. Maintain wide, undisturbed riparian (stream) corridors or consider installing wetland "edge" treatments. Refer to the *Riparian Corridor BMP* for more information.

40. Identify and 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 without obtaining a 404 permit.

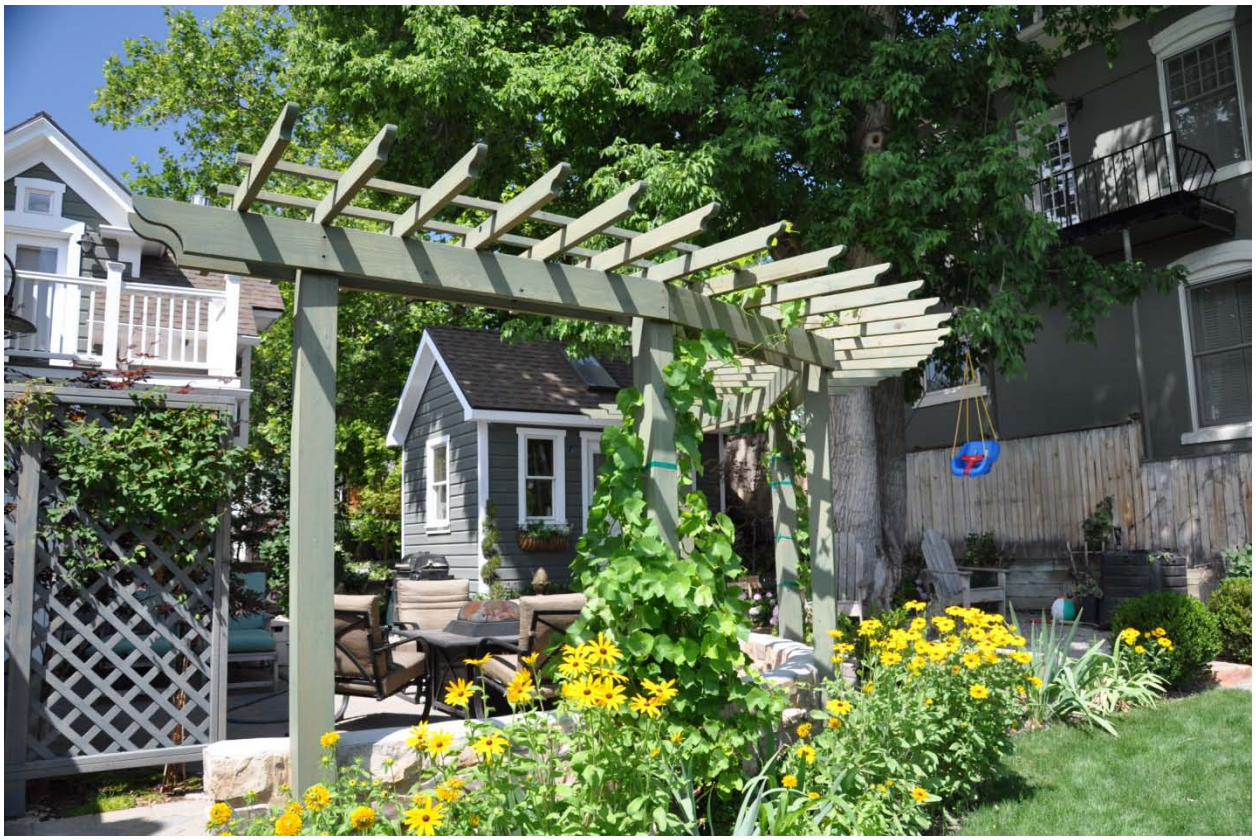
Water Features

41. Water features and pools may be an integral component of a sustainable landscape, provided that certain practices are followed. See the *Water Feature and Swimming Pool BMP* for more information. New commercial development shall count water features as a portion of any planned oasis zones (see *Hydrozone BMP*).

Wildfire

42. Particularly in mountain areas prone to wildfire, plants should be selected and placed at locations that take wildfire hazard and “defensible space” into consideration. Native species are generally the best plant materials for landscaping in defensible space. However, all vegetation, naturally occurring and otherwise, is potential fuel for fire; its type, amount, moisture content, and arrangement has a dramatic effect on fire behavior. There are no truly "fireproof" plant species, so plant choice, spacing, and maintenance are critical to defensible space landscaping. Where and how you plant may be more important than what you plant. This is increasingly critical in areas experiencing beetle kill. See CSU Extension Fact Sheet No. 6.302 Creating Wildfire Defensible Zones (Dennis 2006), Fact Sheet No. 6.303 Fire-Resistant Landscaping (Dennis 2007) and Fact Sheet No. 6.305 FireWise Plant Material (Dennis 2008) for more information, including recommended plant lists.

Hardscapes



43. Hardscapes are an important aspect of landscape design that should be thoughtfully integrated to maximize benefits to the environment.

44. Hardscapes are the most permanent and most energy-, labor- and resource-intensive elements of the landscape and recommends that they be used wisely. Hardscapes also collect radiant heat from the sun and contribute to the urban heat island effect, may also reduce the volume of water (from rain, snow melt, or artificially supplied) entering into the soil, and may increase stormwater run-off. Select materials best suited to the site and those that minimize the negative impacts of heat island effect and stormwater run-off and maximize utilization of precipitation.

45. Minimize disturbance to the site while moving and stockpiling materials.

46. Design practical hardscape areas, and consider the potential negative impacts of increased runoff and elevated ambient temperatures associated with impermeable and permeable surfaces prior to implementing any design.

47. Consider and use on site resources (e.g., existing boulders) when designing the site.

48. Properly install hardscapes: "Build it well, so it's not redone next year."

49. Use local sources for the majority of heavy and bulky materials (e.g., within 100 miles).

50. Consider using non-motorized options for moving and setting materials, where feasible.

51. Save use of large boulders for maximum impact, consider alternate focal objects.

52. Recognize both the positive and negative effects of hardscape on landscape, such as:
    - Creating microclimates for plants.
    - Redirecting runoff to plantings.
    - Locating hardscape and selecting colors with consideration for reflective and heat absorbing qualities.
    - Balancing benefits of raised beds with increased drainage and water use.

53. Use "green" materials, where feasible. Examples include using recycled materials, buying new materials with recycled content, avoiding toxic materials, and others.

54. Use permeable materials in appropriate areas and where feasible.

55. Allow for the evolution or future removal of hardscape by implementing these practices:
    - Use weed barrier/geotextile to separate soil from gravel road base paving.
    - Match materials and methods to anticipated longevity of landscape.
    - Consider using materials and construction methods that allow for future re-use of materials (e.g., drystack methods, where appropriate).

Resources

Center for Water Efficient Landscaping www.hort.usu.edu/html/CWEL/CWELOverview.htm

Low Impact Development Center www.lidstormwater.net

Natural Resources Conservation Services www.nrcs.usda.gov.

US-EPA Stormwater Management Fact Sheet: Porous Pavement
http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Infiltration%20Practice/Porous%20Pavement.htm

Utah Department of Natural Resources/Division of Water Resources. Water-wise Plants for Utah Landscapes. www.waterwiseplants.utah.gov.

Utah Native Plant Society www.unps.org.

Utah Natural Resources Conservation Services www.ut.nrcs.usda.gov.

Utah State University Analytical Laboratories www.usual.usu.edu

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05 Landscape Installation and Erosion and Sediment Control

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Control erosion to prevent sediment from leaving the construction site during landscape installation and provide proper care of the landscape during installation.

Basic Practice Guidelines

Erosion and Sediment Control/Site Protection

1. During construction, protect roadways, sidewalks, drainageways, and waterways from runoff from exposed areas. Applicable practices may include straw bales, silt fences, berms, check dams, sediment basins, waddles, etc. See Appendix A for information on the proper selection, installation, and use of these measures.

2. Care must be taken so that no mud, dirt, or debris of any kind is tracked by vehicles into the public right-of-way or into any drainage or canal system. See SLC Ordinance 18.20.210.

3. Be aware of, and comply with, all land disturbance permit requirements. Construction sites disturbing one (1) acre or more are required to obtain a state permit (Stormwater Pollution Prevention Plan, or SWPPP) and corresponding land disturbance permit from SLC. These permits require the submission of stormwater and erosion and sediment control plans. These plans and the SWPPP are to be prepared by an appropriate licensed design professional. The design professional should coordinate with the General Contractor to ensure that applicable provisions of the permit are followed. SLCPU, 801-483-6733, can provide additional information.

4. All erosion and sediment control BMPs are to be regularly inspected and maintained according to the SWPPP. Minimize the amount of exposed land area and duration of exposure by phasing construction and landscape installation.

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

6. Identify areas not to be disturbed and actively protect those areas from construction activities. This could include, but is not limited to, areas with existing trees, well heads, and environmentally sensitive areas.

7. Landscape materials (soil, rock, mulch, plants, etc) may not be stored in the public right-of-way, such as (sidewalk, curb and gutter, and street without a Right-of-Way Encroachment Permit issued by the SLC Transportation Department.

8. 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.

9. Landscape and excavation work within 100 feet of the edge of City Creek, Red Butte Creek, Emigration Creek, Parley's Creek, or the Jordan River will likely require a Riparian permit. Contact SLCPU 801-483-6727 for more information. See SLC Ordinance 21A.34.130.

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

11. 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 or the SWPPP.

12. 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. It is critical to keep the soil level at the trunk of the tree unchanged. See the *Tree Protection BMP* for more information. Also review the Tree Protection Ordinance.

13. If turfgrass sod is to be utilized, it should be installed as soon as possible in areas where sediment runoff is likely as sod provides excellent erosion and sediment control benefits. Temporary cover crops and other groundcovers may also be installed to protect these areas. Refer to SLC Plant List for appropriate selections.

14. Repair and stabilize areas of excessive erosion.

15. Properly handle, store, and dispose of pesticides, fertilizers, equipment maintenance products (e.g., oil, fuel) and waste created during landscape installation. Good housekeeping dictates that spills are immediately remediated. Follow instructions as outlined in the chemicals Material Safety Data Sheet (MSDS) and see the *Chemical and Equipment Handling BMP* for more detail.

16. Manage noxious and invasive plants to prevent spreading on site or onto adjacent sites and open lands; see *Weeds Management BMP* or visit www.slcgov.com/gardenwise.

Planting and Landscape Installation

17. Perform a comprehensive soil analysis and apply fertilizer and other amendments if specified. Slow-release fertilizers should be used to reduce weed growth and protect water quality. Limit the use of chemical fertilizers, pesticides, and herbicides to the areas to be treated, and never overuse fertilizers, pesticides, or herbicides. See *Pesticide and Herbicide BMP*.

18. Properly amend soil prior to planting or laying sod. Ideally, organic material comprises one-quarter to one-third of the soil profile twelve (12) inches deep. If the site has been compacted, till to a depth of approximately 4 to 6 inches or more prior to adding the

amendment. Proper soil preparation can substantially reduce irrigation requirements. See *Soil amendment BMP* for more information.

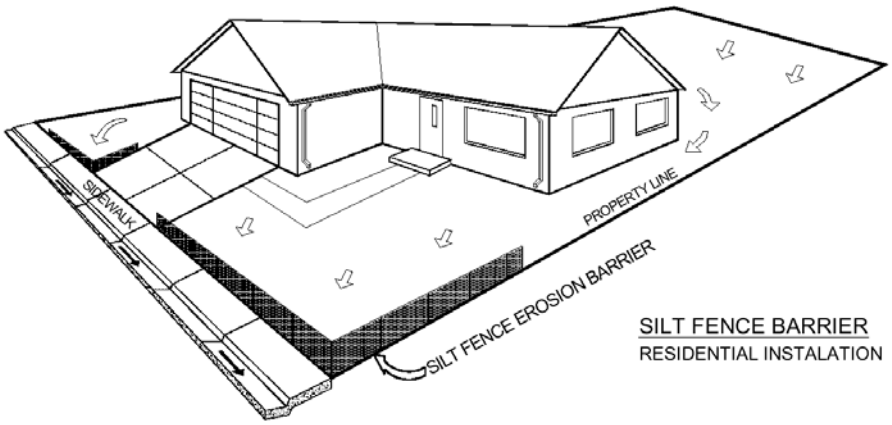
19. For landscape areas being started from seed, sow seed mixtures at the proper time of year specified for the mixture.

20. Mulch all seeded areas and adequately secure the mulch. Maintain mulch by adding and redistributing, as necessary. Refer to *Mulch BMP* for more information.

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

22. Provide adequate irrigation during the vegetation establishment period.

23. 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.

Resources

EPA Municipal Stormwater Site http://cfpub.epa.gov/npdes/stormwater/munic.cfm

SLC Department of Public Utilities GardenWise for weeds information www.slcsaveh2o.com

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06 Soil Amendment and Ground Preparation

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Evaluate soil and, if necessary, improve it to promote efficient water usage and healthy plants. A soil amendment is any material added to the soil to improve its physical properties (tilth), such as water retention, permeability, water infiltration, aeration, and structure, as well as its chemical and biological properties. The goal is to provide a better environment for plant roots (Davis and Wilson 2005). Amendments can also improve availability of mineral elements in the soil.

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.

2. Test soils prior to planting and irrigation system installation to identify the physical and chemical characteristics, and mineral content of the soil. Soil tests are relatively inexpensive and can help to minimize costs associated with soil amendment. In areas where low quality well water or reclaimed water are used for irrigation, or where salt-affected, corrosive, or high pH soils are known to exist, periodic soil testing should be conducted so that irrigation and fertilization practices can be adjusted appropriately. See Resources list for USU Soil Testing Lab contact information.

3. Before amending the soil, determine first whether a problem exists and if its source is mineral deficiency, cultural issues such as overwatering, or a physical soil property such as poor texture or compaction. Use soil test results to determine the correct amount and type of amendment needed—only apply amendments the plants can use and to correct deficiencies.

4. Add proper organic matter to the soil, as indicated by soil test results, to increase the water-holding capacity and improve drainage. If a soil is too sandy or too high in clay, the solution to both extremes is often adding organic matter. Although organic matter is typically a key component of soil improvement in Utah, proper addition of organic matter also means not applying too much, which can lead to salt accumulation or conversely leaching of salts and nutrients into groundwater. Blending organic material into native soil will help minimize soil interface issues.

Quick Facts on Soil Amendments

- Soil amendments improve the physical properties of soils.
- Amendments are mixed **into** the soils. Mulches are placed **on** the soil surface.
- The best soil amendments increase water and mineral-holding capacity and improve aeration and water infiltration.
- Un-composted wood or plant products can tie up nitrogen in the soil.
- When using biosolids, choose “Grade 1” biosolids.

5. Proper soil and ground preparation is critical to the success of a lawn or garden. If the soil has less than 3 percent organic matter, a rule of thumb is to work 3 to 5 cubic yards of organic matter into the soil to a depth of 4 to 6 inches for every 1,000 square feet of area to be seeded, planted, or sodded. If native plants are being used, then soil amendment may not be necessary, provided that native topsoil has been retained at the site. Soil test results in combination with the needs of the proposed plant types determine the appropriate type and amount of amendment. Soils or subsoils in existing landscapes within subdivisions may be highly compacted, and so amending the soil may be appropriate to improve aeration, even when using native plants.

Thoughts on Soil Properties (Klett and Feucht 2007)

Many of our population centers are on heavy, clay soil. These soils have poor aeration that limits root growth. Thus the ability of plants to replenish water loss brought about by low humidity and prevailing winds is limited. Adding more water to such soils further complicates the problem because the water that is added reduces the amount of air in the soil and causes oxygen starvation to the roots. Little can be done to modify humidity and wind, so the obvious solution is to improve the soil.

6. When selecting soil amendments, give attention to amendment characteristics such as salt content and pH, weed seed content, degree of decomposition, potential for mineral leaching (particularly nitrogen and phosphorus), decomposition rate, and other factors. Also consider site or soil characteristics such as the soil texture, soil salinity, and salt sensitivity of plants. Many soil amendments exist with widely varying properties that help to improve various components of the soil such as texture, minerals, drainage, etc. For example, soil amendments could include fertilizer, organic amendments (peat, plant compost, animal waste compost, municipal sludge, etc.), inorganic amendments (zeolites, shales, pea gravel), and topsoil. Organic soil amendments often improve mineral content and physical properties of soils. Some potential soil amendments should be avoided in Utah. For example, un-composted sawdust can worsen common Utah soil problems, sand can cause clay soils to develop a concrete-like consistency; and cattle manure or compost made from cattle manure can increase salt content. Soil weight bearing properties and anchorage of trees should also be considered when selecting amendments and the volume of soil proposed for alteration.

7. Several key characteristics of various soils and several common soil amendments are summarized in Tables 1 and 2, respectively. Soils with high or low permeability or water retention can be balanced by addition of proper amounts of soil amendments with counterbalancing characteristics, as shown in Table 2. Inattention to either the soil or the amendment characteristics can worsen soil conditions by selection of the wrong soil amendment. Table 3 (at the end of this BMP) provides quality classifications for compost.

Table 1 Selected Characteristics of Various Soil Types (Source: Davis and Wilson 2005)

Soil Texture	Permeability	Water Retention
Sand	High	Low
Loam	Medium	Medium
Silt	Low	High
Clay	Low	High

Table 2 Selected Characteristics of Several Common Soil Amendments (Adapted from Davis and Wilson 2005)

Amendment	Decomposition Rate	Permeability	Water Retention
Fibrous			
Peat	Slow (possibly years)	Low-medium	Very high
Wood chips	(*all amendment subcategories*)	High	Low-medium
Hardwood bark		High	Low-medium
Humus			
Compost	Moderate (about 6 months	Low-medium	Medium-high
Aged Manure	(*grass clippings and un-aged manures decompose more rapidly*)	Low-medium	Medium
Inorganic			
Vermiculite	Negligible	High	High
Perlite	(*all amendment subcategories*)	High	Low

8. Biosolids, a byproduct from municipal sewage treatment, are increasingly available as compost, either alone or combined with another product. From a sustainability perspective, biosolids provide opportunities to "reuse" and "recycle." The primary concerns with biosolids are heavy metal content, pathogen levels, and salts. To alleviate these concerns, select "Grade 1" biosolids. Biosolids should not be used for "root crops" where the edible portion of the plant comes in contact with the soil.

9. Fresh manure can harm plants due to elevated ammonia levels; therefore, only aged manure (at least six months old) should be used. Composted manure should reach temperatures of 160 to 170 degrees Fahrenheit to kill pathogens prior to use in vegetable gardens.

10. Some composts and manures are high in salts and have a high pH. Addition of soil amendments high in salts can make salt-affected soil problems worse. As a general rule, an amendment with up to 10 mmhos/cm of total salts is acceptable if it is well mixed into low-salt soils (< 1 mmho/cm). 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 (> 3mmhos/cm), or when growing salt-sensitive species. Sphagnum peat and compost from purely plant sources are low in salts and good choices for such locations.

11. 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, selecting plants tolerant of the salt conditions is one possible approach to consider when designing the landscape. See Appendix G for a list of salt tolerances of various plants.

12. 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.

13. Information on soil permeability, water holding capacity, and maximum allowable depletion are needed to establish appropriate irrigation rates and schedules. See the *Irrigation Technology and Scheduling BMP* for more information.

14. Once the soil has been prepared for planting, keep construction equipment off of the prepared surface.

15. 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. Remove wire caging and as much burlap as possible to avoid root girdling and encourage root growth.

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

17. Un-composted wood products (e.g., sawdust, bark) used as soil amendments can result in nitrogen deficiency in plants.

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

19. High bench or canyon areas may lack adequate top soil to sustain traditional landscape plants. Use native plants adapted to these soils for best results.

20. Importing topsoil into protected watershed areas is prohibited under SLC Ord 17.43.

Table 3 Rocky Mountain Region Compost Classifications and Standards
Source: http://www.extsoilcrop.colostate.edu/Soils/projectscompost.htm

Note: There is no implied warranty or product performance guarantee associated with this Classification System	**CLASS I Fully composted, stable, mature product**	**CLASS II Fully composted, stable mature product**	**CLASS III Semi-composted dehydrated product**	**CLASS IV Non-composted feedstock product**
Minimum Stability Indicator (Respirometry)	Stable to Very Stable	Stable	Unstable to Moderately Unstable	Unstable
Maturity Indicator Expressed as Ammonia N / Nitrate N Ratio	< 4	< 6	N/A	N/A
Maturity Indicator Expressed as Carbon to Nitrogen Ratio	< 12	< 18	< 25	N/A
Maturity Indicator Expressed as Percentage of Germination / Vigor	80+ / 80+	N/A	N/A	N/A
pH – Acceptable Range (1:5 by weight)	6.0 - 8.4	6.0 - 8.4	6.0 – 9.0	N/A
Soluble Salts – Acceptable Range (1:5 by weight)	0 - 5 mmhos/cm	5 - 10 mmhos/cm	< 30 mmhos/cm	N/A
Testing and Test Report Submittal Requirement	STA / TMECC	STA / TMECC	STA / TMECC	Primary & Secondary Nutrient Testing
Chemical Contaminants	Meet or exceed US EPA Class A standard, 40 CFR 503.13, Tables 1& 3 levels	Meet or exceed US EPA Class A standard, 40 CFR 503.13, Tables 1& 3 levels	Meet or exceed US EPA Class A standard, 40 CFR 503.13, Tables 1& 3 levels	N/A
Bulk Density; % Inorganics; % Moisture; Particle Size Distribution, Primary, Secondary Nutrients; Trace Elements; Organic Matter Expressed in Percentage and Pounds Per CY	Must Report	Must Report	Must Report	Must Report

Pathogens	Meet or exceed US EPA Class A standard, 40 CFR 503.32(a) levels	Meet or exceed US EPA Class A standard, 40 CFR 503.32(a) levels	Meet or exceed US EPA Class A standard, 40 CFR 503.32(a) levels	N/A
Minimum Manufacturing Production Requirement	Each composting facility must be fully permitted by the Colorado Department of Public Health and Environment or their appropriate state agency. If it is exempt from state permitting requirements, it will certify that it follows all guidelines and procedures for production of compost meeting EPA 40 CFR 503.13 requirements for production and marketing of Class A material for unrestricted use and distribution. **Written certification from manufacturer is required**.			
Applications *Note: The listed applications for the various compost class designations are intended for general consideration purposes. The actual use or application of any class of material can be subjective depending on the soil characteristics, quantity used, the method of incorporation, and other factors utilized by the buyer or user.*	Horticultural, Nursery, Container Mixes, Turf, Sod, Seed Bed Preparation, Raised Garden, Vegetable Gardens, Top Soil Blends, Backfill, Erosion Control. Watering to leach excess salts not required. Can be applied at high volume. Incorporation can be at shallower depths.	Turf, Sod, Seed Bed Preparation, Raised Garden, Vegetable Gardens, Top Soil Blends, Backfill, Erosion Control. If possible, incorporate at least 60 days prior to planting and water thoroughly before and after planting. Incorporation is important.	Crop production, Turf and Top Soil blends with limitations. Backfill, Erosion Control, Mulch. If possible, incorporate at least 90 days prior to planting. Deep incorporation and thorough mixing very important.	Agriculture
Best Management Practices (BMP) *How compost is applied and/or incorporated; effect on product performance.*	The BMP used by the buyer, user, or applicator will effect the performance of products and also the applications for any product. BMP's will also affect the risks regarding plant germination and vigor associated with the use of soil amendments and compost			
Incorporation Notes	Can be used as a high percentage of the soil profile. Incorporation not critical (top 4" recommended).	Should not be used as a high percentage of the soil profile (30% max). Incorporation in top 6" recommended.	Cannot be used as a high percentage of the soil profile (15% max). Incorporation in top 8" or more recommended.	Cannot be used as a high percentage of the soil profile. Incorporation in top 10" or more recommended.

Resources

Center for Water Efficient Landscaping (CWEL) www.hort.usu.edu/html/CWEL

U.S. Composting Council www.compostingcouncil.org.

Utah State University Analytical Laboratories www.usual.usu.edu

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07 Tree Protection

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Identify trees for protection and implement measures to prevent construction-related damage.

Protection and care of existing trees increases property value, fosters wildlife habitat, mitigates soil erosion and sedimentation of waterways, positively impacts energy use in buildings, and can substantially reduce stormwater runoff and the need for air conditioning in the summer and subsequently decrease the amount of carbon dioxide production associated with development (IES 2007). See the Sustainability BMP for more information.

Basic Practice Guidelines

1. During site development, trees can be injured in several ways Examples of potential sources of injury include but are not limited to: soil compaction; soil grade changes; trenching; alteration to soil drainage patterns and moisture holding capacity; root cutting; bark removal; branch breakage; and construction materials and chemicals leaching into soil. To minimize these injuries, develop a tree protection plan in conjunction with site design; implement the plan prior to construction; monitor and enforce the plan throughout duration of the project; and provide remedial care as needed during and following construction.
2. The tree protection process includes these basic steps:
    - Determine if the site is regulated under SLC Code 21A.48.135 *Landscaping and Buffers: Tree Protection* Evaluate established, healthy trees to see if tree protection is feasible.
    - Involve all parties in planning for tree protection.
    - Inventory trees proposed for protection, relocation, and demolition. A qualified registered arborist should consider factors such as species, size, condition, location, contribution, and sustainability.
    - Establish specific guidelines to prevent tree injury.
    - Ensure delivery of water as needed throughout the construction process.
    - Identify areas for ingress, egress, and staging of equipment and material that is outside the dripline of trees identified for protection. Properly size barricades to prevent tree injury.
    - Information on tree protection requirements should be provided as part of pre-construction conferences with contractors and be an ongoing element of weekly coordination among project participants.
    - Monitor tree health during and after construction for signs of stress and for implementation of remedial treatments. Mechanized equipment can damage tree trunks, root systems, and soil structure.

- Soil compaction and grade changes impair root growth and can cause dieback and death.
- Prepare post-construction maintenance plan for trees.

3. In some cases, smaller trees can be transplanted and maintained off-site or in another portion of the site until time to replant.
4. Be aware that some large trees do not tolerate environmental changes as well as younger trees. Some species adapt better than others, as summarized in Table 1 (Bernard, Dennis and Jacobi 2003).

Table 1 Tree Adaptability to Site Alteration
(Source: Bernard, Dennis and Jacobi 2003; as modified by SLC 2011)

Most Adaptable	Moderately Adaptable	Least Adaptable
Ash, green and white	Aspen	Bolleana white poplar
Common hackberry	Black locust	Black walnut
Cottonwood	Box elder	Colorado blue spruce
Crabapple	Bur oak	English oak
Ginkgo	Eastern redbud	Lombardy poplar
Honey locust	Linden	Northern red oak
London plane tree	Norway maple	White spruce
Serviceberry	Pine (most species)	
White ash	White oak	
Willow	Silver maple	

5. Before beginning construction operations, establish a Tree Protection Zone (TPZ) around trees to be protected by installing barriers and/or construction fences. Allow enough space from the trunk to protect the root zone and the branches from damage (see Table 2). If low branches will be kept, place the fence outside of the dripline. Where this is not possible, place barriers and/or fencing as far away from the trunk as possible. Be aware that many roots extend beyond the dripline.

Table 2 Determining the Tree Protection Zone
(Source: Matheny and Clark, 1998)

	Distance from Trunk (ft) per inch of DBH		
Species Tolerance to Damage	*Young*	*Mature*	*Over mature*
Good	0.5'	0.75'	1.0'
Moderate	0.75'	1.0'	1.25'
Poor	1.0'	1.25'	1.5'
Notes: DBH = diameter at breast height (4.5' above grade); Young = <20% of life expectancy; Mature = 20%-80% of life expectancy; Over mature =>80% of life expectancy			

6. Most tree roots grow within the top two (2) feet of soil. Soil changes within the TPZ should be avoided to the maximum extent practicable.

7. Place and maintain a layer of mulch 4-6" thick from the tree trunk to the protective fencing throughout construction, keeping a 6” space between the mulch and the trunk. Mulch helps protect soil and conserve moisture

8. When entry within the TPZ is required, such as for fine grading, irrigation system installation, and planting operations, follow these guidelines:

    a. Maintain the existing grade around protected trees in as wide an area as practicable.

    b. Limit access and appoint one route as the main entrance and exit, and do not allow any equipment to be stored, chemicals to be dumped, or construction activities to take place within the TPZ.

    c. Where possible, locate utilities outside of the TPZ. If utilities must be located within the TPZ, either bore underneath the roots or use hand tools, taking extreme care not to sever critical roots. Critical roots are those which are essential to the physical support and health of the tree. Their size varies depending on the size and maturity of the tree. Some species are more sensitive to root disturbance than others. Where critical roots are encountered, tunnel under the roots and keep them moist while the trench is open.

    d. To protect exposed roots, implement one or more of the following protective measures: a) place plywood sheeting over trench to limit sunlight on roots; b) mulch exposed roots and keep moist; and c) cover exposed roots with burlap. Cautionary note: if burlap is used to wrap roots make sure to keep it moist otherwise it can act as a wick and accelerate the evaporative process.

    e. Where critical roots must be cut due to trenching or excavation, expose them by hand digging and cut cleanly. Refill the trenches as soon as possible to avoid moisture loss.

    f. Where trenching near trees has already occurred from previous construction operations, make every effort to confine trenching operations to the previously-created trenches, while adhering to the conditions set forth herein. Be aware previously dug trenches can be the site of root growth.

    g. When fill is added under the dripline or over the root spread of a tree, it acts as a blanket that prevents normal air and moisture circulation to the roots. Fill around trees should be avoided to the maximum extent practicable. Minor fills with compost or other organic matter (less than 3 inches) is permissible. If major grade changes are required, a drywell with subsurface linear aeration lines will be needed.

    h. When soil cuts are unavoidable around trees as part of site grading, terrace the grade to maintain the tree’s root system, where practicable. If fill is required, avoid the use of clay soils, and use loamy topsoil.

i. For mature, drought tolerant species grown in low-water conditions, no irrigation or planting should occur closer than 8 to10 feet from the trunk, as watering in this area can lead to root decline.

j. Where irrigation must occur within the TPZ, drip or other micro-emitter irrigation should be used wherever possible. Additionally, only plants with low water needs should be planted within the TPZ of drought tolerant tree species, spaced far apart where close to the tree. Plants may be spaced closer together near the dripline.

9. As part of routine construction inspections, ensure that tree protection measures are enforced and report potential tree health problems to the owner and appropriate contractor or arborist.

10. Post-construction maintenance should begin with evaluation of the trees' condition. Consult with a qualified arborist about necessary maintenance and monitoring needs. Provide clear maintenance guidelines to the site contractor to ensure that proper maintenance occurs (e.g., irrigation, pruning of damaged branches, etc.).

11. To provide incentive for tree protection during construction, the owner may include tree damage fees in the construction contract. Tree protection bonds may be necessary to ensure noncompliance fines, which should be based on appraised tree value and the amount and type of damage.

Resources

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08 Tree Placement in Urban Landscapes

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Matching trees to spaces proposed for planting is vital to their well being. Knowledge of the trees 'full-grown' characteristics is imperative. Select those trees that are best suited to existing or planned site features, below and above ground, including but not limited to; soil type, volume, pH, moisture holding capacity, fertility, and above ground space or restrictions to vertical and lateral development of branches. It is also important to consider current and future use of the site to ensure trees and their placement are compatible with other site needs. Tree placement in urban landscapes is provided as a unique BMP because trees need more space than is provided in many contemporary urban designs. Also important to consider are the location of underground and overhead utilities.

This BMP is adopted directly from the work of James Urban, FASLA, as contained in "*Up By Roots," Lecture Notes as presented at Pro Green Expo 2008. Citation of this BMP should include reference to Urban (2008).*

Basic Practice Guidelines

The following ten principles are intended to guide integration of trees into landscapes from the initial concept sketches through construction and the beginning of the maintenance cycle. The principles evolve around three strategies—Soil, Trees, and Management—and cover all aspects of designing a tree into an urban space. To be successful, the principles must become an integral part of the project's design goals and considered prior to the construction document phase. These principles cannot be easily applied once the design direction is set.

10 Principles of Tree Placement and Planting	
1. Plant the Easy Places First 2. Make Bigger Planting Spaces 3. Preserve and Reuse Existing Soil 4. Improve Soil and Drainage 5. Respect the Base of the Tree	6. Make Space for Roots 7. Select the Right Tree 8. Establish Reasonable Tree and Soil Budgets 9. Create Detailed Tree Construction Documents 10. Design for Maintenance

Soil Based Strategies

These strategies identify, protect, and improve soil resources for trees.

1. **Plant the Easy Places First.** Develop design options that plant large trees in large soil resources. In the urban environment there are always easier places to grow trees. Differences

in growth possibilities may be only a few yards apart, reflecting a change in soil or drainage patterns or suggesting a slight variation in design. These subtle differences may be identified in the site assessment or noticed by the designer with experience working with tree and soil principles. By starting the design with the easier locations, success will be more certain and cheaper to attain. Working with existing soil resources is fundamental to the principles of sustainable design.

2. **Make Bigger Planting Spaces.** Balance the size of paving and open soil areas. Another simple way to improve the health of trees in urban areas is to reduce the area of paving and increase areas of open soil. Of all the principles, this may be the easiest to undertake. Competition for space in the city is severe, but rarely is the question asked if the paving could be reduced, even slightly, to improve space for tree growth. Architects, civil engineers, and landscape architects see paving as a primary element in the design. They may not know how their decisions affect tree health or may believe that the tree can be replaced if it dies. Dimensions of paved areas may be set by larger aesthetic considerations or existing standards. But, studies indicate that roads can be narrower; sidewalks can modulate in width and remain compliant with ADA standards; and plaza paving can be reduced. Fewer, larger spaces for clustered trees are better than many smaller isolated tree planting areas. Small changes in the widths of drives and walks can result in large increases in the amount of available soil. Formulas for determining the amount of soil needed to support a large tree are available. Use them to gain support for larger soil areas.

3. **Preserve And Reuse Existing Soil.** Sustainability starts with protection and conservation of resources. There are often usable soils to be found at urban sites. If these soils can be identified, incorporated into the design, and protected during construction, a small piece of the environment has been preserved. It is hard to make good soil. When it exists, its reuse should be an option. If a project has sustainability goals, preserving, protecting and reusing existing soil must be a priority. Soil reuse, protection, and maintenance are not an easy task in a complex construction process. It demands nearly the same level of effort required to build around existing trees.

4. **Improve Soil And Drainage.** Break compaction, amend or replace soil, maintain or create drainage. Make the soil "right for the tree." Sometimes simply tilling a compacted soil is a sufficient improvement. Other times, complete soil replacement may be required. Knowledge of soils, drainage, and the cultural requirements of the trees to be planted are necessary to make the right decisions. Improper soil amendments may be worse than no amendments. Too much water creates more problems in the urban landscape than too little. Some trees can adapt to dry conditions, but if there are drainage problems, they can be difficult to fix, especially if they are not discovered until after the rest of the project is constructed. Poor drainage will undo all the other principles.

Consider the use of porous or non-contiguous surfaces such as non-mortared or grouted pavers and bricks, vegetation blocks, or mulch in areas of pedestrian use or with no or low-vehicle use to increase air and water circulation to tree roots. See *Landscape Features for Low Impact Development* BMP.

Tree Based Strategies

These strategies respond to the needs of the tree.

5. **Respect The Base Of The Tree.** Do not pave within the area of the tree's future trunk flare. Middle-aged and mature trees can have a pronounced swelling at the base of the tree just before the trunk disappears underground and this flare must be treated with respect. The trunk flare will expand to dimensions dictated by the tree, not the designer. Just beyond the trunk flare, the first set of large roots extends out underground and rapidly tapers over the next 6 to 8 feet away from the trunk. These are the roots that cause the most conflict with paving and curbs and must be acknowledged and protected in all phases of the design, construction, and follow-up care.

6. **Make Space For Roots.** Design spaces for roots under the pavement and utilize different approaches to root space design as conditions change. It may be impossible to provide sufficient soil for the tree in an area separate from paved areas, and designers must then provide space for roots growing under the pavement. How this is accomplished may limit the type of paving that can be used and will increase the cost of the project. It is possible to encourage root growth under pavement in ways that do not impact the stability of the pavement. There are many approaches available to improve rooting space under sidewalks. Use as many of them as are appropriate to optimize the budget to grow large, healthy trees.

Special Considerations for Tree Placement

- Blue Stakes Program is an excellent resource for identifying the type and location of underground utilities. Call 811 or 1.800.662.4111.
- Do not place trees within 10 feet of underground water or sewer mains. Verify location with SLCDPU
- Verify separation requirements of underground cables with appropriate agency or company
- Do not plant trees in easement without express permission of easement owner
- When placing trees under overhead power or other lines, select shorter, site appropriate varieties. See www.slcgov.com/publicservices/forestry.

7. **Select The Right Tree.** Put the right tree in the right place and make the place right for the tree. After the previous six principles have been followed, the designer can make tree selections. By adopting this order of priority, a much wider range of trees will be available. Trees can be selected primarily for their ability to perform desired functions and or aesthetic contributions. Selecting the right tree also assumes a high level of professional competence about these requirements. Designers must learn the nuances of arboriculture. This is more

than a quick look at a text book or a digital plant selection program, which may be good tools but are no substitute for personal experience with the plants being considered. Local climate, maintenance, nursery availability, regional soil differences, and other variables must be considered. Once the tree has been selected, make sure that the site has been made right for that particular tree.

Management Based Strategies

These strategies implement the soil and tree based strategies.

8. **Establish Reasonable Tree And Soil Budgets.** Balance the design quality of all elements in the landscape. Planting and maintaining a large, healthy urban tree requires about the same budget resources as is required to install and maintain a good quality street light. As budgets become limiting, adjust the quality or quantity of everything a little bit. For example, it may be necessary to plant fewer trees and use less expensive paving material in order to save money for better soil and drainage.

9. **Create Detailed Tree And Soil Construction Documents.** Make construction decisions that are project specific and respect the requirements of selected and existing trees and the attributes of the soils upon which trees depend. The construction document process must continue with the same commitment to the principles of soil science and tree biology developed in the concept plan. To ensure that the construction mirrors the intent of the conceptual plan, follow these guidelines:

    - Prepare a separate soil and drainage installation plan and make detailed sections of each condition.

    - Draw the trees in sections to scale, accurately depicting the root ball size.

    - Make sure that trees fit the space at the time of construction and that the mature root system will fit in the space in 30 or 40 years. Draw the predicted mature root system, at least during the detail development period, to test the suitability of details.

    - Create buildable plans and specifications to ensure that the contractor can actually place the soil in the locations and in the sequences of other construction.

    - Avoid typical details. Concepts will invariably fail when the conditions are not "typical."

    - Make frequent inspections of materials at their source and during the construction process to ensure quality. Inspect root balls at the nursery, not at the job site.

    - Soil must be tested and reviewed to assure that it supports the plants selected and is compatible with the drainage assumptions.

    - Contractor mistakes may be quickly covered with soil and mulch. Drainage systems, sub-grade conditions, soil installation, soil compaction, and root balls must be reviewed while they are exposed.

10. **Design for Maintenance.** Create designs that are maintainable. Urban environments are dependent on maintenance. In intensely used urban settings the concept of low maintenance is not a practical reality. The source and capability of that maintenance must be identified during the design process. Understanding the maintenance capabilities of the client should be a fundamental design criterion. Many projects that receive wide acclaim for design success have small armies of maintenance staff who can overcome soil design flaws. When another designer tries to emulate these award-winning projects without the same level of maintenance, plant failure is almost assured. Design choices do impact the ability to maintain the design. Maintenance providers must be equally knowledgeable as the designers in soil and tree biology when making maintenance decisions. How soil and trees are treated during the maintenance periods is as crucial as it was during construction.

11. **Structural Soils.** A related topic in urban landscapes involves the use of "structural soils" in ultra-urban settings to provide space for tree roots, while still allowing paved surfaces. Structural soil is a mixture of stone aggregate and soil, with a small amount of polymer gel to hold the mix together. This soil mix can be compacted to 95 percent of dry density to support paving and still allow for tree root growth. The mix takes advantage of the fact that there are about 20- to 25 percent void spaces between pieces of compacted gravel, in which roots will grow.

Resources

SLC Plant List www.slcsaveh2o.com

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09 Tree Planting

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Properly select and plant trees to promote their long-term health.

This BMP is adopted directly from ***Avoiding Excessive Soil Over the Root Systems of Trees: A Best Management Practice (Morton Arboretum et al. 2005).*** These best management practice guidelines are intended to assist growers, landscape professionals, arborists, and all other purchasers and planters of trees in learning to recognize, prevent, and take action to correct root systems that are too deep. This BMP focuses on trees being planted and managed in urban and suburban landscapes, generally 2-inch caliper and larger. This BMP is not intended to apply directly to lining-out stock sold in nurseries that will be grown in the field or in containers, though practices used during such production can ultimately affect trees in the landscape. Trees with root balls can be produced by several methods, and these guidelines apply to all of them.

Basic Practice Guidelines

Background on Development of this BMP

An industry-wide working group was formed in 2003 to develop consensus on a complex national issue: tree decline and death in the landscape resulting from excessive amounts of soil over the root system. When structural roots are too deep below the soil surface, lack of oxygen can kill roots and lead to decline and death of the tree, especially in urban soils. In some species, prolonged moisture at the base of the trunk may increase root and collar rot diseases. This effort was coordinated by The Morton Arboretum in Chicago, and included representatives of the American Nursery and Landscape Association (ANLA), the International Society of Arboriculture (ISA), the American Society of Landscape Architects (ASLA), the Associated Landscape Contractors of America (formerly ALCA, now PLANET), Tree Care Industry Association (TCIA), and the American Society of Consulting Arborists (ASCA). The working group completed these BMP guidelines based on the practical experience of many professionals and the relevant scientific research available at the time.

How Deep Should Structural Roots Be?

1. Generally, on a young tree, the uppermost structural roots (two or more) should be within the top one to three inches of the soil surface, measured three to four inches from the trunk. As a tree matures, roots thicken faster on the top, effectively reducing the amount of soil above the structural roots and forming the root flare. Special situations requiring exceptions to this general guideline include the following:

    - Some species may develop more strongly descending root systems; therefore, the

structural roots may have to be located nearer the trunk.

- On landscape sites with poorly drained soil, the roots may need to be shallower to facilitate tree survival. Structural roots may need to be at, or slightly above, the surrounding grade if soil conditions are poor.

- In some species and nursery stock, the roots regenerated after transplanting can grow back toward the trunk and become girdling roots. Initial research shows that very little soil over the structural roots could be problematic. *Celtis occidentalis* (hackberry), *Fraxinus pennsylvanica* (green ash), *Acer rubrum* (red maple), *Acer platanoides* (Norway Maple)l *Tilia cordata* (littleleaf linden), *Populus* spp. (poplars), and *Malus* spp. (crabapples) are species for which this is known to be a problem. Other species with aggressive root systems may also exhibit this tendency.

Terms and Definitions

Balled and burlapped (B&B): Established in the ground and dug with a portion of the root system and undisturbed soil immediately around the roots.

Container grown: Grown and marketed in a container.

Containerized: Grown in the ground and subsequently dug with a soil ball (described as "balled and processed" by ANSI Z60.1) or bare root (described as "process balled" by ANSI Z60.1) and placed in a container until sold.

In-ground fabric bag: A method used to grow trees in the ground using a specially designed fabric bag to restrict root spread.

Root flare, trunk flare: Interchangeable terms for the area of transition between the vertical stem and structural roots at the base of the tree's stem or trunk. The "flare" develops over time as the tree grows and may not be evident on young trees.

Structural roots: Woody roots relatively large in diameter, giving characteristic form and shape to a root system.

How to Locate Structural Roots

2. Checking root depth can be done in the nursery before digging, which is preferred (see *Tree Placement in the Landscape BMP*), or in the B&B or container root ball just prior to planting. Presence of a visible root flare is a good indicator that the structural roots are just below the soil surface. However, on grafted trees, be careful not to confuse the swelling of the trunk below the graft union with the actual root flare. A gap between the soil and the trunk is a sign that the first roots are at least several inches below the soil surface.

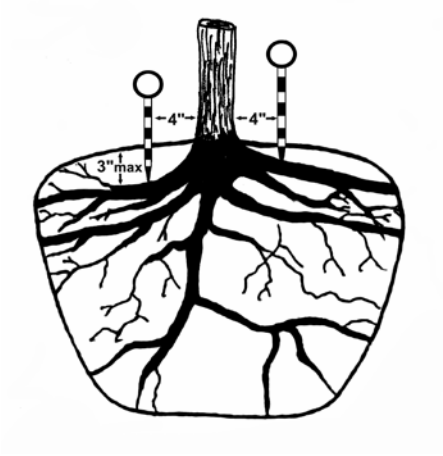

Figure: A root ball can be probed nondestructively to locate at least two roots within 1 to 3 inches of the soil surface. A surveyor's chaining pin is a convenient tool to use.

3. If none of these easily recognized signs are present in the field, or if the root ball burlap and twine cover the base of the tree, a surveyor's chaining pin or similar tool can be used to quickly and nondestructively probe for the roots. Probing approximately 3 to 4 inches away from the trunk will determine the true depth of the roots, rather than the depth of the enlarged root flare, if present. At least two roots (preferably more) should be located within 1 to 3 inches of the soil surface.

Nursery Stock Selection and Handling

4. It is possible for trees to leave the nursery with structural roots too far below the surface of the root ball. Depth of structural roots can increase at several stages of nursery production, including planting, cultivating, transplanting, and harvesting, and possible changes in root architecture can occur during the production process. It is always preferable to avoid trees with roots too deep below the soil surface rather than trying to make corrections later.

5. The American Standard for Nursery Stock (ANSI Z60.1, 2004) states that, for B&B trees, "soil above the root flare … shall not be included in the ball depth measurement and should be removed." If the resulting depth measurement of the root ball does not meet the minimum provided in the standard, the ball is not deep enough to encompass a sufficient mass of roots for the vigor of the tree in the landscape, and the tree can be rejected. Be sure growers and suppliers understand what is expected. It can be difficult and time consuming to evaluate and adjust root balls on site or to reject nursery stock with root balls of insufficient depth.

Planting Process

6. When root balls arrive on site, the depth of the structural roots should be checked before placing the tree in the planting hole.

7. Bud-grafted cultivars, and some seedling trees, are cut back during production. Evidence of the "dog leg" in the stem and of a change in bark texture should be approximately 1 to 2 inches above the soil surface for a young tree, with a maximum of 4 to 5 inches between the pruning wound and the uppermost structural roots.

8. If the structural roots have been located within 3 inches of the surface, the root ball should be planted with the surface no lower than the same level as existing grade. One to two inches higher usually is preferable to allow for settling and "pancaking" of the root ball. Unless conditions are extreme, do not plant so high that the cut ends of the structural roots at the edge of the root ball are above the surrounding grade. Planting the tree any higher may expose roots after minor erosion or contribute to surface root formation in the long run.

9. If the structural roots are found to be deeper than 3 inches below the root ball surface, the root ball and the planting depth will have to be adjusted. Elevate the root ball so that the structural roots are at the correct depth relative to surrounding grade. It is best to leave B&B root balls intact until placed in the planting hole, rather than to un-wrap them and strip the soil off the top before moving the root ball into the planting hole. Moving an unwrapped root ball may cause damage to its stability.

10. If there is extra soil over the structural roots, it may be acceptable in some situations to leave the root ball intact, with the extra soil remaining above grade through the guarantee period. Some contractors prefer to leave the burlap, rope, and wire basket in place for a time to keep the root ball more stable and make it easier to straighten later, if needed. If the wrappings are not removed at planting time, the tree should be checked at the end of the guarantee period, and any remnants of the wrappings or excess soil remaining above grade should be removed.

If upon placement of the root ball in the hole it is stable enough to remove wire, rope, and burlap without compromising its integrity, proceed with caution and backfill immediately. If stability of the root ball does not allow removal of these items then as a minimum remove burlap and twine or other wrapping material from contact with trunk and remove burlap from the surface of root ball. Score remaining burlap on the sides of the root ball to provide breakout points for emerging root growth.

11. Suddenly removing excess soil could be problematic for other reasons. The extra soil over the structural roots could be filled with fibrous roots which, if removed suddenly, could cause extra stress. There have been reports of cold or sunscald damage of the newly exposed tissue on trees when the extra soil was suddenly removed from the base of the trunk (this could actually be a portion of the original primary root [tap root], in some cases). Late-fall plantings may be the most susceptible to cold damage. Earlier plantings may have time to harden off normally. Thin-barked trees may be most susceptible to sun injury.

12. Until this situation is more fully understood, exercise caution when removing soil and exposing tissue that has been below grade. Leaving the extra soil in place above grade to be removed slowly or erode away may help to protect sensitive trunk tissues. Mulch can be used to hide the protruding root ball. If the soil is removed, covering newly exposed tissue with organic mulch may help to protect it from sun and cold damage. A trunk wrap may provide some protection from the sun. This material should degrade within one year or must otherwise be removed from the tree in that time period.

Mulching

13. Mulching is an excellent way to conserve soil moisture, reduce competition from other plants, and prevent lawn mower injury. Three to four (3 to 4) inches of mulch is the appropriate depth for 2- to 3-inch caliper trees. Later applications to “refresh” the mulch should not increase the depth. Keep the mulch away from the trunk. Avoid thick layers of mulch around the base of the tree (often called “volcano mulching”), as is far too often seen in landscapes. Do not pile the extra soil around the base of tree and use mulch to hide it—excess soil should be removed from the planting site. Avoid organic material that can mat down and create a hydrophobic layer.

Remediation

14. There are many trees already planted in the landscape with the structural roots too deep. These trees are likely to have reduced vigor and shorter life spans if no remedial action is taken. For recently planted trees (less than two to three months since planting), the greatest long-term benefit will be achieved by replanting the tree at the proper depth. For partially established trees, the best remedial treatment may depend on several factors. Replanting a partially established tree will cause additional stress; therefore, the benefits of replanting such a tree must outweigh the risks. If the tree is in good health and growing vigorously, it may be best to do nothing. A tree that appears to be struggling may need to be replanted at the proper depth, as long as the tree is in good enough health to survive the additional stress

of replanting. Do not waste money replanting trees that already show signs of serious decline. Trees on low-quality, poorly drained soils are more likely to need to be replanted than those on high-quality sites.

15. For larger, fully established trees, a practice being used regularly by arborists is a root collar excavation to remove the excess soil in contact with the trunk. Removal of this soil reduces the possibility of basal and collar rot diseases, and it improves aeration to the structural roots at lower depths.

16. Roots regenerated after planting originate mostly at the perimeter of the root ball and usually grow up to their natural depth closer to the surface. Do not expose these roots. When the structural roots moved with the tree are too deep, the newly generated roots sometimes have been observed to grow toward the trunk rather than away from the trunk, as is normal. Removing the soil near the trunk can expose these "misdirected" roots and allow their removal thereby reducing risks of developing girding roots. The excavated soil is sometimes replaced with well-aerated mulch or gravel.

Resources

Salt Lake City Division of Urban Forestry
http://www.slcgov.com/publicservices/Forestry/default.htm

Utah State University Cooperative Extension Forestry http://forestry.usu.edu/

Utah Urban Forest Council www.utahurbanforest.org

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10 Irrigation Efficiency (General Principles)

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Properly design, install, maintain, and operate irrigation systems to ensure uniform distribution, efficient delivery of water, and to avoid over-watering, thereby conserving water and protecting water resources. When sprinkler systems and equipment are water is efficiently managed and water is properly applied, landscapes can be attractive, healthy, and water efficient.

For more information on irrigation system design, irrigation installation, irrigation system maintenance, Irrigation audits, turf management, and mowing, please see those respective BMPs (see the index for a complete list of related subjects).

Basic Practice Guidelines

The Irrigation Association's 2005 "Turf and Landscape Irrigation Best Management Practices" identified five overall Best Management Practices (BMPs) for irrigation systems:

1. Assure the overall quality of the irrigation system.
2. Design the irrigation system for uniform distribution and efficient management of water.
3. Install the irrigation system according to the design criteria.
4. Maintain the irrigation system to adhere to the design criteria, for optimum performance.
5. Manage the irrigation system according to changing weather conditions and plant water requirements.

Basic Concepts

Irrigation can be defined in terms of:

- ***Rate***: the irrigation precipitation rate, typically in inches/hour.
- ***Duration***: the length of time of an irrigation event, in minutes or hours.
- ***Frequency*****:** the number of days between irrigation events.

Efficient Irrigation is applying the right amount of water at the right time.

Distribution Uniformity is how evenly water is applied.

Landscape Irrigation

1. Do not over water—plants will develop deeper roots and ultimately require less frequent watering, when not over-watered.
2. Never water if the soil is visibly wet. When determining the watering needs of planted areas, probe the soil 4 to 6 inches to determine the moisture content. 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.

3. Irrigate according to the requirements of the plants, not on an irrigation schedule that is based on fixed (unchanged) *duration* and *frequency*.

4. Irrigation strategies may be constrained by local regulations or other factors. For this reason, two basic approaches to adjusting the irrigation schedule are recommended:

    - Preferred irrigation strategy: water all plants deeply but infrequently to encourage deeper, healthier rooting. Provide prolonged intervals between watering (*frequency*) to encourage plant root zone development. The *duration* of irrigation should be based on replacing the managed soil moisture depletion in the root zone (i.e., managed allowable depletion [MAD]).

    - Alternative irrigation strategy: if the *frequency* of irrigation is fixed by an administrative authority (e.g., odd/even addresses, every third day or designated days), then the *duration* of irrigation should be modified based on plant water use (e.g., evapotranspiration [ET]).

5. Apply only enough irrigation water to replace depleted soil moisture and the leaching fraction. Match irrigation application rate to soil type and root depth. Avoid applying more water than can be contained in the root zone. Daily plant stress observation is optimal to determine the appropriate changes in the irrigation schedule. If impractical, weekly plant stress observation should be conducted, at a minimum.

6. Until plants have established and developed deep roots, they may need more frequent watering than established plants. Because the root zone is not fully developed, irrigation should also be shorter in *duration*.

7. Water early in the morning or between the hours of 12 midnight and 6 A.M. when temperatures and winds are at their lowest levels to reduce evaporative water loss. Sprinklers may also have better performance during these times due to higher water pressure.

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

9. Water lawns separate from trees and shrub/perennial beds. These should be on different irrigation zones, possibly with different delivery systems, and with different irrigation schedules.

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

11. When watering plants with fixed spray heads (but not including multi-trajectory/multi-stream heads), program the controller to apply a series of several light applications (cycle and soak)

instead of one continuous application. , This is particularly true for slopes and compacted or clay soils to accommodate lower infiltration rates.

12. Watering too frequently prevents oxygen from getting to the roots and may promote some diseases in the landscape.

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

7. Water pressure can affect system efficiency. See the BMP Irrigation System Design for more information.

8. All irrigation systems utilizing culinary water require proper backflow prevention assemblies. See Backflow Prevention BMP.

9. Late fall and early spring watering may be critical for minimizing stress to trees, shrubs, perennials when there is low winter precipitation. This is especially likely to be the case with newly planted evergreens. Be prepared to provide water during these non-traditional watering periods.

Nursery, Greenhouse, and Garden Center Irrigation Practices

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

1. Group plants together that have the same water requirements, i.e., use hydrozoning concepts to organize nursery stock layout. This will also assist customers in selecting plants with similar watering needs.

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

3. Use drip tubes or spray sticks for each individual container, when practical.

4. When using programmable irrigation booms adjust travel rate and flow rates (change in nozzle size) 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. Fertilizer application rates for most sub-irrigation systems can be reduced by 50 percent.

6. If using hoses to irrigate nursery stock, supply each hose with a positive pressure nozzle and educated employees to not leave water running in hoses when not attended.

7. Minimize leaching from containers by pulse-irrigating 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 soil leachate or the root substrate.

8. 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. Re-circulated water cannot negatively affect neighboring properties, and evaporate or infiltrate within 24 hours, but not run-off onto other properties or into the stormdrain.

9. Plug sprinklers that are not watering plants, keep sprinklers as low as possible to the plants, and use larger water droplet size to reduce irrigation time and lessen loss to evaporation.

Homeowner Guidelines for Irrigating Turf Areas

1. Homeowners can call 1.877.728.3420 to sign up for free sprinkler checks. Salt Lake city Department of Public Utilities has partnered with USU, Metropolitan Water District of Salt Lake and Sandy, and Sandy City to bring free sprinkler checks to the community. For more information, visit www.slcsaveh2o.com.

2. Review the practices identified in the Landscape Irrigation Section of this BMP; though written for the landscape professional, the information is useful and valid for homeowners and other property managers responsible for decisions regarding lawn watering.

3. The goal is to wet the soil four to six inches deep. To check, push a screw driver into the soil—it will take little effort if it is moist, and be hard to push in at the point the soil has become dry.

4. To wet the soil to the desired depth will typically take one-half (1/2) inch of water. To determine how long it will take to deliver one-half inch of water, perform a catch cup test.

    a. Collect some empty cans—soup cans work fine—and using a permanent marker, place a mark of the outside and inside of the can one-half (1/2) inch from the bottom of the can. Use at least four cans for each irrigation zone.

    b. Place the cans in an even pattern over the lawn, one irrigation zone at a time. Place the cans so that they are not immediately next to a sprinkler head, but rather, between sprinkler heads.

    c. Turn on that irrigation zone and check the water level in the can periodically until the water volume in the can reaches the one-half inch mark.

    d. Note the length of time it took to deliver one-half inch of water; this is the run time for that zone.

    e. Repeat this process with each lawn sprinkler zone.

    f. To establish the run time for each zone, divide the length of time it took to deliver one-half inch of water by three. For instance, if it took 18 minutes to fill the can

one-half inch, divide 18 by 3. Program the controller to turn on that zone for that length of time (six minutes, in the example), but schedule it to turn on and off three times during the night for that length of time. In other words, if you set the irrigation controller to turn on at 1 am, zone one should be scheduled to run for six minutes and then shut off. The next turf zone should be scheduled in a similar manner, to turn on and run for six minutes (if that is what provides the third of the delivery for that zone) and then turn off, and the next turf zone, and the next, until they have all run for one "cycle." Program the clock to repeat this cycle two more times (for a total of three times) over the course of the night. This is called the "cycle and soak" method of irrigation. It allows water to break the surface tension of the soil, percolate into the soil, and move through the soil profile. This means that more water will go into the soil and less will run off the soil and be wasted.

i. Clay soils absorb all the water they can after about eight minutes. If you applied the total run time of water all at once, much of it would just flow away. By watering with the "cycle-soak" method, more water penetrates the soil and reaches the roots of the plants.

ii. Use this technique for any spray-head or rotor-head sprinkler system, whether you are watering lawns, shrubs, perennials, or trees.

iii. Ideally, allow about one hour between the times a specific zone runs through each "soak."

g. During the growing season, change the number of days, the interval, between irrigation applications, but keep the cycle-soak period the same. Add days between waterings when the weather is cool or moist, or when the day length begins to shorten in the fall. Shorten the interval between irrigation applications as the weather warms, with the shortest intervals being during the hottest part of the summer—from the middle of June to the middle of August.

h. Periodically check your sprinkler system to ensure that it is functioning properly. Look for and repair:

i. Broken or cracked spray heads;

ii. Straighten crooked, leaning nozzles;

iii. Redirect nozzles away from driveways, sidewalks, other hardscape, and buildings;

iv. Cleaned clogged nozzles;

v. Add risers to sprinkler heads that are below the grade of the turf; and

vi. Don't forget to check the fittings below the heads.

i. If you'd rather not conduct your own catch-can test or schedule a free test, the chart below may be used as a general guide.

General Guidelines for Frequency of Turf Irrigation	
Month	The number of days between delivering ½ inch of water (called the "interval")
Start-up until April 30	Once every 7 to 14 days (dry, warm springs may require weekly irrigation, while moist, cool springs may require every other week or not at all)
May	Once every 4 to 7 days
June, July, August	Once every 3 to 4 days
September	Once every 7 to 10 days
October to Shutdown	Once every 7 to 14 days (dry, warm springs or falls may require periodic watering though shortening day length and cooler night-time temperatures makes it unlikely that a lawn would need as much irrigation as in the summer months; cool, moist springs or falls means less frequent watering)
You may need to water less or more depending on the weather. If it rains or is windy, remember to turn off the automatic sprinklers.	

Resources

American Landscape and Nursery Association www.anla.org

California Urban Water Conservation Council. 2002. H_2OUSE Water Saver Home. www.h2ouse.net.

Irrigation Association www.ia.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

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11 Irrigation System Design

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Design the irrigation system for the uniform distribution of water. As part of the design process, develop a base irrigation schedule to promote the efficient use of water. New construction that falls under SLC Ord. 21A.48.055 Water Efficient Landscape must submit a water budget with construction documents.

Consider a design that includes a dedicated irrigation-only meter. Visit www.slch2o.com for more information.

This BMP is based largely on *Practice Guideline 2* from *"Turf and Landscape Irrigation Best Management Practices" (The Irrigation Association 2005).*

Basic Practice Guidelines

Design Principles

1. Design irrigation systems based on a direct knowledge and comprehensive understanding of site conditions including: 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 reference evapotranspiration, and annual rainfall; and the construction budget. Note that landscapes having irrigation-dedicated meters will receive water budgets from the SLCDPU. Developments needing to comply with SLC Code 21A.48.055: Water Efficient Landscaping will need to submit a water use budget along with construction plans. See *Water Budgeting BMP* for more information.

2. Consider site and irrigation system hydraulic factors, such as pressure, flow, friction losses, elevation changes, gravity drainage, pressure circumstances that require control devices, and other factors associated with the water supply, when designing irrigation systems.

3. 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). See *Backflow Protection BMP* for more information,.

5. Follow these maximum safe flow practices 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.

- Size the meter based on AWWA Standard M22. (Brad needs to re-write standard). .

- The velocity of water flow through the service line or pipe supplying the meter should not exceed 7.5 feet per second (fps).

- Select main and lateral pipe sizes so that the velocity of water moving through the irrigation pipe does not exceed state and local requirements, or the industry standard of 5 fps.

6. Design for an overall operational site lower-quarter distribution uniformity (DU_{LQ}) as shown in Table 1. These values recognize that some small or odd shaped areas are difficult to irrigate efficiently, while large open areas will likely be irrigated more efficiently.

Table 1
Minimum Operational Uniformity

Type of Zone	Type of Uniformity	Minimum Uniformity
Spray	Lower Quarter DU	65%
Rotor	Lower Quarter DU	70%
Drip/micro-irrigation	Emission Uniformity	80%

7. Design the layout of heads and other emission devices for zero overspray across or onto a street, public driveway or sidewalk, parking area, building, fence, or adjoining property. Overspray may occur during operation of the irrigation system due to actual wind conditions that differ from the design criteria.

8. Design system such that no sprinkler heads are below ponding water such as drainage swales and detention ponds.

9. When selecting system components, place a high priority on avoiding surface runoff. Select components to keep the sprinkler precipitation rate below the infiltration rate of the soil and/or use repeat cycles to allow the water to soak into the root zone. Design and install separate stations/zones for sprinklers at the top, middle, and toe of sloped areas.

10. Properly size pipes for less than 10 percent variation in pressure within a zone, between the most distant sprinklers.

11. Base zone layout on soil properties, slope, plant water requirements, root zone depth, weather conditions, site conditions, supply pressure, and minimum/maximum acceptable application rates. Irrigation system design goes hand-in-hand with the landscape planting design—irrigation zones should correspond to hydrozones and microclimates on landscape plans. Always zone turf separately from plants and shrubs. Developments to which SLC Code 21A.48.055: Water Efficient Landscaping applies must hydrozone and submit hydrozone schedule with construction documents. See *Water Budgeting* and *Plant List* BMPs for more information.

12. Specify manufacturer, model, type, and size of all components to eliminate ambiguity at construction and to facilitate management of the system. The selection of pipe, electrical wire, and other materials shall be based on design parameters, environmental conditions, and code requirements. Properly size valves and pipelines to maintain proper pressure and coverage (distribution uniformity) in irrigation system. The selected equipment should be appropriate for the size and use of the landscape to minimize water waste.

13. Design the system in accordance with the manufacturer's recommendations for the selected system components.

14. For systems on a municipal supply, allow for a reduction in static pressure of up to10 psi to accommodate possible expansion in the supply network.

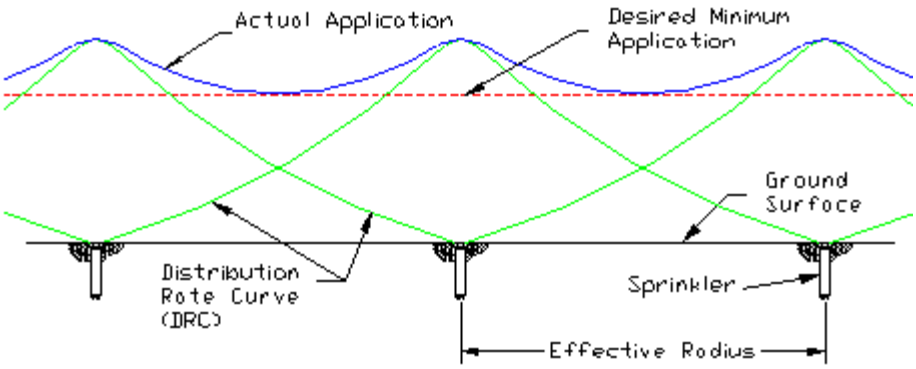
15. Specify pressure regulation.

16. Specify the recommended operating (working) pressure at the maximum design flow rate of the system.

17. Where applicable, specify a water source that meets peak demands for landscape water with an irrigation-duration of no more than 10 hours per day. This guideline helps determine the correct size of the supply meter. Also consider local statutes, anticipated irrigation intervals, or site uses that may dictate different irrigation durations (for example, golf courses). This guideline is intended to match the system requirements to the particular site, not dictate the actual hours of operation on any given day.

18. Sprinklers 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 sprinklers within the same zone. Ideally, do not mix sprinklers within a zone from different manufacturers.

19. Properly space sprinklers based on nozzle performance and pressure requirements to provide uniform coverage, making sure to account for influences such as slopes and wind. The recommended maximum sprinkler spacing to obtain reasonable uniform coverage is "head-to-head." Ensure that irrigation laterals have matched precipitation rates for the sprinkler arcs.



Head-to-head sprinkler spacing for uniform water distribution.
(Source: Stephen Smith, Aqua Engineering; as modified by Ram Dhan Khalsa).

20. For drip irrigation systems, properly select drip emitters to meet the different water needs of plants. On slopes, drip emitters should be placed uphill of the plants. Properly designed drip systems have a "potential" DU_{LQ} of 0.90 or higher. Specific design guidelines include:

    a. Specify filtration at the control valve to remove particulate matter.

    b. Separate drip/micro-irrigation zones from overhead irrigated zones since drip/micro-irrigation systems are not as susceptible to water losses due to evaporation, wind, or surface runoff, and apply water at a much slower rate. Separate zoning allows the irrigator to adjust water duration requirements given these differing conditions.

    c. Consider differing plant water requirements and root zone depths and use separate drip/micro-irrigation zones where practical.

    d. Specify pressure-compensating devices to improve overall uniformity.

    e. Specify pressure regulation upstream from the drip/micro-irrigation components. The pressure of city water sources may be increased periodically by the city for flushing or other purposes, and can potentially damage a drip/microirrigation system that has no pressure regulator on the zone controls. Pressure compensated emitters do not serve this function. Pressure regulating devices can be omitted only when the absolute maximum possible pressure is known to be lower than the maximum allowable pressure for all drip/micro-irrigation components.

    f. Connect (loop) the ends of individual laterals to improve system uniformity and limit possible contamination if drip tubing is damaged. This helps to equalize system pressure and can increase uniformity, and also allows water to flow from both sides of damaged drip tubing, thus flushing out any debris.

    g. Use air release valves to minimize ingestion of dirt or other contaminants into the emitters.

    h. Use flush valves to flush the laterals after completion of the irrigation cycle.

21. For commercial installations, specify a metering device that measures the total landscape water use separate from other use. For residential installations, a separate metering device is recommended.

22. Ease of installation, operation, maintenance, and repair should be considered in the design. The selection and placement of sprinkler and drip/micro-irrigation components should be guided by the expected size of larger specimen plants through a minimum three-year establishment period for shrubs and ten years for trees.

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

24. Use drip/micro-irrigation where appropriate to reduce evaporation losses and surface runoff, and to avoid applying water on hardscapes.

25. Provide a monthly irrigation water budget. This is a requirement for landscapes of developments covered by 21A.48.055: Water Efficient Landscaping. See *Water Budgeting* and *Plant List BMPs* for more information.

26. For landscapes in developments covered by 21A.48.055, , include an estimate of the future monthly landscape water allowance, based on historical reference ET, landscape area, and the landscape water adjustment factor provided by the purveyor or water provider. See *Water Budgeting BMP* for more information.

27. Provide monthly base irrigation schedules where the frequency of irrigation (when to irrigate) depends on replenishing allowable depletion (how much to irrigate) of the soil moisture between irrigations based on monthly reference historical ET data. For each station/zone (or hydrozone as applicable), the designer shall specify the plant type, soil type, average root zone depth, precipitation rate, lower quarter distribution uniformity, area square footage, target gallons per minute flow rate, recommended operating pressure range, and maximum recommended cycle run time without runoff. The designer shall recommend a site specific rainfall factor to convert historical rainfall to effective rainfall. This is useful for budgeting purposes and for schedule compensation when a rain shutoff device is not installed. Developments covered under 21A.48.055: Water Efficient Landscaping are required to submit irrigation schedules with construction documents.

Alternative Water Sources *(*Also see *16 Irrigation Using Non-potable Water BMP)*

28. Where non-potable water is to be used, care must be taken to avoid unexpected negative consequences. Non-potable water characteristics must be known before allowing use in watershed, parkway, secondary drinking water aquifer recharge zones, or well influence zones. Rain catchment is regulated by the State, and is only currently allowed for residential use; visit http://www.waterrights.utah.gov for more information and for permits. Greywater is regulated under the International Plumbing Code, the State of Utah, and the Salt Lake Valley Health Department and is only allowed for residential, non-food crop applications; visit www.slvhealth.org for more information, regulations, submittals, and permitting requirements.

29. When designing systems using non-potable water, ensure that applicable backflow prevention and cross connection regulations are followed. Irrigation systems utilizing non-potable water sources cannot be connected to a system utilizing culinary water without an approved backflow prevention system. See *Backflow Prevention BMP* and SLC Code 21A.48.055: Water Efficient Landscaping for more information.

30. 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 an irrigation system.

31. In areas where irrigation canals water is used, water may not be of sufficient quality for irrigation.

32. A salt test (e.g., electrical conductivity [EC]) should be conducted on such water prior to selecting plant materials. *See the Non-potable Irrigation BMP for more information.*

Water Conserving Equipment and Methods (Also see 15 *Irrigation Technology and Scheduling BMP)*

33. For long, narrow or small irregularly-shaped landscape areas, such as interior parking lot landscaping and parkstrips, use low-volume irrigation systems 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 drip irrigation (SDI) systems. Avoid install spray type sprinkler systems for median strips less than 8 feet wide. New construction must meet guidelines established in SLC Ordinance 21A.40.050 Water Efficient Landscape.

34. Install a master valve to minimize leakage from a damaged irrigation system.

35. Consider soil infiltration rate, slope, and sprinkler precipitation rate when selecting sprinklers to reduce potential for runoff.

36. Specify low-angle sprinklers in windy areas to mitigate wind drift effect.

37. Specify water-conserving devices such as check valves, flow regulators, and pressure regulators. Also, use 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.

38. Install anti-drain (check) valves to minimize or prevent low-head drainage, or use sprinklers with a built-in anti-drain feature.

39. Pressure regulating valves should be used where pipeline pressure is greater than 10 psi or 20 percent different from design operating pressure. Flow regulators can be used in individual sprinklers to correct for differences in lateral pressure.

40. Specify water-conserving irrigation management methods such as smart controller technology that uses ET data or soil moisture sensors to automatically schedule irrigation.

41. Specify an irrigation 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. Also see the *Irrigation Technology and Scheduling BMP*.

42. Avoid sprinklers that produce mists or fine sprays.

43. Consider pump intake filters to prevent plugging the pump impeller, and finer mesh filters on the discharge side of the pump where source water quality is an issue and to decrease plugging of irrigation equipment.

Documentation and Follow-up

44. Provide temporary irrigation schedules to establish new vegetation.

45. Provide a complete irrigation design package to the owner. Written irrigation plans should include: the precipitation rate for each zone; the calculated flow rate for each emitter or low-volume zone; an irrigation schedule for both the establishment and post-establishment plant life cycle periods; and a general operating schedule of run-times based on projected plant ET for each zone, during each month of the irrigation season. The manufacturer and part numbers for specified system components should also be provided. See the Irrigation Association for more detailed recommendations.

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

Resources

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Salt Lake City Department of Public Utilities Water Conservation www.slcsaveh2o.com

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12 Irrigation System Installation

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Install the irrigation system according to the design specifications, which should be in accordance with manufacturer's specifications, SLC 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 2005).

Basic Practice Guidelines

Installation

1. Install the irrigation system to meet the design criteria, and install the irrigation system's components according to the design specifications and manufacturer's published performance standards.

2. Contact all appropriate utility companies prior to beginning installation, to locate underground utilities including gas lines, electrical, telephone, cable, and so forth. State laws (and some Federal laws) require anyone who digs to notify utility companies before starting. Installation shall not be started until all underground utilities are located and marked.

3. Dedicated irrigation meters must have a separate connection to the water main.

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

5. Before commencing installation, verify that the point of connection, water supply, flow rate and static and dynamic pressures meet design criteria. If alterations are required, contact designer to develop revisions.

6. Review planting plans prior to installation to minimize the obstruction of sprinkler spray patterns by larger plants. Also review construction plans for conflicts between hardscape and sprinkler head placement.

7. Inform the property owner and irrigation designer of unusual or abnormal soil conditions which may impact the design and management of the irrigation system.

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

9. Install PVC pipe in dry weather above 40 degrees and allow joint to cure according to manufacturers' instructions.

10. Backfill to six inches above pipe with soil free of rocks over one inch, backfill final four inches of soil above pipes with soil comparable to existing soil.

11. All new landscaping areas should be stabilized with temporary BMP until roots are established and the site permanently stabilized.

12. Where deviations from the design are required (e.g., running pipe around a tree or other structure, or adding sprinklers 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. Redline the plan drawing to note any deviations. In some instances, alterations to the plan will require a re-submittal of irrigation design plans; see SLC Ord 21A.48.055: Water Efficient Landscaping.

13. 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, sprinklers, control wire, irrigation controller and water conserving devices.

14. 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.

System Testing

15. Flush main line and system before installing sprinkler heads to remove debris.

16. Contain flushed water on site.

17. Run a pressure test on the system prior to backfilling to checks for and correct leaks.

18. Test the irrigation system to verify that the system meets the design criteria. All developments covered under SCL Code 21A.48.055: Water Efficient Landscaping must have an independent audit preformed and report submitted. See ordinance for details.

19. Perform an irrigation audit using an accepted procedure. Provide the end user (or owner) with system specifications and a performance summary report by station/zone that includes the plant type, soil type, average root zone depth, precipitation rate, lower quarter distribution uniformity (DU_{LQ}), area square footage, target gallons per minute flow rate, recommend operating pressure range, and maximum recommended cycle run time without runoff. Retain a reference of each station/zone's DU_{LQ}, precipitation rate, operating pressure, and flow rate at the controller. A reference of each zone's precipitation rate should be retained at the irrigation controller. New developments are required to submit an independent sprinkler audit to receive Certificate of Occupancy (see SLC Code 21A.48.055: Water Efficient Landscaping).

System Start-up

20. Create an irrigation schedule to meet the water requirements of the plants. Review the irrigation schedule, specifically its rationale, and how to set irrigation days, station (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. Irrigation schedules are required to be submitted when landscape falls under SLC Code 21A.48.055: Water Efficient Landscaping. If schedule is altered from original submittals, revised schedule shall be submitted per ordinance.

21. Explain to the end user (or owner) the location and operation of the irrigation controller, valves, sensors, pressure regulators, backflow prevention devices, and sprinklers. Review advanced programming features such as multi-cycle irrigation to prevent run-off and the use of the percentage water increase/decrease function. Educate the owner on features and capabilities of the system including the maintenance requirements.

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

23. Provide the end user (or owner) with recommendations for landscape water conservation. Emphasize the following topics:

    a. The importance of maintaining proper operation of system components

    b. Landscape irrigation is meant to supply water to supplement rainfall.

    c. Plant water requirements may change from day-to-day.

    d. Importance of hydrozoning according to plant water requirements.

    e. Benefits of using drip/micro-irrigation components.

    f. Benefits of applying water-conserving landscaping practices such as the use of mulch and soil amendments.

    g. Benefit of assigning someone to be held accountable for water use in the landscape.

Other Considerations

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.

Seal pipe threads, but do not over-tighten a plastic-cased sprinkler onto the riser: it can crack the sprinkler body, causing leaks.

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

When installing reclaimed water irrigation systems, be sure to provide appropriate cross-connection prevention devices and obtain appropriate inspections. See 40 *Backflow Prevention BMP*.

Resources

American Landscape and Nursery Association www.anla.org

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Irrigation Association www.ia.org

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PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

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13 Irrigation System Maintenance

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

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

This BMP is based primarily on *Practice Guidelines 4 and 5* from *"Turf and Landscape Irrigation Best Management Practices" (The Irrigation Association 2005).*

Basic Practice Guidelines

Basic System Maintenance Practices

1. **Establish a maintenance schedule.** Inspect, test, and report 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.

    - Post irrigation schedules, zone location map, and other relevant programming information in each controller (or clearly identify where information is kept).

    - 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. For developments covered under SLC Code 21A.48.055: Water Efficient Landscaping, audits may be required if a property exceeds the submitted water allowance.

2. **Make Corrections and Repairs**. 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. **Inspect System Components.** 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:

   - 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 distribution uniformities and operation efficiency. Install pressure reducing valves (PRVs) on laterals where needed, and flow control devices on individual sprinklers to stop misting due to excessive pressure. Verify that pressure regulators are adjusted for desired operating pressure.

   - Verify that the backflow prevention device is working correctly; annual testing is required for some systems. See SLC Code 21A.48.055: Water Efficient Landscaping for more information.

   - Adjust valves and flow regulators for proper pressure and flow operation. Valves must shut off tightly to prevent leakage and soggy spots, and operate without slamming open or closed to prevent pipeline and sprinkler damage from water surges.

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

   - Verify that sensors are working properly and are within their calibration specifications.

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

   - Examine filters and clean filtration elements as required.

   - Verify proper operation of the controller. Confirm correct date/time input and functional back-up battery.

   - Repair or replace broken hardware and pipelines with originally specified materials, thereby restoring the system to the original design specifications.

   - Complete repairs in a timely manner to support the integrity of the irrigation design and to minimize the waste of water.

   - Notify the end-user (or owner) of any deviations from the original design.

   - Test all repairs.

4. **Use correct replacement components**. Ensure that the replacement hardware used for system repairs matches the existing hardware, and is in accordance with the design. Aftermarket replacement nozzles may not match original parts well enough to preserve distribution uniformity and the precipitation rate. Conduct a performance audit every three to

five years to assure that the system is working efficiently and with the desired DU_{LQ} and precipitation rate specifications.

5. **Adjust sprinkler heads as plants grow.** As plants mature, trim or remove vegetation as required to preserve system performance. Add additional sprinklers or other hardware as required to compensate for blocked spray patterns or changes in the irrigation needs of the landscape. Ensure that system modifications are in keeping with design specifications and do not cause landscape water demand to exceed the hydraulic capacity of the system. =or the water budget schedule.

6. **Establish a "winterization" protocol.** Also establish a corresponding process for system activation in the spring. Winterization primarily consists of removing all the water from the irrigation system and equipment to prevent cracked pipes, broken sprinklers, and other problems. This is typically accomplished by turning off the main water supply, opening all drains, and blowing the water out of all pipelines, valves, and sprinklers with compressed air.

7. **Update utilizing improved technologies**. Whenever possible, update and retrofit existing irrigation systems to take advantage of new water-saving technology (e.g., rain shut-off devices, "Smart" controllers, soil moisture sensors, rotator nozzles, and drip irrigation).

8. **When using contractors, check for licensing**. Ensure that the maintenance contractor is licensed, insured, experienced, and reputable. The maintenance contractor should be legally authorized to maintain irrigation systems in the local jurisdiction.

Maintenance Practices for Managing Changing Water Needs of Plants

9. **Manage water for the season and for plant needs.** Manage the irrigation schedules to respond to the changing seasonal requirements for plant water needs in the landscape. The most efficient systems match irrigation application amounts to landscape water requirements through effective irrigation scheduling. Whenever possible, irrigation scheduling should incorporate the use of evapotranspiration data, soil moisture measurements, and precipitation data.

10. **Inspect irrigation controllers.** Irrigation controllers should be inspected at least bi-monthly to change irrigation frequencies or run times.

11. **Work the controller.** Understand the capabilities of the irrigation controller and use these features to efficiently irrigate; see the *Irrigation Technology and Scheduling BMP*.

12. **Establish a water budget based upon system performance and plant water requirements**. Use the water budget to compare actual water usage to the amount of water budgeted. Adjustments should be made based on stated uniformity requirements in concert with the water budget to maintain or improve water efficiency.

13. **Perform irrigation audits**. Make needed repairs or manage watering schedules to maximize efficiency. Sites covered under SLC Ord 21A.48.055: Water Efficient Landscaping may be required to complete audits and submit reports. See ordinance for more information.

14. **Understand and use a reliable source for grass reference ET (ETo)** rates (See Appendix F). Appropriately modify reference ET to calculate local water needs (plant ET) for the various plants 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" distribution uniformity and precipitation rate of the sprinkler zones, the water-holding capacity of the soil, the changing weather conditions (ET), and the plant's water requirements. Set the schedule cycles to minimize runoff.

15. **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.

16. **Inspect cross-connection and backflow prevention devices**. Properties with non-testable cross connection/backflow prevention devices must submit to SLCDPU a letter stating that the device(s) are functioning as intended and are unaltered. Testable cross-connection and backflow prevention devices must be inspected on an annual basis by a certified cross-connection control technician, and reports submitted for certain systems. See *40 Backflow Prevention BMP* and SLC Code 21A.48.055" Water Efficient Landscaping for more information.

17. **Use good judgment.** 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.

Resources

American Landscape and Nursery Association www.anla.org

California Urban Water Conservation Council. 2002. H_2OUSE Water Saver Home. www.h2ouse.net.

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TPI Turfgrass Producers International www.turfgrasssod.org

Salt Lake City Department of Public Utilities Cross-Connection Group **www.slch2o.com**

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14 Irrigation Efficiency Audits

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Auditing sprinkler systems is a valuable tool for ensuring that plants receive the moisture required to grow and thrive, and for ensuring that water efficiencies are still being achieved. Audits on new systems ensure that sprinklers were installed and operating as designed; audits on existing irrigation systems identify needed improvements to reduce landscape water waste and improving irrigation efficiency. This process is sometimes called a "catch can test."

This BMP is divided into two important components: the pre-audit to correct existing malfunctions in the irrigation system and the irrigation audit itself, which is used to assess distribution uniformity and precipitation rates for the irrigation system.SLC would like to achieve an efficiency of 65 percent average for fixed spray heads and 70 percent average for gear-driven rotor heads, over the entire site.

Salt Lake City Department of Public Utilities offers free irrigation audits for residential and commercial properties. Commercial properties are required to develop an over-all water conservation plan and agree to implement improvements as identified in the irrigation audit report to qualify for the free audit. Visit www.slcsaveh2o.com for more information.

Basic Practice Guidelines

Most of the guidelines presented in this BMP were developed by the Irrigation Association (IA) and are intended to function as recommendations in the evaluation and performance of landscape irrigation systems. The IA recommends conducting irrigation audits approximately once every five years. These guidelines have been designed to aid landscape professionals in fieldwork procedures and in irrigation performance calculations and techniques. Recommendations and projections from the guidelines and their accuracy depend upon the quality of measurements and data provided by the individual user. The IA makes no warranty, implied or expressed, as to the results obtained from these procedures, and intends that these procedures by used as guidelines, not a set of regulations or standards.

Step #1: Pre-Audit Assessment and System Correction

1. Complete a pre-site inspection to document system components and conditions. As part of this step, obtain as-built drawings and water use history for the past three years, where available.
2. Determine whether irrigation system meets all local codes.

3. Repair operational defects so that the system is in working condition. Make sure all heads are in proper position.

4. Schedule the inspection after a mowing day to reduce interference from tall grass.

Utah State University Extension (USU Ext) has developed an irrigation system walk-through, which can be used as a checklist to document the landscape and irrigation system conditions. This form is provided in Appendix G and can be easily understood by a homeowner. In many cases, correction of the items identified in the pre-audit significantly improves irrigation system performance. Representative items covered in the pre- audit checklist include:

- Documentation of existing irrigation schedule and methods of adjustment over the irrigation season.
- Description of irrigation system zone (station) equipment.
- Description of water saving devices (e.g., rain shutoff, soil moisture sensor, weather-based controllers).
- Description of landscape features (e.g., slope, exposure, soil conditions, plant types and conditions in each zone).
- Condition of sprinkler nozzles (e.g., broken, tilted, spray direction) and drip systems (e.g., plugged, missing pressure regulator).

Step #2: Irrigation Efficiency Audit

The irrigation efficiency audit, which assesses distribution uniformity and precipitation rates, is completed by conducting a catch-can test and comparing the average distribution uniformity of the lower quarter of the catchment samples (DU_{LQ}) with the overall average of catchment samples (DU_{AVG}). Good distribution uniformity is indicated when the average values of the lower quarter are similar to the overall average.

Test Conditions (*as specified by the Irrigation Association*)

1. Maximum wind allowable during audit = 5 mph or less (ASAE S398.1).
2. Audit must be conducted under normal operating conditions.
3. Pressure tests must be conducted at normal operating conditions at the sprinkler using the appropriate pressure testing device at the beginning, middle, and end of operation of each audited zone.

Placement of Catch Cups

4. Catch cups for a test area should be spaced in a grid pattern. All catch cups must be uniform in size and type. See photo next page.

Placement of catch cans for irrigation efficiency audit.
Photo Source: Kenneth Solomon

5. Catch cups along the edge of the zones should be placed 12 to 24 inches in from the edge.

6. Catch cup spacing:

   - Fixed spray and rotor sprinklers: place catch cups near a head and half-way between the heads

7. Unusual areas

   - Large areas with rotor sprinklers (i.e. athletic fields): place catch cups in a uniform grid, spacing 10 to 15 ft between cups

   - Small areas with spray sprinklers (i.e., narrow turf area less than 8 ft wide): place cups in a uniform grid of 5 to 8 ft spacing

Test Run Times

8. Test run times must be consistent among zones.

9. When the test area contains multiple zones, the zone run times must be adjusted to run for the same amount of time in each zone.

10. Rotor sprinklers must run for a minimum of five rotations during the test, or until a reasonable amount of water is in each catch cup.

11. All catch cup volumes must be read in milliliters (mL), and it is recommended that a minimum of 25 mL of water be collected.

Data Collection and Recording

12. The following data must be documented:

    a. Catch cup locations
    b. Catch cup volumes
    c. Testing run times
    d. Sprinkler locations
    e. Sprinkler spacing
    f. Pressure readings with locations
    g. Make, model, nozzle of sprinklers
    h. Soil types and root zone depths
    i. Wind speed readings
    j. Date and time of testing

Step #3. Calculate distribution uniformity

13. The lower quarter distribution uniformity (DU_{LQ}) is calculated with the following method:

    Step 1: Order the individual catch-can volumes in a list from smallest to largest. Spreadsheets help to significantly reduce calculation time.

    Step 2: Separate out the catch cup values for the quarter of the cups containing the least amount of water. Calculate the average catch cup volume of these cans (V_{LQ}).

    Step 3: Calculate the average catch cup volume for all the cups (including the low quarter) (V_{avg}).

    Step 4: Calculate the lower quarter distribution uniformity (DU_{LQ}) as a percentage using the following formula:

    $$DU_{LQ} = (V_{LQ} / V_{avg}) \times 100$$

    Where:

    V_{LQ}= Average Catch Volume in Lower Quarter (mL)
    V_{avg} =Average Catch Volume in Zone (mL)
    DU_{LQ} =Distribution Uniformity (in %)

14. Table 1 can be used to assign a qualitative rating to the lower quarter uniformity (DU_{LQ}) for overhead irrigation systems, rated as "excellent, very good, good, fair, or poor" based on the type of sprinkler head used in the zone. If the overall DU_{LQ} has a rating of "fair" or "poor," consider redesigning the system, replacing sprinkler heads that are not performing well, adjusting sprinkler head spacing, adjusting alignment and radius of throw, adjusting relative timing of overlapping zones, and correcting operating pressure problems.

Table 1. Irrigation Association Ratings of Lower Quarter Distribution Uniformity for Sprinkler Zones (Source: Irrigation Association 2001)

Type of Zone	**Excellent** (%)	**Very Good** (%)	**Good** (%)	**Fair** (%)	**Poor** (%)
Fixed Spray	75	65	55	50	40
Gear Driven Rotor	80	70	65	60	50
Impact Rotor	80	70	65	60	50

15. Table 1 can be used as a guideline for initial planning and design purposes in addition to use in system performance evaluation. While DU_{LQ} as measured with catch-cans is a good indication of sprinkler hardware performance, it does not always accurately reflect soil moisture uniformity within the root zone. This is because of the tendency of soil moisture to move laterally through the soil profile, which is not reflected in catch-can measurements. Based on a study in turfgrass irrigation using test plots with different soil textures, an improved representation of soil moisture uniformity *for scheduling purposes* is the *lower-half* of the distribution uniformity (Irrigation Association 2005).

16. The catch cup results can also be used to calculate the net precipitation rate for irrigation scheduling purposes. The net precipitation rate (PR_{net}) is based on the amount of water that actually reaches the landscape using the following formula:

$$PR_{net} = (3.66 \times V_{avg})/(t_R \times A_{CD})$$

Where:

PR_{net} = zone precipitation rate (inches/hr)
V_{avg} = average catch volume for zone (mL)
t_R = test run time (min)
A_{CD} = catch device throat area (in^2)
3.66 = constant for unit conversion

Resources

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TPI Turfgrass Producers International www.turfgrasssod.org

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15 Irrigation Technology and Scheduling

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Irrigation systems can be equipped with a variety of water conserving devices such as rain sensors and shutoff devices; weather stations; high wind shutoff devices; freeze protection devices; and advanced automated "Smart" control systems that incorporates soil moisture data and evapotranspiration (ET) conditions. Over the past decade, such devices, once used predominantly for large landscapes, are now affordable for many homeowners and smaller commercial properties.

Landscape professionals and homeowners should be aware of the benefits of water conserving technology and make use where appropriate.

Irrigation scheduling addresses the frequency (how often) and duration (how long) of water application. A key benefit of advanced irrigation technology in controllers (clocks) is increased ease of scheduling and more precise scheduling; accordingly, irrigation scheduling is discussed along with technology.

Basic Practice Guidelines

Technologies

1. Be aware of the various categories of irrigation technology that can increase water efficiency and know the strengths and weaknesses of each. Table 1 summarizes some common water waste problems and identifies some technology-based solutions to the problems. Representative categories of water saving devices include:

    a. Rain sensors or shutoff devices

    b. Soil moisture sensors

    c. Wind shutoff devices

    d. Smart controllers (ET or soil moisture controllers)

    e. ET add-ins to conventional controllers (e.g., add an ET component without replacing the whole controller)

    f. Drip irrigation for non-turf areas

    g. Sub-surface drip for turf areas or planted borders

    h. Rotary nozzles for spray heads

    i. Real-time flow sensing (this feature identifies abnormally high water use and shuts down the system)

    j. Mini-weather stations that incorporate rain, wind, and freeze devices

    k. Central control systems for large common areas, playing fields, golf courses, etc.

    l. Pressure regulating devices (e.g., flow compensating nozzles at individual sprinklers or pressure

regulators on irrigation valves)

2. In addition to these specific devices, many contemporary basic irrigation controllers incorporate a "percent key" or "global adjust key" that enables adjustment of the irrigation system based on a water budget. For example, in May, a user could easily schedule the controller to apply only 25% of the peak water budget for July.

Table 1
Common Sources of Water Inefficiency in Irrigation Systems and Possible Technology-based Solutions

Runoff Problem	Irrigation System Related Solution
Misting and fogging due to high pressure	• Install pressure regulating devices, which can have an added benefit of reducing water waste when the nozzle is missing or damaged, and may improve distribution uniformity because the nozzles will be operating at optimum pressure
System leakage at low point	• Install in-stem check valves to prevent water from draining out of the system at the lowest head
Over- or under-watering due to nozzle issues	• Replace mismatched nozzles to ensure matched precipitation rates • Keep fixed spray heads, rotors, and multi-stream/multi-trajectory nozzles on separate zones • Consider replacing old nozzles with high efficiency nozzles, being sure to match precipitation rates and adjust irrigation scheduling accordingly
Runoff due to compacted soils or slopes	• Install controllers with multiple start times ("cycle and soak") features to enable irrigation precipitation rates to be less than the soil infiltration rate • Design and install irrigation so that the top, middle, and foot of slopes are on separate zones to allow for differing run times
Overwatering of shrubs and beds	• Install drip irrigation systems to deliver water directly to the plants roots • Provide water to shrubs, trees, and perennials on zones separate from turf areas
Overwatering due to weather or seasonal changes	• Install automatic rain and wind shutoff devices • Install controllers with rain delay features (postpones irrigation following rain) • Install controllers with water budget features and weather based (e.g., ET, soil moisture) programming • Install controllers based on soil moisture sensors (e.g., based on "managed allowable depletion" [MAD])
Overwatering due to varying plant types and environmental conditions	• Install controllers with multiple independent programs that accommodate watering based on "hydrozones" requiring differing frequencies and durations of irrigation • Water turf on zones separate from other planted areas

3. Minimum features that should be included on irrigation controllers include:
    a. Select watering days
    b. Multiple start times (cycle and soak feature)
    c. Multiple run times for different zones
    d. Programmable rain delay
    e. "Percent key," "global adjust
    f. key" or basic water budgeting features
    g. Master valve option
    h. For more complex controllers, a diagnostic feature to help identify problems and battery backup
4. Technology has also evolved for sprinklers; a few examples to consider include:
    a. Rotary nozzles for spray heads which allow lower precipitation rates (e.g., 60-75% less than conventional spray nozzles) and more heads per zone, reducing overall system complexity and cost. These nozzles have multiple rotating streams that uniformly distribute water, typically in the 10 to 30 foot range.
    b. Check valves that eliminate water draining out of the lowest head.
    c. Pressure regulating sprinkler heads for improved uniformity.
5. Drip irrigation systems should include operating specifications that include pressure compensating and non-draining emitter features.
6. Central control systems are not discussed in detail in this Manual due to their nuances and site-specific complexity. Briefly, these are computer-based systems that allow programming, monitoring and operation from a central location. Example applications include a single large site such as an office park or multiple sites owned by a single entity such as a school district or parks department. Central controls can monitor and automatically adapt system operation and irrigation run times in response to conditions in the system (e.g., pipe break) and surrounding weather. Green Industry professionals operating such systems should be well-trained to ensure proper operation of the system. Often, the product vendor offers training on this type of product.
7. Irrigation equipment manufacturer's catalogues are good sources of information. Typically, a good catalogue will identify which types of sprinklers are designed for different areas (e.g., turfgrass at high or low mowing heights, high traffic areas, high winds, high vandalism areas, reclaimed water, etc.). Keeping these catalogues handy in maintenance vehicles can also help to ensure that nozzle replacements are based on matched precipitation rates when sprinklers are repaired. Similarly, catalogues will also identify which types of valves are most appropriate for lower quality water, high pressure systems or reclaimed water.
8. Educate employees and clients on the proper functioning of water conserving technology. An improperly programmed advanced irrigation controller can result in as much or more water waste that conventional technology. Also, advanced controllers do not correct existing problems in distribution uniformity or other irrigation system damage—these controllers are just one tool to promote water efficiency.

9. Consider these issues when using advanced irrigation technology:

    - The best irrigation technology is only as good as the operator who uses it
    - Do not disconnect or override technology without good reason
    - Be sure to reset controllers to the active technology mode after manual operation
    - New technology must be learned; do not hesitate to contact the manufacturer for information on operation and maintenance
    - Keep operation manuals, zone descriptions (e.g., locations, precipitation rates, landscape types, irrigation types) and irrigation schedules with the controller for future reference
    - Train customers on the operation of all new irrigation equipment and educate the customer regarding irrigation schedules
    - For new landscape installations, the landscape installation is not complete until the initial landscape establishment irrigation schedule is replaced with the normal irrigation schedule

10. Be aware that advanced irrigation technologies have in many cases decreased significantly in cost, enabling cost recovery over a shorter time period of time, which may be particularly relevant in locations where tiered rate structures are in place. Customers of SLC Department of Public Utilities are eligible for rebates provided by the Central Utah Water Conservancy District for specific irrigation components and controllers. Visit www.slcsaveh2o.com for more information.

11. Several resources are easily downloadable for use in evaluating the benefits and drawbacks of various control technologies, including the U.S. Environmental Protection Agency's new WaterSense labeling program (U.S. Environmental Protection Agency www.epa.gov/WaterSense

12. When using reclaimed water, be aware that some soil moisture sensor based systems provide an added benefit of identifying when salt concentrations have reached levels requiring leaching, based on electrical conductivity (EC) measurements.

WaterSense is a partnership program sponsored by the U.S. Environmental Protection Agency. Its mission is to protect the future of our nation's water supply by promoting and enhancing the market for water-efficient products and services. The WaterSense program will intersect the Green Industry in two areas: 1) certification of irrigation professionals and 2) labeling of products. For more information on products with the EPA WaterSense label, go to http://www.epa.gov/watersense/.

EPA established specifications on October 27, 2006, to recognize certification programs for irrigation professionals in three areas: system design, installation and maintenance, and system auditing. Any certification program that meets the criteria outlined in the specification for one of these areas will be eligible for the WaterSense label.

With regard to products, the program focuses on labeling of weather- or sensor-based irrigation control technology that uses local weather and landscape conditions to tailor irrigation schedules to actual conditions on the site or historical weather data. Instead of irrigating according to a preset schedule, advanced irrigation controllers allow irrigation to more closely match the water requirements of plants. These new control technologies offer significant potential to improve irrigation practices in homes, businesses, parks, and schools across the United States. WaterSense plans to label landscape irrigation systems and controls.

Irrigation Scheduling

1. Irrigation scheduling is where all aspects of the green industry come together: soils, slopes, plant types and health, aspect/exposure, irrigation technology, etc. To properly schedule irrigation, it is necessary to consider all of these factors in order to determine the appropriate application rates and frequencies. Schedules should be based on a water budget that considers:

    - Sprinkler precipitation rates (know how much water is being applied). Be sure to recognize differences for drip irrigation systems such as the size and number of emitters, as well as scheduling run times in terms of hours rather than minutes.

    - Soil characteristics such as infiltration rates, water holding capacity, and maximum allowable depletion, and precipitation rates should not exceed infiltration rates; this can be controlled by utilizing the “cycle and soak” scheduling method instead of one continuous cycle.

    - Plant water requirements (based on ET, adjusted seasonally).

    - Weather monitoring/rain shut-off features.

    - Local government recommendations regarding water times and frequencies.

2. When establishing irrigation durations and frequencies, take into consideration the water holding capacity of the soil. Sandy soils do not hold water and plants grown in them benefit from frequent watering. Clay soils hold water longer and reach capacity quickly, and thus benefit from a cycle/soak method and more time between watering applications. Loamy soils hold water but it moves more readily through the soil profile than in either sandy or clay soils, though cycle/soak is still the preferred method of application.

3. When selecting a controller, it is important to match the customer and expected maintenance staff to the complexity of the device so that irrigation scheduling is completed correctly and adjusted regularly. The controller selected should be reliable, flexible, and relatively easy to use based on the experience of the operator.

4. Irrigation application rates should not exceed the infiltration rate of the soil. This is particularly relevant on clay soils and slopes. See Table 2 for maximum precipitation rates recommended by the U.S. Department of Agriculture, based on slope, soil texture and vegetative cover.

Table 2
Maximum Precipitation Rates for Slopes

Maximum Precipitation Rates for Slopes (inches/hour) (Source: U.S. Department of Agriculture)								
Soil Type	**0% to 5% slope**		**5% to 8% slope**		**8% to 12% slope**		**12%+ slope**	
	Cover	**Bare**	**Cover**	**Bare**	**Cover**	**Bare**	**Cover**	**Bare**
Coarse sandy soils	2.00	2.00	2.00	1.50	1.50	1.00	1.00	0.50
Coarse sandy soils over compact subsoils	1.75	1.50	1.25	1.00	1.00	0.75	0.75	0.40
Light sandy/loam soils	1.75	1.00	1.25	0.80	1.00	0.60	0.75	0.40
Light sandy/loam soils over compacted subsoils	1.25	0.75	1.00	0.50	0.75	0.40	0.50	0.30
Silt/loam soils	1.00	0.50	0.80	0.40	0.60	0.30	0.40	0.20
Silt/loam soils over compacted subsoils	0.60	0.30	0.50	0.25	0.40	0.15	0.30	0.10
Heavy clay or clay/loam soil	0.20	0.15	0.15	0.10	0.12	0.08	0.10	0.06

5. Be aware that scheduling for drip emitters requires longer run times than conventional pop-ups and rotors. Adjust irrigation run-times according to the desired application volume.

Table 3
Guidance for Drip Emitters (adapted from Hunter 2008)

Emitter Discharge Selection (gallons per hour [gph])									
Soil Type	Heavy Clay			Loam			Sandy		
Discharge	0.5 gph			1 gph			2 gph		
Number of Emitters/Plant									
Canopy (ft)	1'-2'	3'-4'	4'-5'	6'-7'	8'-9'	10'	11'-12'	13'-14'	15'
# of Emitters	1	2	3	4	5	6	7	8	9

6. Spreadsheet-based scheduling tools can aid in combining the various factors (e.g., soils, plant types, sprinkler precipitation rates, ET data) needed to develop a sound irrigation schedule. Salt Lake City does not currently **have desi**gnated watering days, though during declared drought conditions that circumstance may change.

Resources

American Landscape and Nursery Association www.anla.org

California Urban Water Conservation Council. 2002. H_2OUSE Water Saver Home. www.h2ouse.net.

Center for Irrigation Technology www.californiawater.org.

Irrigation Association www.ia.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

Irrigation Association. 2006. Smart Water Application™ (SWAT™) Performance Reports (various devices). www.irrigation.org

U.S. Bureau of Reclamation's (2007) report: *Weather and Soil Moisture Based Landscape Irrigation Scheduling Devices,* which evaluated the performance of weather-based controllers from 20 different manufacturers and soil-moisture, based products for eight manufacturers. See www.usbr.gov/waterconservation/docs/Controller2006.pdf for the evaluation results

U.S. Environmental Protection Agency www.epa.gov/WaterSense

References

Irrigation Association. 2005. *Irrigation Best Management Practices*. http://www.irrigation.org/gov/pdf/IA_BMP_APRIL_2005.pdf.

Irrigation Association. 2005. *Landscape Irrigation Scheduling and Water Management* http://www.irrigation.org/gov/pdf/IA_LISWM_MARCH_2005.pdf.

Mecham. B. undated. Scheduling Methods Using ET as a Management Tool. Northern Colorado Water Conservancy District. www.ncwcd.org/ims/ims_turfandurban_tech_rep.asp

Mecham. B. undated. A practical guide to using soil moisture sensors to control landscape irrigation Northern Colorado Water Conservancy District. www.ncwcd.org/ims/ims_turfandurban_tech_rep.asp

Mecham. B. undated. The Effects of Matched Precipitation Rate Nozzles on Distribution Uniformity. Northern Colorado Water Conservancy District. www.ncwcd.org/ims/ims_turfandurban_tech_rep.asp

Northern Colorado Water Conservancy District (undated). Turfgrass Irrigation Management, Turfgrass Irrigation Management (TIM) Program and Checkbook Irrigation Scheduling (CIS) Program www.ncwcd.org/ims/scheduler.asp.

16 Irrigation Using Nonpotable Water

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Nonpotable water may be used for irrigation purposes as a method to conserve potable or higher quality water sources for human consumption (drinking water). Nonpotable water sources are not treated to potable (drinkable) water standards and may include water from irrigation canals, lakes, ponds, or a reclaimed (wastewater) treatment system. Use of reclaimed (treated sanitary wastewater) water is a viable, but currently unavailable in Salt Lake City's water delivery area.

Contact Salt Lake City Department of Public Utilities prior to implementing a nonpotable water option. Water from irrigation or ditch companies is the most common source of nonpotable water in Salt Lake City. As an alternative supply source, it has two shortcomings: first, one must have a share in an irrigation or ditch company to utilize this supply; and second, as its source is the same as our culinary supply (that being run-off from Wasatch Mountain snow melt), it does not in fact utilize a different source.

This BMP is divided into three practices: General Nonpotable Water; Reclaimed Water; and Rainwater Harvesting. Although greywater reuse is advocated as a conservation measure for landscape irrigation in some parts of the country, there exist public health and soil health issues associated with its use; see the sidebar at the end of this BMP for more information.
Many of the practice guidelines related to reclaimed water use in this BMP have been developed based directly on work completed for Denver Water by ***Aqua Engineering (2004)*** *and* ***Yaling Qian, Colorado State University (2005)****. These papers were provided courtesy of* ***Donna Pacetti, Denver Water****. These sources should be credited as sources of much of the technical information contained in the reclaimed water portion of the BMP.*

Basic Practice Guidelines

Note: Care must be taken to avoid unexpected negative consequences when utilizing nonpotable water sources. Water characteristics must be known before allowing use in watershed areas, primary or secondary drinking water aquifer recharge zones, or well influence zones. See Salt Lake County Regulation 9.25, and the SLC Ord Groundwater Source Protection 21A.34.060.

Nonpotable water cannot be connected to an irrigation delivery system that is also utilizing culinary water without an approved backflow prevention system. See *Backflow Prevention BMP* for more information.

General Nonpotable Water Guidelines

1. Where untreated water is available for irrigation and is of reasonable water quality to support vegetation, such sources should be considered to conserve potable water sources. Prior to relying on such sources, water quality should be tested to determine its suitability and/or

potential mitigation strategies needed for the water source. In situations where problematic water quality and/or soil quality conditions are identified, the landscape professional should consult a qualified expert for guidance.

2. Proper water rights are required to utilize water from wells and other non-potable water sources. If drilling a new well or utilizing an existing spring, contact SLCDPU for testing parameters and other permitting requirements.

3. Salt problems may be introduced to a landscape through a combination of irrigation water management strategies, salt in the water, fertilizer, pre-existing high salt content in the soils, a high water table, or previous irrigation practices. Soils should be tested a minimum of once per irrigation season at sites using nonpotable water for irrigation without a history of soil problems, and more frequently at sites with poor vegetation conditions or that have a history of soil problems.

4. In addition to water chemistry considerations, the physical characteristics of the water must be taken into consideration, for example, water transferred in ditches or pumped directly from streams or ponds may contain sediment and plant debris that can clog or damage irrigation equipment. Filters or screens should be considered when designing such irrigation systems.

5. All irrigation water conveyance systems should comply with the existing standards of the responsible irrigation or drainage company, district, association, or other entity. In designing such systems, factors such as water rights, pipe materials specifications, pressure and flow velocities, backfill materials, and other typical design criteria must be considered. A special consideration for nonpotable water includes inlet design features that minimize the intake of trash and sediment.

6. Rain catchment systems, including rain barrels, must be registered with the State of Utah, Division of Water Rights. Visit www.waterrights.utah.gov for more information regarding the rules and regulations surrounding rainwater harvesting.

7. Long-term effects of nonpotable water irrigation are complex and further research is needed to provide more detailed guidelines to maintain healthy landscapes.

8. Many irrigation supply companies provide purple covers for spray heads (as well as other system components) to identify non-potable or reclaimed water as a source. Additionally, reclaimed water users should select valves that are resistant to chemicals and conditions present in reclaimed water.

9. When using reclaimed water, be aware that some soil moisture sensor based systems provide an added benefit of identifying when salt concentrations have reached levels requiring leaching, based on electrical conductivity (EC) measurements.

Water Quality Regulations

10. Use of reclaimed water in Utah is regulated by the Utah Code Annotated 19-4-112, and DEQ R317. Additionally, the supplier of the reclaimed water must possess water rights allowing the use of the reclaimed water for irrigation. Water rights in Utah are administered by the State Engineer's Office. This regulation identifies how reclaimed water may be used for irrigation, identifies minimum treatment requirements and water quality standards, identifies conditions of use, public education/signage, and monitoring, record keeping and reporting requirements. Representative standards are summarized in Tables 1 and 2. In order to legally use reclaimed water for irrigation, both the entity treating the wastewater and the end user must receive a Notice of Authorization from the Water Quality Control Division prior to any use of reclaimed water. Civil and criminal penalties may apply to improper use of reclaimed water for landscape irrigation. For this reason, Green Industry professionals must familiarize themselves with the terms of use of reclaimed water on properties that they maintain or manage. Obtaining information about the source of water, water quality and seasonal water quality fluctuations is important for Green Industry professionals.

Table 1 Water Quality Standards for Categories of Reclaimed Water
(Source: CDPHE 2007)

Water Quality Category	E. coli (#/100 mL)	Total Suspended Solids (mg/L)	Turbidity (NTU)
1 (Secondary Treatment +Disinfection)	126/100 ml monthly geometric mean and 235/100 ml single sample maximum.	30 mg/L as a daily maximum.	NA
2 (Secondary Treatment +Filtration + Disinfection)	126/100 ml monthly geometric mean and 235/100 ml single sample maximum.	NA	Not to exceed 3 NTU as a monthly average and not to exceed 5 NTU in more than 5 percent of the individual analytical results during any calendar month.
3 (Secondary Treatment +Filtration + Disinfection)	None detected in at least 75% of samples in a calendar month and 126/100 ml single sample maximum.	NA	Not to exceed 3 NTU as a monthly average and not to exceed 5 NTU in more than 5 percent of the individual analytical results during any calendar month.

Table 2 Approved Uses of Reclaimed Water for Landscape Irrigation
(Source: CDPHE 2007) UTAH REGS?

Approved Landscape Irrigation Uses	Category 1	Category 2	Category 3	Additional Conditions (See Notes)
Restricted Access	Allowed	Allowed	Allowed	
Unrestricted Access	Not Allowed	Allowed	Allowed	1

Resident-Controlled	Not Allowed	Not Allowed	Allowed	1,2

Applicable Table Notes from CDPHE (2007):

[1]No reclaimed water piping shall be extended to or supported from any residential structure and there shall be no accessible above grade outlets from the reclaimed water system at any residential structure. At least one exterior hose bib, supplied with potable water, shall be provided at each residential structure.

[2]The treater shall develop and implement a public education program to inform residents and plumbing contractors and inspectors who deal with the Resident-Controlled Landscape Irrigation systems about the need to: a) strictly prohibit cross-connections between the reclaimed water and potable water systems; b) clearly and distinctively identify the potable service lines and plumbing from the reclaimed water service lines and plumbing; and c) avoid contact with and strictly minimize ponding or runoff of the reclaimed water. The treater shall implement a cross-connection inspection program and shall have the authority to discontinue reclaimed water service to any resident who flagrantly or repeatedly misuses reclaimed water in a manner inconsistent with this regulation. The treater shall maintain a map indicating all areas where reclaimed water is provided for Resident-Controlled Landscape Irrigation.

11. Operation of the reclaimed water irrigation system, including valves, outlets, couplers, and sprinkler heads may be performed only by personnel authorized by the user and trained regarding health hazards. Workers must be informed of the potential health hazards involved with contact or potential ingestion of reclaimed water and must be educated regarding proper hygienic procedures to protect themselves Utah Regulation?

12. Utah Regulation states that irrigation application rates must be controlled to strictly minimize ponding and runoff and to minimize the amount of applied water and associated pollutants that pass through the root zone of the plants to be irrigated (e.g., rain shutoff devices, application at evapotranspiration rates adjusted for irrigation efficiency, daily inspections, or other means). The regulation defines agronomic application rates as the rate of application that is necessary to satisfy the plants' nutritional and watering requirements, while strictly minimizing the amount of nutrients that run off to surface waters or which pass below the root zone of the plants.

13. Irrigation may only be conducted at times and conditions (e.g., access may be restricted) specified in the Utah Regulation.

Practices to Promote Healthy Landscapes Irrigated with Reclaimed Water

14. Prior to choosing reclaimed water as the irrigation water source, it is critical to consider the existing and expected long-term conditions present in the landscape. For example, in a landscape with poorly drained soils, poor water quality will have a more detrimental impact on the landscape than a landscape that has ideal drainage conditions. In well drained soils, constituents are less likely to accumulate and be taken up by plants because they are easily leached (Aqua Engineering 2004).

15. In addition to water quality monitoring required under Utah regulation, it is also important to monitor water quality and soil conditions both prior to implementing a reclaimed water use program, as well as over the long-term as irrigation continues. Collect and test soil samples from a wide variety of test locations in the landscape, and at an adequate frequency, so subsequent test results can be monitored and actual trends measured. Prior to beginning irrigation, it is important to establish soil quality and water quality baselines (Aqua

Engineering 2004). Representative recommended constituents for analysis are described in Table 3, and Table 4 identifies salt contents that will require special management measures. For context, Aqua Engineering (2004) provides this brief overview regarding the landscape implications for several key water quality parameters:

- Salinity – The total soluble salt content in water, measured as electrical conductivity (ECw) or total dissolved solids (TDS). When salt content in irrigation water is too high, the ability of plants to use water is impacted. Salts tend to accumulate in the soil profile because plants use the irrigation water and leave the salts behind. Over time, salts will build up in the soil profile to concentrations that are higher than that of the irrigation water applied. If salts are not removed from the root zone, soil salt concentrations will become detrimental to landscapes.

- Sodium Adsorption Ratio (SAR) – A measure of the proportion of sodium ions to calcium and magnesium ions in a water solution. A high SAR value indicates that sodium ions are high relative to calcium and magnesium ions. High SAR water applied to soils tends to disperse soil, which can create water infiltration problems. The adjusted SAR (SARadj) is also used to measure the additional influence that bicarbonates in irrigation water have on infiltration. The salinity and SAR should be considered together when evaluating sodium impacts on infiltration.

- Sodium – Excess sodium ions in irrigation water may also be toxic to plants when taken up through the roots or when absorbed through the leaves from sprinkler irrigation. Sodium toxicity can physically damage the appearance of plants.

- Boron – Excess boron ions in irrigation water can accumulate in the soil to levels that are toxic to plants. Although boron is needed to some degree to maintain plant health, high levels can physically damage plants.

- Chloride – Excess chloride ions in irrigation water are toxic to plants. Chloride ions can be taken up through the soil or be absorbed through the leaves of the plant.

- Nitrogen – Excess nitrogen in irrigation water can over-stimulate growth, delay plant maturity, and contribute to poor plant quality. (Typically, references to nitrogen are in the form of nitrate (NO3-N), because nitrate-nitrogen (NO3-N) is the form of nitrogen that occurs most frequently in irrigation water).

Table 3 Guidelines for Interpretation of Water Quality for Irrigation
(Source: Ayers and Wescot [1985], as summarized by Aqua Engineering [2004])

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
Salinity				
EC_w	dS/m	< 0.7	0.7 - 3.0	> 3.0
TDS	mg/L	< 450	450 - 2000	> 2000
Infiltration				
SAR =	EC_w =			
0 - 3		> 0.7	0.2 - 0.7	< 0.2
3 - 6		> 1.2	0.3 - 1.2	< 0.3
6 - 12		> 1.9	0.5 - 1.9	< 0.5
12 - 20		> 2.9	1.3 - 2.9	< 1.3
20 - 40		> 5.0	2.9 - 5.0	< 2.9
Specific Ion Toxicity				
Sodium (Na)				
Surface Irrigation	SAR	< 3	3 - 9	> 9
Sprinkler Irrigation	mg/L	< 70	> 70	
Chloride (Cl)				
Surface Irrigation	mg/L	< 140	140 - 350	> 350
Sprinkler Irrigation	mg/L	< 100	> 100	-
Boron (B)	mg/L	< 0.7	0.7 - 3.0	> 3.0
Bicarbonate (HCO_3)				
Sprinkler Irrigation	mg/L	< 90	90 - 500	> 500
Miscellaneous Effects				
Nitrogen (NO_3 - N)	mg/L	< 5	5 - 30	> 30
pH			Normal range 6.5 - 8.4	

Summary of assumptions used to develop guidelines (see Ayers and Wescott (1985) for more detail on applying these guidelines):

- 1 mg/L = 1 ppm
- EC_w = electrical conductivity of water; SAR = sodium adsorption ratio. SAR can be compared directly with adjusted SAR (SARadj).
- TDS = Total Dissolved Solids = EC_w x 640, expressed in mg/L (approximate).
- Soil textures range from sandy-loam to clay, with good internal drainage. Rainfall is low and does not play a significant role in meeting crop water demand or leaching requirements. Drainage is assumed to be good, with no uncontrolled shallow water table present.
- Normal sprinkler irrigation methods are used. Water is applied infrequently as needed, and the crop utilizes a considerable portion of the available stored soil water (50% or more) before the next irrigation. At least 15% of the applied water percolates below the root zone.
- Salinity increases with depth and is greatest in the lower part of the root zone. The average salinity of the soil solution is about three times that of the applied water.
- These guidelines are intended to apply to traditional agricultural crops but also apply to turf grass and landscape ornamentals.

Table 4 Classification of Salinity Limits for Irrigation Water
(Source: Bauder, Waskom and Davis, 2007, CSU Fact Sheet No. 0.506)

Classes of Water	Electrical Conductivity (EC_w) in dS/m
Class 1, Excellent	<0.25
Class 2, Good	0.25-0.75
Class 3, Permissible[1]	0.76-2.00
Class 4, Doubtful[2]	2.01-3.00
Class 5, Unsuitable[2]	>3.00
[1]Leaching or special management needed. [2]Good drainage need. Sensitive species may be impacted	

16. Soil conditions should also be monitored for the constituents listed in Table 3, along with phosphorus, calcium, magnesium and exchangeable sodium percentage (ESP). Qian (2004) summarizes a few representative guidelines for soils including:

    - An EC higher than 4.0 mmhos/cm is considered saline, and ESP or SAR values greater than 15 indicate sodic soils with excessive sodium in soil particles. Excess sodium can cause soil to be hard and cloddy when dry, to crust badly, and to absorb water very slowly. High ESP or SAR can reduce soil permeability and water percolation rate. Salt leaching would become less effective when soil percolation and infiltration rates are reduced. Sometimes, sodium can initiate deterioration of soil structure at ESP well below 15. ESP that is greater than 9 can cause problems on fine-textured (clay) soils over time, on highly trafficked sites, or when irrigation water is too pure. (When water is too pure, there are few cations to counteract with sodium).

    - Mass (1978) provides guidelines for boron content in soils. Sensitive plants (such as some fruit trees) will show growth decline as soil boron exceeds 0.5-1.0 mg/kg. Moderately sensitive plants will start to decline when soil boron exceeds 1.0-2.0 mg/kg. Kentucky bluegrass can tolerate soil boron content at 2.0-4.0 mg/kg.

17. When using reclaimed water, the following irrigation practices are important (Qian 2005):

    - Provide adequate leaching and sufficient drainage to remove excess sodium and salts from the root zone. (*Note: This must also be conducted in a manner that fulfills the Utah? requirement to "strictly minimize leaching.")* The leaching requirements can be estimated using the technique presented in Doorenbos and Pruitt (1975) based on the electrical conductivity of the reclaimed water or other local guidance.

    - Carefully irrigate based on evapotranspiration and leaching requirements. Use drip irrigation for shrubs or trees when possible.

    - Select appropriate irrigation frequency to avoid frequent wetting and drying cycles on the tree leaves.

- Depending on the water quality, it may be necessary to either blend conventional water with reclaimed wastewater or use the two sources in rotation. As a last resort, it may be necessary to provide dual plumbing to irrigate greens with conventional water in cases of excessively high sodium absorption ratio (SAR) or high salinity. See Utah reg for strict requirements regarding reduced pressure principle backflow prevention devices or air gaps when supplemental water sources will be used. Additional backflow prevention regulations will be found in SLC Code 21A.48.055: Water Efficient Landscaping. For more information, see *Backflow Prevent BMP*.

18. Implement soil compaction controls such as deep aeration and/or water injection to maintain oxygen diffusion and water movement. Additionally, traffic control programs may need to be implemented to control compaction (Qian 2005).

19. When determining fertilization requirements, be sure to account for nutrients already present in the reclaimed water, which will likely reduce the amount of supplemental nitrogen and phosphorous needed. Conversely, proper fertilization may be needed to alleviate nutrient imbalances in the reclaimed water (Qian 2005).

20. Based on soil monitoring over time, additional chemical amendments may be periodically required to displace sodium and reduce ESP. Gypsum may be added to irrigation water to adjust the SAR of the water (Qian 2005).

21. When selecting plants for landscapes using reclaimed water, select varieties that are climate and soil adapted and that include salt tolerant species and cultivars (Qian 2005). See *Appendix G* for the salt tolerances of various plants. Annual and Kentucky bluegrass are more sensitive to high soil salt levels than perennial rye grass and fescue (Swift and Koski 2003). Trees, shrubs, and ornamental plantings are typically more sensitive than turf grass (Ayers and Westcot 1985). Investigations into the use of recycled water at golf courses in Colorado have shown that pine trees are particularly sensitive to long-term salt accumulation. Denver Water (2003) has published a guide to using recycled water on trees and shrubs called “Recycled Water for Trees & Shrubs” (Aqua Engineering 2004).

22. Closely observe plant health and adjust maintenance practices as needed because healthy plants are better able to withstand higher salinity (Qian 2005).

23. Document and measure all management changes implemented to address water quality induced problems (Aqua Engineering 2004).

24. Improve and increase drainage capabilities in selected areas that exhibit drainage concerns (Aqua Engineering 2004).

25. Continually improve irrigation management and irrigation scheduling (Aqua Engineering 2004).

26. Table 5 provides a summary of practices that may be used to address water quality concerns. These recommendations were developed by Aqua Engineering (2004) for Denver Water’s use in their reclaimed water irrigation program.

Table 5 Recommended Management Practices for Mitigating Potential Negative Impacts of Reclaimed Water Quality Limitations (Source: Aqua Engineering 2004)

Water Quality Concern	Mangement Practices for Mitigating Negative Impacts
Salinity	Leaching Improve drainage (artificial & soil aeration) Select less sensitive plants
Ion Toxicity	Blend with higher quality water
Sodium	Alter watering schedule: less frequent, low temperature (night), low wind, high humidity Irrigate sensitive plants with methods that minimize overhead spraying
Sodium - Infiltration	Improve aeration physically through cultivation (increase soil aggregation) Leaching Apply calcium based amendments (e.g. gypsum) Acid-injection or sulfur burner if accompanied by high bicarbonates and pH levels
Nitrogen	Monitor levels and adjust fertilizer program Apply growth regulators in problematic areas Remove grass clippings Mixing and selective irrigation with higher quality water Irrigation water aeration

Rainwater Catchment for Irrigation

In 2009, the Utah State Legislature amended state water law to allow limited rainwater catchment use for home landscape irrigation. Collection and use of rain water is limited to residential properties and a volume not to exceed two one-hundred gallon capacity barrels, or the equivalent.

Greywater Systems

Greywater refers to the reuse of water from baths, showers, washing machines, bathroom sinks, (indoor wastewater excluding toilet wastes), and sometimes cooling tower or swamp cooler water, for irrigation, indoor closed systems, and other water conservation applications.

Use of greywater not permitted in Salt Lake County (Salt Lake Valley Health Department Health Regulation #13). Greywater is regulated by the State of Utah through the county health departments. A lack of research on the impacts of greywater use on public health and soil health have dissuaded most health agencies from permitting greywater use in the landscape. To view regulation, visit www.slvhealth.org.

NOTE: Long-term effects of nonpotable water irrigation on public health and soil health are complex and further research is needed to provide more detailed guidelines to maintain healthy landscapes. Until that work is complete, SLCDPU recommends against the practice of using greywater to irrigate landscapes.

Resources

American Landscape and Nursery Association www.anla.org

California Urban Water Conservation Council. 2002. H_2OUSE Water Saver Home. www.h2ouse.net.

Irrigation Association www.ia.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

American Water Works Association website: www.awwa.org

Salt Lake Valley Health Department www.slvhealth.org

Utah State Engineers Office Rainwater for rainwater use permitting www.utah.gov/waterrightsContact information for the USU soil testing laboratory is: Soil - Water - Plant – Feed – Water Testing Lab; Utah State University - Soil Testing Laboratory; 4830 Old Main Hill; Logan, UT 84322, (435)797-2217
http://www.extsoilcrop.colostate.edu/SoilLab/soillab.html

Water Reuse Association www.watereuse.org

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17 Landscape Maintenance Scheduling

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Practice landscape maintenance appropriate for the site, with attention to tree and plant requirements including practices such as pruning, weeding, mulching, fertilization, and irrigation system maintenance, balanced with efficient water-use, stormwater run-off reduction, and water source protection.

Basic Practice Guidelines

Maintenance Scheduling and Record Keeping

1. Implement regular maintenance schedules that include checking, adjusting and repairing irrigation equipment; resetting the automatic irrigation controller; aerating turf; replenishing mulch; monitoring for plant insects and/or diseases and providing treatment as needed; applying fertilizer based on assessment of soil conditions and mineral content deficiencies; pruning, and weeding. See the related *SLC BMPs* on these specific topics for more detailed information.

Spring	Summer	Fall	Winter
Perennial clean-up	Dead-heading	Dead heading	
Monitor trees and plants for signs and symptoms of pests and treat as needed	Monitor trees and plants for signs and symptoms of pests and treat as needed	Access trees and plants in preparation for winter weather and provide appropriate care	Service trees, plants and site needs as conditions and weather allow
Shrub pruning	Prune trees and plants as their condition or site features require		Shrub pruning (late winter)
			Cut back ornamental grasses (late winter/early spring)
Lawn and Tree Root Zone Aerating		Lawn and Tree Root Zone Aerating	Watering if dry conditions exist
Weed control[1]	Weed Control	Weed control	
Mulch	Check/refurbish mulch	Check/refurbish mulch	Check/refurbish mulch
Fertilize		Fertilize	
Mowing	Mowing	Mowing	
		Leaf raking	Leaf raking
Equipment maintenance	Equipment maintenance	Equipment maintenance	Equipment maintenance
Equipment cleaning	Equipment cleaning	Equipment cleaning	Equipment cleaning
Irrigation tune-up	Irrigation check (should occur at least monthly	Irrigation check	
		Irrigation shut-down	

[1] Be aware of state and county-specific noxious and invasive plants that must be controlled.

2. Monitor landscape quality to identify strengths and weaknesses of existing landscape management. Results should be used to revise management and maintenance strategies, or to re-design landscape.

3. 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.

Equipment Maintenance

4. Frequently and routinely inspect equipment (e.g., mowers, irrigation system, saws, pruners) to determine when maintenance, repair, or replacement 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.

5. When maintaining equipment such as lawn mowers, tractors, etc., properly capture and dispose of oil, grease, fuel, etc., so that it does not contact turf, soil, or plants; and does not enter storm drains and waterbodies.

6. Sanitize equipment between different landscapes to avoid the spread of fungal disease and weed seeds.

Pruning

7. Remove dead or dying plants, and properly prune dead, damaged, or diseased tree branches or plant material to reduce future interventions and problems, such as the spreading of diseases or winter breakage.

8. Schedule shrub pruning to suit the requirements and growing habits of particular shrubs. For more specific information on pruning, see appropriate BMPs. Here are some general guidelines for timing pruning activities:

    - Shrubs that bloom on new wood (late spring and summer bloomers) are best pruned in later winter

    - Spring bloomers, such as forsythia and lilacs, are best pruned immediately after flowering

    - Evergreens are best pruned in late spring to early summer by removing the candle growth

    - Ornamental grasses do not require pruning, but cut down to within 6 inches of soil surface in late winter or early spring, before new growth emerges

    - Cut back perennials in late winter to early spring

- Remove summer annuals before winter snows arrive

Weed, Pest, and Disease Control

9. 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. Contact IFAS for information regarding specific weed and pest problems and appropriate bio-controls.

10. Clean up plant litter and remove weeds before they go to seed or diseases and pests spread.

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

Source: Wright Water Engineers, Inc.

Resources

Irrigation Association www.ia.org

Irrigation Training and Research Center, Cal-Poly State University, San Luis Obispo, CA. www.itrc.org

PLANET Professional Landcare Network www.landcarenetwork.org

Salt Lake City Landscape Website www.slcsaveh2o.com

TPI Turfgrass Producers International www.turfgrasssod.org

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18 Tree Care

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

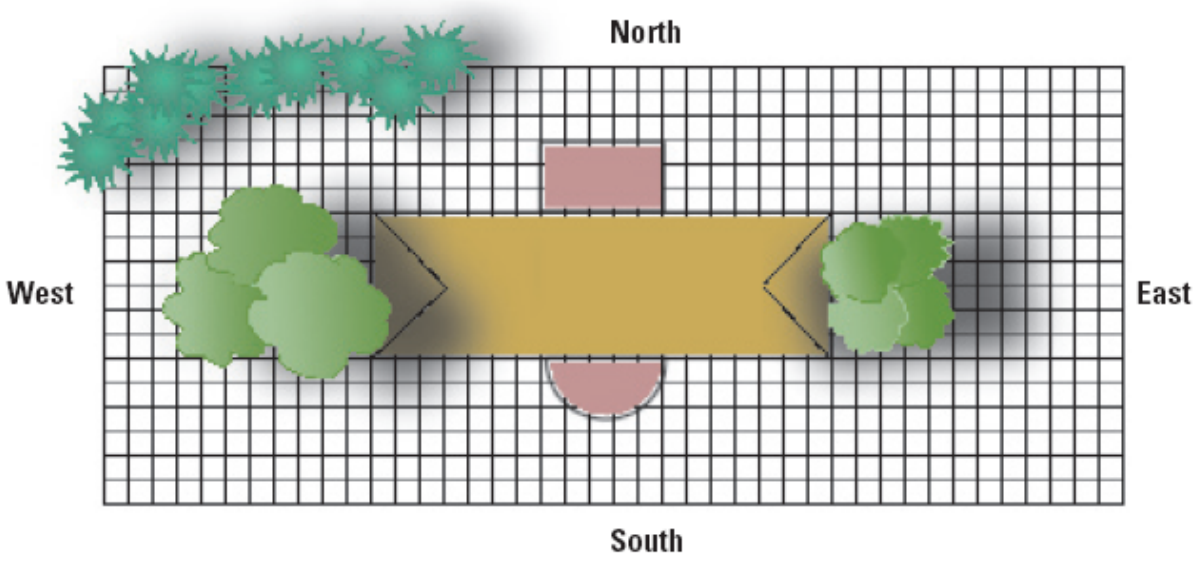
Description

Properly plant and maintain trees to maximize plant health.

Basic Practice Guidelines

Plant and prune trees in accordance with the Utah State University Bulletin NR-460, *Selecting and Planting Landscape Trees* and ANSI A-300 standards.

In the Salt Lake Valley, a goal of 25 percent canopy coverage is recommended. The "urban forest" provides multiple benefits such as increasing property value; reducing stormwater runoff; absorbing pollutants and particulate matter from the air; buffering sounds of traffic; and providing habitat for urban wildlife. Trees also shelter homes and other buildings from summer heat and winter wind, thereby lowering a building's carbon footprint and reducing energy costs related to cooling and heating. Consider the benefits of trees when matching species to planting locations.



Tree Placement for Energy Conservation

To save energy, plant trees to shade your house or building on the east, west, and south sides. The trees will provide shade during the heat of the summer, and then shed their leaves in the fall to allow heat gain from the winter sun. Evergreens planted on the north or northwest side can provide a winter windbreak. (Diagram Source: Xcel Energy 2005).

Selection

1. When selecting and planting trees, be sure to consider:

- Soil volume, type, drainage, pH, and fertility available to support root growth of mature tree.

- Maintenance requirements including susceptibility to insects and disease, keeping in mind species diversity for protection against tree loss during insect or disease outbreaks.

- Appropriateness for climate (hardiness) and water requirements, remembering that summer heat needs to be considered as well as winter cold. See Appendix E for relative water requirements of various species.

- Mature size and location relative to underground and overhead utilities and power lines.

2. Select native and introduced acclimated species compatible to the planting site's climate, soil, site features, uses, and landscape design needs. For specific plant lists by elevation, exposure, moisture requirements, mature size, and other information, see Resources at end of BMP. Also see Appendix H for a list of the relative salt tolerances of various trees.

3. When purchasing trees from a nursery, ask where the stock was grown. Trees originating from the South and West Coast may be less hardy than stock grown in northern nurseries.

Planting

4. Plant tree so that the root collar (root crown) is one to two (1 to 2) inches above grade to facilitate tree establishment and long-term health. Planting holes should be shallower than the root ball for this to occur. See the *Tree Planting BMP* for more detail.

5. When planting, avoid soil interface problems by limiting or preventing use of soil amendments. Place root balls on firm, undisturbed soil. Score root ball and the sides of the hole to aid root growth into the native soil. Do not fertilize during planting or during the first year.

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

7. Trees in heavily urbanized areas, such as streetscapes, require the proper amount of soil and water to support growth and long-term health. See the *Tree Placement BMP* for more information.

Large roots and small feeder roots occupy a large area underground. Typically, the root system of an urban tree extends outward where favorable growing conditions allow, up to two times the height of the tree.
(Image Source:
http://saver.denverwater.org/saveourshade.asp)

Environmental Benefits of Trees (Xcel Energy 2005; IES 2007)

- Decreased energy use in homes and buildings due to shade and wind reduction
- Improved air quality by trapping particulates, absorbing carbon dioxide, and producing oxygen
- Carbon sequestration which may help to slow climate change
- Interception of precipitation, thereby reducing runoff associated with urbanization
- Improved wildlife habitat
- Increased property values
- Enhanced social interaction in communities
- Noise masking and decreased noise

Irrigation

8. When planning irrigation for trees, provide an irrigation zone separate from turf where possible. Trees will adapt better with deep, less frequent waterings than is typically applied to turf. See *SLC Plant List* and *Irrigation System Design BMPs* for information. All construction covered under 21A.48.055 must hydrozone.

9. Regular, appropriate watering of trees is important because moisture stress is a precursor to many diseases and insect problems. Trees may not show stress for several years after being under-watered or suffering from drought damage. It is also important to keep in mind that too much water can also cause problems by causing root decline due to decreased availability of oxygen in the soil.

10. Trees require water to grow. This includes winter watering when there is no snow cover, higher than normal temperatures, or little rain, particularly evergreens and newly planted trees.

11. Tree root systems, in urban settings, can spread two times wider than the height of the tree. Most of the tree's roots are in the top 24 inches of the soil, depending on soil type. Apply water so it moistens the root zone to a depth of at least 12 to 18 inches. For evergreens, water should also be applied three to five feet beyond the dripline. Methods for watering trees include a deep root fork or needle, low-flow emitters, soaker hose, or soft spray wand. Apply water to many locations under and outside of the dripline. If a deep root fork or needle is used, vary insertion depth of the device from 8 to 12 inches into the soil.

12. During prolonged dry periods in the fall and winter (October through March), some species and sites may need watering one to two times per month. Water only when temperatures are above 40 degrees and no snow cover exists.

13. The desired water application rate for trees varies by species, location, size, season, and watering device. Watering frequency should be based on the moisture content of the soil and root ball and the moisture retentive characteristics of the soil, which can be assessed through a "soil ball" test (see www.mt.nrcs.usda.gov/technical/ecs/agronomy/soilmoisture/index.html for guidance). As a general rule, small and medium size trees with moderate water needs in low stress locations use approximately 10 gallons of water per inch of trunk diameter as measured four and one-half (4.5) feet above the ground for each watering. The frequency of watering for small trees (1-3") is once per week in the spring and fall, and twice per week during the high temperature summer months (July and August, typically). Medium size trees (4"-8") may require watering one to two times per month in the spring and fall, and three times per month during the high temperature summer months. Water large trees (10"+) twice per month at a rate of 15 gallons of water per inch of trunk diameter. Newly planted trees (those in the landscape less than a year) and trees in high stress locations may require more frequent water applications in all size categories. See Appendix E for relative water requirements of various trees. See the SLC Plant List for more information.

Maintenance Practices

14. Maintain mow-rings with no turf around the base of trees planted in lawns, to a distance of at least three (3) feet, though ideally to the trees dripline. This will protect the tree from damage caused by lawn mowers and weed trimmers; and reduce the instance of moisture and nutrient competition with turf

15. Apply aged organic mulch within the dripline at a depth of 3 to 4 inches to conserve soil moisture. Leave a 6-inch space between the mulch and trunk of trees to discourage pest damage to the root collar. Mulch materials may include wood chips, bark, leaves, and evergreen needles.

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

17. Properly prune young trees to establish good structure and minimize potential damage from snow and wind.

18. Prune trees to remove dead, broken, crossing, and diseased branches. Do not "top" or "lion tail" trees. Careful selection and placement of trees relative to power lines can avoid the practice of severe pruning for power line clearance. While the presence of heavy insect infestation can compel severe pruning, not all insect infestations in trees cause negative health effects. Monitor the tree for overall health before pruning a tree to control insects.

19. Protect young trees from winter sun damage by wrapping the trunk with white tree wrap from early November and until late March. It is important to remove the wrap in the spring to minimize risks of insects and diseases becoming established beneath the wrap.

20. Many tree species can be harmed by misuse of herbicides and by maintenance equipment such as grass-edgers, mowers, and weed trimmers. Trees weakened by other sources of stress or damage are more vulnerable to decline.

21. Trees whose roots and/or growing sites have recently been altered by construction work may need supplemental care. See the *Tree Protection BMP* for more information.

Resources

International Society of Arboriculture, Rocky Mountain Chapter www.isarmc.org.

Salt Lake City Plant List www.slcsaveh2o.com

Save Our Shade Web Site: http://saver.denverwater.org/saveourshade.asp

USU Tree Browser

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19 Herbaceous Plant Selection, Installation, and Care

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Herbaceous plants are those garden plants that die to the ground each year leaving no living woody structure; this includes perennials, biennials, and annuals. Perennials return year after year; biennials usually grow one year, flower the next year and then do not return; annuals typically grow only one season, though some annuals reseed, making the planting seemingly perennial.

Properly plant and maintain herbaceous plants to optimize plant health; conserve water; and to protect stormwater and source water quality.

Basic Practice Guidelines

Plant Selection

1. Choose perennials, bulbs, biennials, and annuals based on site conditions and maintenance skill level and availability. When assessing the site, consider soil conditions; sunlight (time of day as well as volume); water availability; access (for maintenance and enjoyment); and available space. Refer to the *SLC Plant List and Hydrozone Schedule* for information and suggestions.

2. Consider plants with lower water requirements, including natives and introduced, adaptive species.

3. Consider when the garden will be most utilized and select plants that will be flowering and at their best; or select plants with a variety of bloom times to create a long season of interest.

4. Consider including plants with great foliage or structure to provide a bridge during those times when the garden is not at its peak. Ornamental grasses, small shrubs, and perennials with good foliage can provide counterpoints to blooming plants and reduce maintenance needs. See the *SLC Plant List and Hydrozone Schedule* for suggestions.

Site Preparation

5. Test soils prior to planting and irrigation system installation to identify the physical and chemical characteristics, and mineral content of the soil. Soil tests are relatively inexpensive and can help to minimize costs associated with soil amendment. In areas where low quality well water or reclaimed water are used for irrigation, or where salt-affected, corrosive, or high pH soils are known to exist, periodic soil testing should be conducted so that irrigation

and fertilization practices can be adjusted appropriately. See Resources list for USU Soil Testing Lab contact information.

6. Prepare soil before planting by loosening it to 12 inches. If a heavy clay or sandy soil is present, loosen soil to a depth of 12 inches, add two to three (2 to 3) inches of aged compost on the soil surface, and then use a garden fork or tiller to mix it in to a 12-inch depth, incorporating the compost into the soil. See *Soil Amendment BMP* for more information.

7. Prepare the entire area to be planted and not individual planting holes; this will provide better soil quality throughout the garden area and encourage roots to spread out and plants to establish.

Planting

8. Plant containerized stock so that the crown of the perennial is above soil grade, one-half to two inches, depending on the size of the container. This is to ensure that as the soil settles with watering, the perennial's crown will not be below grade and therefore rot.

9. As a general rule, perennial bulbs are planted three-times as deep as the width of the bulb.

10. Plant annuals so that the plant crown is even or just above grade.

11. Water plants in well, with a gentle stream of water. Even the lowest-water demanding plants need water to establish.

12. Check newly planted perennials and annuals daily for signs of stress; provide water as needed, which may be daily or nearly so for the first few weeks.

Maintenance

13. Apply three to four (3 to 4) inches of organic mulch between flowers to reduce moisture evaporation from the soil, inhibit water-using weeds, and control dust. This practice is particularly critical during drought conditions, but helps to conserve water under all conditions.

14. 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.

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

Irrigation

16. Annual and perennial flowers under water stress will have drooping leaves and a lack of blooms. Foliage often appears gray-green in color.

17. Water when signs of stress become obvious. Apply irrigation in the evening or early morning to minimize evaporation. Avoid over-head watering between the hours of 8 A.M. and 8 P.M. Watering with low-flow emitters can occur at any time.

18. In many instances, placing mulch on top of low-flow emitters is the best practice.

19. Overhead spray irrigation is the least water-wise method because much water is lost to evaporation and wind drift. Soaker hoses or drip irrigation (low-flow emitters) 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. Overhead spray may also damage blossoms, lead to diseases, and negatively affect plant aesthetics.

20. 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. See the *SLC Plant List f*or ideas and suggestions. If the project is a landscape covered under SLC Ord 21A.48.055 Water Efficient Landscaping, plants not included in the *SLC Plant List* or other approved list are limited to comprising no more than 20 percent of the landscapeable area.

21. Irrigation practices affect plant rooting depth. By watering less frequently and more deeply, some native and low water use plants will develop deeper roots, decreasing supplemental irrigation requirements. Irrigation practices should be changed gradually for best results.

22. Group plants with similar water needs together and water accordingly. See *SLC Plant List* for water requirements of various plants. New and remodeled construction covered under SLC Code 21A.48.055: Water Efficient Landscaping are required to hydrozone and submit a hydrozone table with construction documents.

23. 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.

24. See *Irrigation BMPs* and *SLC Plant List* for more information

Pruning and Deadheading

25. See *SLC Plant List* for recommendations regarding specific perennials and annuals.

26. As a general rule, perennials are not pruned during the growing season, but rather are cut back in late winter or early spring (late February to early April). Cutting back in the autumn is not recommended for the following reasons:

    - Pruning encourages new growth and autumn is a time of year for perennials to move into dormancy
    - Old foliage protects crowns from winter damage

- Persistent seed heads and foliage are attractive in winter months, providing interest in the garden and forage opportunities for migrating birds

27. Removing spent flowers, a practice called deadheading, may encourage more blooms and a longer blooming time, for both annuals and perennials.

Resources

Denver Botanic Gardens and Colorado State University Extension Plant Select® Website: www.plantselect.org.

Salt Lake City Water Conservation www.slcsaveh2o.com

U.S. Composting Council www.compostingcouncil.org.

Utah State University Analytical Laboratories for soil testing www.usual.usu.edu

Utah State University Extension for information on specific annuals and perennials https://extension.usu.edu/htm/publications

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20 Turf Management

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

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. Table 1 provides a summary of the advantages and disadvantages of several Turfgrass species. 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 fine fescues, 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 such as native or introduced/adaptive species groundcovers that are lower water use, as well as patios, decks, permeable paving, or mulches for some areas (e.g., narrow strips, hard-to-water areas, steep slopes, low-usage areas), when these alternatives meet the needs of the area. See the *Landscape Features for Low-Impact Development BMP* for more information regarding permeable paving.

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

5. When possible, avoid placing turf in narrow areas under eight (8) feet, on steep slopes, in hard-to-maintain corners, against buildings or fences, and isolated islands due to difficult mowing and irrigation challenges. Turf is better suited to larger, relatively flat areas.

6. Avoid placing turf adjacent to walks, driveways, and streets to reduce or eliminate run-off, and lessen negative impacts to turf from road salts. See *Irrigation Design* and *Landscape Design* BMPs.

7. Good surface drainage can be achieved by ensuring that lawns slope away from buildings and properly grading low areas and steep slopes to prevent future trouble spots. Where appropriate, grade to allow turf to take advantage of runoff from impervious surfaces such as driveways and roofs.

Table 1 Comparison of Tall Fescue, Buffalograss, and Kentucky Bluegrass for Lawn Use
(Source: Turfgrass Species/Variety Selection Guidelines, Kelly Kopp, USU Extension, Utah State University Extension)

Characteristic	Tall Fescue	Buffalograss	Kentucky Bluegrass
LEAF TEXTURE	Somewhat coarser, soft	Very fine, soft	Fine, soft
COLOR	Light to dark green	Light green to blue green	Light to dark green
LENGTH OF GREEN SEASON	Long; March-November	Short; May-September	Long; March-November
MOWING REQUIREMENT	More frequent	Infrequent/none	More frequent
MOWING QUALITY*	Generally good	Good	Generally good
FERTILIZER REQUIREMENT	Low	Very low	High
IRON CHLOROSIS	Infrequent	Infrequent	More frequent
DISEASE PROBLEMS	Infrequent	Almost none	More frequent
INSECT PROBLEMS	Almost none	Almost none	More frequent
TRAFFIC TOLERANCE	Excellent	Fair	Excellent
RECUPERATIVE POTENTIAL**	Fair to good	Good to excellent	Good to excellent
THATCH FORMATION	Little (slow to form) to none	Generally not a problem	Can be excessive
COMPACTION TOLERANCE	Fair	Very good	Good
HEAT/COLD TOLERANCE	Excellent	Excellent	Excellent
SHADE TOLERANCE	Good/Excellent	Poor to fair	Poor to fair
SALT TOLERANCE	Very good	Fair	Poor to fair
SOD AVAILABILITY/COST	Less available/higher cost	Uncommon/highest cost	Very common/low cost
IRRIGATION REQUIREMENT	Often lower than bluegrass, but can be the same - or higher	Very low	Low to high, depending on soil

*A dull mower blade can shred the tips of grass leaves (most common with tall fescue), which then turn brown.
**The ability of a grass to recover from traffic injury, spreading to fill-in worn, bare areas in the lawn.

8. 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-based) for supplemental irrigation. Therefore, the water use of bluegrass is largely management related.

9. Some areas of Salt Lake City, particularly the western side, 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 found in Appendix H: Salt Tolerant Plants.

Installation

10. 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://extension.usu.edu/files/publications/Turfgrass.pdf for turfgrass species and cultivar guidelines.

11. 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 3 cubic yards of organics per 1,000 square feet at least 4 inches deep.
    - Level and rake the installation site until it is smooth.
    - Grade areas to be planted in turf and that are adjacent to sidewalks and driveways approximately 1½ inches below the top of the concrete.
    - If site is not to be immediately seeded or sodded, refer to the *Landscape Installation and Erosion Control* and the *Soil Amendment BMPs*, and *Appendix A* for information on erosion control.

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

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

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

14. 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. Do not let the sod dehydrate.

    - Join ends and sides of the sod strips making sure there is no overlapping.

    - Fit the sod around obstacles or in smaller places by cutting through the dirt side with a sod knife.

15. 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 4 inches.

    - During the following two weeks, the amount of water needed will be similar to that provided in Table 2. 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 watering, depending on the season and weather.

16. After the third week, adjust watering times and irrigation controllers to reduce water use and waste, to meet water budget, or to conform to any announced water restrictions.

17. When starting a lawn from seed, amend the area in a manner similar to planting 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. Care should be taken on slopes to watch for erosion and riling to avoid sediment transport into stormdrains.

18. 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.

Maintenance

19. The approximate amount of water that needs to be applied each week for an average, traditional lawn to supplement normal rainfall is listed in Table 2.

Table 2 Approximate Supplemental Water for an Average Traditional Lawn (inches per week)

Condition	April*	May	June	July	Aug	Sept	Oct**
Average Conditions	0.5"	1"	1.5"	1.5"	1.5"	1"	0.5"
During Drought Restrictions	See the SLC Water Shortage Contingency Plan on slch2o.com for more information						

*For established lawns, water may not be required during April. Base decision on weather conditions.
**For established lawns, water is typically not required after Oct 15.

The data in Table 2 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. During times of drought and watering restrictions, visit www.slcsaveh2o.com for more information.

20. Additional information regarding turf water requirements for the Salt Lake City area can be obtained from the *SLC Plant List* and http://extension.usu.edu/files/publications/publication/HG_517.pdf.

21. Measure the water applied by using rain gauges or cans placed on the lawn in areas covered by sprinklers. See *Irrigation Audits BMP* for more information.

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

23. Mowing turfgrass at a height of 2.5 to 3.0 inches helps turfgrass develop deeper root systems.

24. Grass clippings left as mulch can return roughly 25 to 30 percent of the needed nitrogen that grass requires, thereby reducing fertilizer requirements. Allowing grass clippings to collect onto streets, sidewalks, gutters, and ditches is prohibited under SLC Ord. 9.08.170: Befouling Gutters and Ditches Prohibited, and SLC Ord. 14.28.010: Depositing Material on the Streets Prohibited. These ordinances are intended to reduce nutrient pollution to surface waterbodies. If grass clippings are not left on the turf, dispose of grass clippings in city-provided tan can or at SL County Landfill Compost Section. It is also prohibited to dump lawn and other

garden debris into watercourses such as creeks and ditches (SLC Ord. 17.84.700: Watercourse Protection).

25. 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 over-fertilization, and aerating the lawn. Also see *Lawn Aeration BMP* for aerating guidelines.

26. 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 fertilizer application guidelines.

27. Apply fertilizer according 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 warm. One application about mid-June and another at the beginning of August is usually sufficient.

28. Water the lawn uniformly until the soil is moistened 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.

29. 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 other planted areas or to hardscapes. See the *Irrigation BMPs for* more information and http://extension.usu.edu/files/publications/publication/HG_517.pdf.

30. Follow a proper maintenance schedule to prevent stress, disease, and turf injury. See http://extension.usu.edu/files/publications/publication/HG_517.pdf for guidance.

Resources

Center for Irrigation Technology www.californiawater.org.

CWEL (Center for Water Efficient Landscaping, Utah State University)
www.hort.usu.edu/html/CWEL/CWELOverview.htm

Irrigation Association www.ia.org

Irrigation Association. 2006. Smart Water Application™ (SWAT™) Performance Reports (various devices). www.irrigation.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

SLC Water Conservation Page www.slcsaveh2o.com

TPI Turfgrass Producers International www.turfgrasssod.org

Turf Resource Center www.turfgrasssod.org

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Turfgrass Producers International. 1998. *Turf Resource Center: Soil Prep for Beautiful Lawns* http://www.turfgrasssod.org/trc/soilprep.html.

21 Fertilizer Selection and Application

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

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

Note: Fertilizer applications within watershed areas, adjacent to riparian corridors, and within groundwater re-charge zones must follow the regulations as outlined in 17.04.375: Herbicide, Pesticide, and Fertilizer Restrictions; 21A.34.130: Riparian Corridor Overlay District; and 21A.34.060: Ground Water Source Protection Overlay District.

Basic Practice Guidelines

Be familiar with existing state and federal regulations on pesticide application, certification, and weed control. Several federal and state laws control the handling, storage, application, disposal, and reporting of chemical spills. Examples include 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 Utah Water Quality Control Act (25-8-601 and 25-8-606) also contains requirements for notification of the Utah Department of Environmental Quality of spills and accidental discharges and provides the Department 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.

Selection and Need

1. Base fertilizer application on soil analysis. Be aware that at many new home sites whose yards are filled with “basement” topsoil, obtaining representative soil samples may be challenging.

2. Apply fertilizer to achieve a clearly defined objective such as increasing shoot growth, root growth, flowering, or fruiting; enhancing foliage color and plant appearance; or correcting or preventing nutrient deficiencies in identified by soil testing. Avoid fertilizer application in the presence of good plant and vigor.

3. Do not apply fertilizer to weak, diseased, or stressed trees, shrubs, perennials, and other ornamental plants.

4. Only apply nutrients the plants can use.

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

6. Phosphorus is commonly overused and application should always be based on soil tests. Phosphorus washing into surface waterbodies leads to excessive algae growth in local and state waterbodies. Phosphorous does not move out of the soil like nitrogen, so constant additions are unnecessary.

7. Potassium-needs are best determined by a soil test as availability varies throughout area.

Application

8. Read the label before using any fertilizer, petroleum-based or organic, and follow those instructions carefully.

9. Clean up any spills immediately following manufacturers' instructions.

10. Prior to fertilizing, amend soil as needed to improve nutrient uptake. See the *Soil Amendment BMP* for more detailed guidance.

11. 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 and may lead to water pollution, thatch buildup, and excessive mowing.

12. A common misconception is that organic fertilizers are inherently safer for the environment than inorganic, or chemical, fertilizers. Improper use of organic fertilizer can also contribute to surface and ground water pollution, may induce nutrient deficiency or toxicity, or cause salt burn of plants.

13. Utilize split applications of slow-release (controlled-release) fertilizer forms such as IBDU, sulfur-coated urea, natural organic-based fertilizers, and aged compost 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.

14. When applying fertilizer, broadcast it uniformly over the targeted area of the landscape.

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

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

	USU 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 Extension, 2003.

17. 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 controlled release fertilizer up until late October; after that the fertilizer should be a fast-release nitrogen fertilizer. Apply at least approximately two to three weeks before the ground freezes.
18. As a general rule, wait until the second growing season to fertilize trees or ornamental (woody) plants.

19. Commercial fertilizer should not be used in the backfill where it comes in direct contact with the roots.

20. If fertilizing specifically for trees avoid use of products that contain broadleaf weed-killer; schedule applications after fall leaf shed or before spring leaf emergence; and keep in mind trees generally to not require annual applications of fertilizer.

Watering after Application

21. 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.

Stormwater, Source water, and Waterway Protection

1. 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 or into the landscape.

2. Maintain a buffer zone around wells or surface waterbodies where fertilizers are not applied to minimize pollution. SLC Ord Ground Water Source Protection identifies setbacks for wellheads; Riparian Corridor Overlay suggests that no fertilizers or other chemicals be applied within 25 feet of the high water mark. Always follow label instructions regarding water bodies.

3. In areas within groundwater recharge zones, 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. See SLC Ord 21A.34.060 Groundwater Source Protection Overlay District for map and applicability.

Resources

Utah State University Analytical Laboratories (USUAL) http://www.usual.usu.edu/

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22 Pesticide, Fungicide, and Herbicide Selection and Application

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Apply pesticides, fungicides, and herbicides at dosages in accordance with the label and targeted to specific pest problems.

NOTE: Pesticide and herbicide applications within watershed areas, adjacent to riparian corridors, and within groundwater re-charge zones must follow the regulations as outlined in 17.04.375: Herbicide, Pesticide, and Fertilizer Restrictions; 21A.34.130: Riparian Corridor Overlay District; and 21A.34.060: Ground Water Source Protection Overlay District.

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

Basic Practice Guidelines

Be familiar with existing state and federal regulations on pesticide application, certification, and weed control. Several federal and state laws control the handling, storage, application, disposal, and reporting of chemical spills. Examples include 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 Utah Water Quality Control Act (25-8-601 and 25-8-606) also contains requirements for notification of the Utah Department of Environmental Quality of spills and accidental discharges and provides the Department 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.

Identifying and Diagnosing Problem

1. Accurately diagnose the pest, disease, or weed and host plant prior to intervening with chemicals. 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. For assistance in identifying pests, and noxious or invasive plants, contact the Salt Lake County Extension Office at http://extension.usu.edu/saltlake, or the Utah Plant Pest Diagnostic lab at http://utahpests.usu.edu/uppdl.

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

2. 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, efficient, and cost-effective manner.

3. Utilize products at times recommended by manufacturer to minimize chance of plant damage. Many products do not function effectively or become more volatile during higher summer temperatures.

4. If pest problem is limited in scope and consequence, spot treat pests, diseases, and weeds rather than treating the entire area.

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

6. Time the application of pesticides and herbicides to minimize impact to host-plant, beneficial insects, the environment and the public, and to maximize pest control.

7. Rotate annual garden plants, including vegetable plants, to reduce the buildup of soil-borne pests.

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

9. Remove infested plant residue from the garden in the fall so that pests do not have a place to over-winter.

10. Implement cultural controls such as proper plant selection, appropriate planting time and planting method, maintenance practices, and avoid plant monocultures to reduce susceptibility to insects, pests, and diseases, thereby reducing pesticide usage. See *Landscape Design* and *Planting BMPs* for additional information.

11. 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.

12. 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 predators; visit http://utahpests.usu.edu/uppdl for more information on beneficial insects.

13. Increase plant diversity to reduce occurrence and impact of pests and diseases

14. Consider applying environmentally friendly chemicals such as insecticidal soaps, horticultural oils, and other such measures when practical and effective. Remember, though, that these products can be harmful to the environment or to people if improperly used.

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

Source: Denver Water.

Selecting a Treatment Methodology

15. Apply pesticides and herbicides only when needed. Do not use pesticides and herbicides on a regular or preventive basis unless preventive treatments are appropriate as interventions for such problems as anthracnose and powdery mildew.

16. Apply treatments during the manufacturers' recommended time of year and when the temperatures are appropriate.

17. Select pesticides and herbicides best suited to the characteristics of the host plant and the particular pest or weed. Half-life, solubility, and absorption 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), unless systemic chemicals which may be persistent and more helpful are better suited to controlling the pest and pose no negative impact.

18. Consider non-chemical responses to weed, pest, and disease problems, such as manual, mechanical, or biological controls, where appropriate. Visit the Utah Plant Pest Diagnostic Lab website for information regarding biological controls and beneficial insects (http://utahpests.usu.edu/uppdl).

19. Noxious and invasive plants may develop resistance to a particular herbicide over time. Use in rotation with mechanical control methods such as hand pulling or mowing. See *Weeds BMP* for more information.

20. General Guidelines for Salt Lake City Properties

21. For public or commercial sites, check that no events are scheduled to take place that will conflict with the application.

22. No spraying is allowed around public playgrounds, and is not recommended around commercial or private playgrounds. Signs should be posted on sites that apply chemicals in the vicinity of playgrounds to warn users.

23. When spraying, sign the areas properly and never spray alone.

24. Have a spotter to inform the public that spraying is occurring, to keep the work zone safe in accordance with label directions, and to direct the public to stay clear until the chemical is dry.

25. Remove signs and go to the next site when dry.

26. Coordinate to have applicator forms submitted for mapping.

27. When done spraying always triple rinse sprayer as well as the containers the products came in before disposing of them into the sanitary sewer. See Chemical Disposal BMP for more information.

Application Practices

28. Use caution at all times when handling and applying chemicals so as to minimize risks to both the public, the person applying the product, and non-target insects and plants.

29. Ensure commercial 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 Utah Department of Agriculture (UDA). Limited commercial applicators and public applicators applying restricted pesticides must register with the UDA. Only trained professionals with herbicide applicator licenses may apply restricted-use herbicides. Limited commercial applicators and public applicators not applying restricted pesticides, who have submitted to the jurisdiction of the UDA, must follow all record-keeping and other procedures as established by the UDA. Thoroughly complete all applicator forms, where applicable.

30. Treat for and control noxious and invasive plants or pests as needed prior to installing the landscape using a treatment targeted to the weeds or pests that are present and applied in accordance with the product label.

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

32. Prior to use of any chemical, read the product label.

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

34. Mix chemicals in a well ventilated area and have a spill kit available.

35. Apply pesticides and herbicides according to the label. It is a violation of federal law to use any herbicide or pesticide in a manner that is inconsistent with the label.

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

37. When applying pesticides or herbicides in watershed areas, follow the procedures as noted above in BMP Description.

38. Maintain a buffer zone around wells or surface waterbodies where pesticides and herbicides are not applied to minimize pollution. SLC Ord Ground Water Source Protection identifies setbacks for wellheads; Riparian Corridor Overlay suggests that no pesticides, herbicides, or other chemicals be applied within 25 feet of the high water mark. Always follow label instructions regarding water bodies.

39. Make certain the weather conditions are appropriate for application, with no wind or rain, and the appropriate temperature.

40. Be certain that the irrigation system will be shut off for the appropriate duration of application and absorption. If the site was watered, do not apply products.

41. For public or commercial sites, check that no events are scheduled to take place that will conflict with the application.

42. No spraying is allowed around public playgrounds, and is not recommended around commercial or private playgrounds. Signs should be posted on sites that apply chemicals in the vicinity of playgrounds to warn users.

43. Employ application techniques that increase efficiency and allow the lowest effective application rate to adequately control the pest or weed. Carefully calibrate application equipment and follow all label instructions. Hand-apply all chemicals when near buffer zone boundaries, and do not allow over-spray from mechanical applications into buffer zones.

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

Disposal and Record-Keeping

45. Maintain records of all pesticides applied (both restricted and non-restricted use), including name and address for whom application was made, target pest, brand name, formulation, EPA registration number, amount, date and time applied, site, crop, commodity or structure treated, exact location of application, measurement of area or number of plants treated, and

name 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.

46. Properly handle and dispose of containers, rinse water, unused product, and waste. Store pesticides in secured and covered areas. Never pour lawn and garden chemicals down storm drains or sanitary drains and keep off impervious surfaces during application. Check labels and MSDS sheets for specific instructions on disposal of the product and the product container.

47. For more information on disposal of hazardous materials, including garden products, from your home, visit www.slvhealth.org for more information. Use local recycling centers to dispose of chemicals when appropriate. See the *Pesticide, Fertilizer and Other Chemical Storage, Handling, and Disposal BMP* for more information.

Source water, Stormwater, and Waterway Protection

48. Keep pesticides, fungicides, and herbicides off of streets, sidewalks, and driveways to prevent water pollution. Chemicals that inadvertently fall on impervious surfaces should be swept up and disposed of properly.

49. Maintain a buffer zone around wells or surface waterbodies where chemicals are not applied to minimize pollution. SLC Ord Ground Water Source Protection identifies setbacks for wellheads; Riparian Corridor Overlay suggests that no chemicals be applied within 25 feet of the high water mark. Always follow label instructions regarding water bodies.

50. In areas within groundwater recharge zones, it is particularly important to avoid over-application of chemicals that could leach into groundwater. These areas may be particularly well suited to slow-release chemical forms and conservative application rates. See SLC Ord 21A.34.060 Groundwater Source Protection Overlay District for map and applicability.

Resources

Utah Plant Pest Diagnostic Lab. http://utahpests.usu.edu/uppdl/

Salt Lake County Extension Office at http://extension.usu.edu/saltlake, for weed identification

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23 Pesticide, Fertilizer, and Other Chemical Storage, Handling, and Disposal

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Pesticides, herbicides, fertilizers, fuel, and other maintenance chemicals must be properly stored, handled, and disposed of to prevent contamination of surface water and groundwater. Misuse of chemicals can result in adverse impacts to aquatic life, non-target insects and plants, and people, even at low concentrations. Misuse of fertilizer can result in increased algae growth in waterbodies due to excessive phosphorus and nitrogen loading.

See BMPs 21 and 22 for application information.

NOTE: Pesticide and herbicide applications within watershed areas, adjacent to riparian corridors, and within groundwater re-charge zones must follow the regulations as outlined in 17.04.375: Herbicide, Pesticide, and Fertilizer Restrictions; 21A.34.130: Riparian Corridor Overlay District; and 21A.34.060: Ground Water Source Protection Overlay District.

Basic Practice Guidelines

Be familiar with existing state and federal regulations on pesticide application, certification, and weed control. Several federal and state laws control the handling, storage, application, disposal, and reporting of chemical spills. Examples include 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 Utah Water Quality Control Act (25-8-601 and 25-8-606) also contains requirements for notification of the Utah Department of Environmental Quality of spills and accidental discharges and provides the Department 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

Permits

1. A Salt Lake City and/or State of Utah Industrial Stormwater Permit may be required to store chemicals in bulk. Contact State of Utah Stormwater Coordinator for permit requirements.

Equipment

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.

Mixing

3. All mixing and loading operations must occur on an impervious surface, with appropriate containment, and if applicable, in according to the Industrial Stormwater Permit. Have absorptive material available in the event of a spill.

Backflow Prevention

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 Utah Plumbing Code and SLC Ordinance 21A.48.055: Water Efficient Landscaping.

Storage

5. All raw materials must be stored in approved storage areas.

6. 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, ventilation, and spill clean-up materials should be present. Floors and shelves should be non-porous (e.g., metal, concrete) to prevent absorption 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.

7. Above-ground storage tanks must be appropriate to the materials being stored, and require secondary containment in the event of a tank rupture. Contact Salt Lake City Building Services for requirements and permits.

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

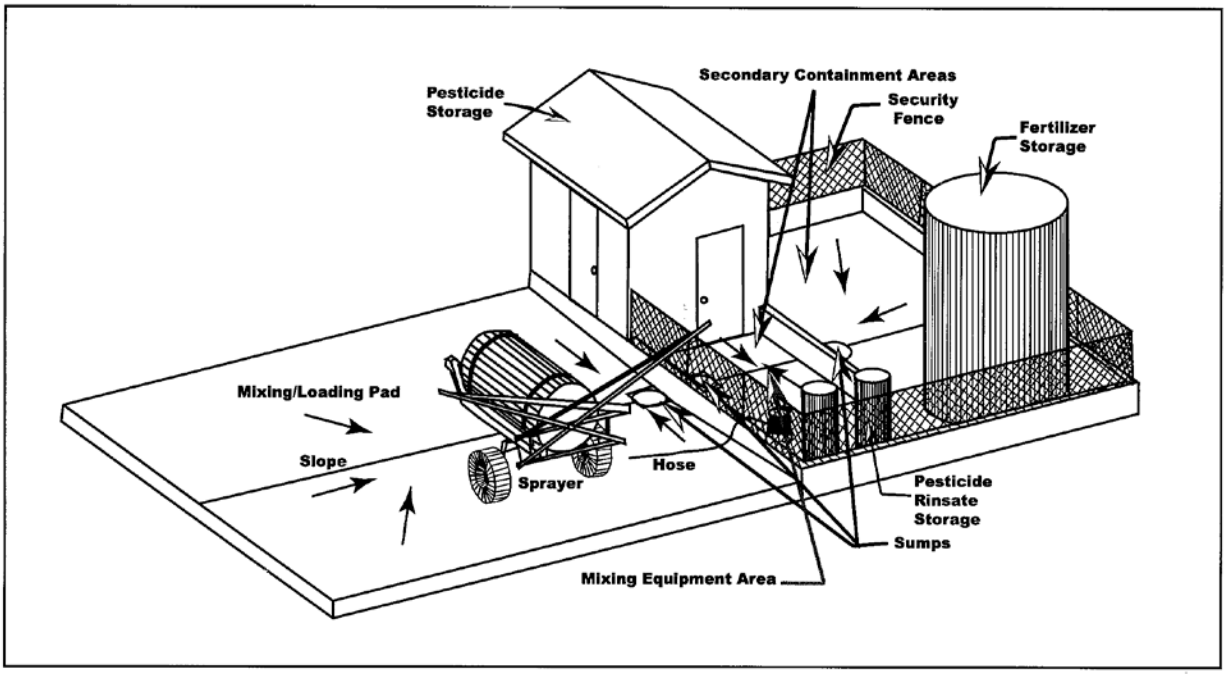
9. Store chemicals in their original containers, tightly closed, with original labels intact. Also inspect containers regularly for leaks.

10. Dry chemicals should be stored above liquids and on pallets to ensure that they do not get wet in the event of leaks.

11. Locate chemical storage and maintenance areas, as well as vehicle refueling and maintenance areas, away from wells and surface waterbodies in accordance with Salt Lake City Buffer Zone setbacks (see 21 and 22 for setback rule),

12. Make available all Material Safety Data Sheets (MSDSs) areas readily accessible to employees, inspectors, and emergency response personnel. A list of all hazardous chemicals in the work place must be completed to ensure that all MSDSs are readily available.

13. 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, fertilizers, and other chemicals thereby reducing storage issues.



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)
MidWest Plan Service, Agricultural Engineering, Iowa State University, Ames, IA. 1991

Spills and Disposal

14. In the event of a spill, contact SLC Public Utilities Dispatch and SL Valley Health Department Hotline. See contact information in Resources.

15. Keep chemical spill cleanup equipment, personal protective equipment, and emergency phone numbers readily available at all times.

16. 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.

17. Basic spill reporting requirements include: name, address, and phone number of person reporting and of person responsible for release; date and time of incident; type, name, and estimated amount of substance released, along with the reportable quantity of each substance;

location/address of released substance; size/description of affected area; containment/cleanup actions taken; and other agencies/persons contacted.

18. If any materials enter the sanitary sewer, immediate notification of the SLC Reclamation Plant is required. Any release to the stormdrain system must be reported to SLCDPU Dispatch. . See Resources for contact information.

19. Commercial applicators must dispose of chemicals, rinse water, and containers in appropriate and approved manner.

20. Never pour lawn and garden chemicals, rinse water, or other materials down storm or sanitary drains, or into streets, gutters, and other surfaces. Use local recycling centers to dispose of chemicals. Salt Lake Valley Health, in conjunction with Salt Lake City Department of Public Utilities, hosts periodic chemical disposal events for residential, non-commercial customers. Visit www.slvhealth.org for more information.

21. 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.

Resources

Life Threatening emergency 911

Salt Lake City Department of Public Utilities 24/7 Dispatch 801.483.6700

Salt Lake City Department of Public Utilities Waste Reclamation Facility 80.1799.4000

Salt Lake City Emergency Management www.slcgov.com/departments/emergency_man/

Salt Lake Valley Health Department 24/7 Hotline 801.580.6681

References

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24 Lawn Aeration

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Aerate lawns to improve nutrient and water uptake, reduce runoff, reduce compaction, help to control thatch, and promote fertilizer movement into turf root zone. Additionally, aeration can contribute to overall nitrogen application, thus reducing chemical fertilizer needs and reducing potential opportunities for fertilizer run-off to enter surface water or storm sewer systems.

Basic Practice Guidelines

1. 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. Spring and fall are ideals times for aerating. Heavy traffic areas will require aeration more frequently.
2. 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.

3. 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 lawns with thatch, it is preferred to leave the cores on the lawn, allowing them to work back into the grass.

5. Lawns may be fertilized and seeded immediately after aeration. There is no need to top dress lawns following aeration unless you are adding organic material to improve the soil quality.

6. 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.

Resources

American Landscape and Nursery Association www.anla.org

California Urban Water Conservation Council. 2002. H_2OUSE Water Saver Home. www.h2ouse.net.

Irrigation Association www.ia.org

National Turfgrass Evaluation Program www.ntep.org

TPI Turfgrass Producers International www.turfgrasssod.org

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25 Lawn and Landscape Waste Disposal/Composting

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

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

Basic Practice Guidelines

Disposal

1. SLC Ord. 9.08.170: Befouling Gutters and Ditches Prohibited, and SLC Ord. 14.28.010: Depositing Material on the Streets Prohibited prohibits landscape debris, including grass clippings and leaves, from being deposited into the public right-or-way, which includes gutters, streets, and waterways, and sidewalks, and drive approaches. The Best Practice is to not leave landscape debris on any hardscape area, whether in the public right-of-way or on private property, in order to avoid movement into stormdrains.

2. Leave grass clippings on the lawn to provide supplemental nitrogen and to improve the soil's organic matter content. Remove the catch-bag of the lawn mower to leave clippings in place.

3. When blowing walkways or mowing lawns, direct equipment so that the clippings blow back onto the lawn rather than into gutters, streets, waterways, sidewalks, and other hardscape areas. Blowing clippings onto sidewalks and into gutters and streets is a violation of SLC Ord. 9.08.170: Befouling Gutters and Ditches Prohibited, and SLC Ord. 14.28.010: Depositing Material on the Streets Prohibited. See above for more information.

4. Chip and use trimmings of woody plant material from shrubs and trees as mulch for water conservation and weed control.

5. Leave spruce and pine needles under evergreen trees and in other planted areas as mulch.

6. When site constraints require off-site disposal of lawn waste, use a SLC Tan Can or transport material to one of the landfills and recycling/composting facilities designed for yard waste. Grass clippings and landscape debris are not allowed in SLC Trash Waste bins.

Composting

7. Compost organic plant material for later use as a soil amendment.

8. Compost piles located near a public right-of-way or stormdrain should be contained to prevent sediment, debris, or runoff from moving.

9. Select the compost location in an area with partial shade and protected from the wind.

10. 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.

11. 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. Larger material may be utilized if it is first shredded or clipped prior to being added to the compost pile.

12. 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.

13. Compost should be kept evenly moist, but not soggy.

14. Mix one part green to two parts dry material to maintain the best nitrogen balance. See References.

15. Adding some soil to the compost pile will increase the rate of decomposition.

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

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

18. Salt Lake City's winter temperatures may extend the time necessary to produce "finished" compost. Additionally, our dry climate may require addition of supplemental moisture to compost to maintain microbial activity.

Resources

American Landscape and Nursery Association www.anla.org

Irrigation Association www.ia.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

U.S. Composting Council www.compostingcouncil.org

References

Utah State University Extension. https://extension.usu.edu/files/publications/factsheet/HG-Compost-01.pdf

Wilson, C.R. and J.R. Feucht. 2001. Gardening—Composting Yard Waste Fact Sheet No. 7.212 (www.ext.colostate.edu/pubs/garden/07212). Ft. Collins, CO: Colorado State University Extension.

26 Mowing

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

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. Dispose of clipped blades properly to protect stormwater quality.

Basic Practice Guidelines

General Mowing Practices

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 leaf blade left on the plant still functions efficiently. The preferred height of turfgrass species used in Utah such as Kentucky bluegrass and tall fescue is 2½ to 3 inches. The minimum height is 2 inches. Mowing grass to a height of less than 2 inches reduces drought and heat tolerance, and may cause a higher incidence of insect, disease, and weed problems. "Scalping" is never recommended. Lawns with little foot traffic can be mowed as high as 4 inches during the hottest months.

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. Leaving clippings on the lawn also reduces the chance of grass clippings entering the stormdrain system, and reduces the volume of waste delivered to the landfill.

4. Mowing as a practice of noxious and invasion plant control is only effective if plant debris and seeds are captured, contained, and disposed of properly. See *Weed Management BMP* for more information, so as a practice its value needs to be weighed with the beneficial practice of leaving clippings in place

5. Mowing after (but not during) the hottest period of the day, watering the lawn following mowing, and allowing the lawn to be dry for a day or two prior to mowing are all actions that help to reduce lawn stress. Mowing results are best when the lawn is dry, but not stressed.

6. 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.

Seasonal Mowing Adjustments

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

8. Drop mower blade height in fall to reduce chance of winter fungus and mold.

Debris Disposal

9. SLC Ord. 9.08.170: Befouling Gutters and Ditches Prohibited, and SLC Ord. 14.28.010: Depositing Material on the Streets Prohibited prohibits landscape debris, including grass clippings and leaves, from being deposited into the public right-or-way, which includes gutters, streets, and waterways, and sidewalks, and drive approaches. This means it is illegal to blow or sweep landscape debris, including lawn clippings, onto the sidewalk, or into the gutter or street. The Best Practice is to not leave landscape debris on any hardscape area, even within private property, in order to avoid movement into stormdrains.

Equipment and Clean-up

10. 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 manuals provided with the

mower, and consistently perform the suggested maintenance. Equipment should be thoroughly inspected on a regular basis in accordance with manufacturer specifications.

11. Thorough cleaning of mowers used on diseased lawn areas will prevent the spread of disease from one property to another. See the *Pesticide, Fertilizer, and Chemical Handling BMP* for information regarding controlling waste by-product as a result of equipment cleaning.

Resources

CWEL (Center for Efficient Landscaping)
http://www.hort.usu.edu/html/CWEL/CWELOverview.htm

EPA Resource Conservation http://www.epa.gov/osw/conserve/rrr/composting/grassmulch.htm

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

Salt Lake City Stormwater www.slch2o.com

TPI Turfgrass Producers International www.turfgrasssod.org

References

Associated Landscape Contractors of America. 2003. *Landscape Maintenance Training*. Herndon, VA: ALCA. *(As of 2008, offered by Professional Land Care Network [PLANET].)*

Colorado State University Extension. 2001. Mowing Guidelines. Plant*talk* Colorado 1515 (www.ext.colostate.edu/ptlk/1515). Ft. Collins, CO: CSU.

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Colorado State University Extension. 2001. Lawn Mower Maintenance. Plant*talk* Colorado 2015 (www.ext.colostate.edu/ptlk/2015). Ft. Collins, CO: CSU.

International Turf Producers Foundation. 2001. *Water Right—Conserving Our Water, Preserving Our Environment*. Rolling Meadows, IL: ITPF.

27 Mulching

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Use approved mulches on the soil surface to reduce water loss from evaporation, soil loss due to exposure to wind and runoff, to suppress weeds, and to provide a more uniform soil temperature, all of which reduces water demand and the need for chemical interventions.

Basic Practice Guidelines

Mulch Types

1. Approved mulch includes:

   - Plant-based which includes bark, wood chips, chopped leaves, compost, and pine needles, as examples;
   - Rock-based: includes gravel, pebbles, decomposed granite and similar products;
   - Manufactured products including fiber barrier and woven biodegradable ground cloth; and
   - Hay or straw that is not certified weed-free.

2. Undesirable mulch may include:

   - Non-degradable barriers;
   - Plastic sheeting; and
   - Rubber or synthetic-rubber products

Mulch planted areas to help conserve water.

Mulch Selection

3. Plant-based mulches are suited for most landscape setting, and are compatible with most landscape plants used in this area. Unsuitable uses of plant-based mulch would be on steep slopes where the mulch would float down hill. Plant-based mulches may help to improve soil conditions over time, as the mulch breaks down and works its way into the soil profile. This process may enhance the soil environment for beneficial organisms, improving conditions for landscape plants,

4. Some plants are better suited to rock mulches due to propensity to root rot, particularly desert plants. Check the *SLC Plant List* regarding suitable mulches for specific plants.

5. Do not use plastic sheeting, rubber, or other non-biodegradable manufactured products as mulch. Plastic sheeting and similar non-organic mulches may inhibit water penetration, oxygen transfers with the soil; and may cause temperature increases in soil, all of which may disturb the microbial life and result in diminished soil health and therefore, diminished plant health. Additionally, these products are not compostable and must be disposed of in landfills adding to the burden at landfills.

6. Use of non-biodegradable fabric barriers is discouraged with the use of plant-based mulches, as the fiber barriers inhibit these mulches from working in to the soil layer and improving soil conditions. Additionally, these barriers may also inhibit plants from expanding either through crown growth or rhizomes, a behavior that is desirable in perennial borders or shrub masses. Fiber barriers may be appropriate with rock mulches, but weed seeds may still germinate in the leaf debris that collects between the rocks.

7. Avoid the use of hay and straw to prevent the introduction of invasive and noxious plant species.

8. Consider the impact of mulch on the ambient air temperature. Rock mulches may increase air temperature, especially when used in full sun, but this may desirable for the selected plants.

Mulch Application

9. Delivery of mulch should be to the property and not in a public right-of-way such as a street, sidewalk, or gutter.

10. Mulch planting beds with partially composted organic material in a layer three to four (3 to 4) inches deep to reduce weeds, keep roots cool, keep soil moist, and reduce the frequency of required watering.

11. Apply mulch to the soil surface around the full dripline of a plant, and not against the plant stem or within six (6) inches of tree trunks to minimize disease and pests.

12. Apply mulch to areas of disturbed soil to prevent erosion and sediment transport to drainageways. In areas prone to significant runoff or with steep slopes, the use of anchored biodegradable cloth or rocks is preferable to loose, plant-based mulches.

Maintaining Mulch

13. Check mulched areas on a routine basis; at least monthly, and augment mulch as needed.

Mulching Lawns

14. Lawns can be mulched by leaving lawn clippings in place after mowing, and by an application of well-aged compost at a depth of one-quarter (1/4) inch over the lawn area in the early spring or fall.

Resources

American Landscape and Nursery Association www.anla.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

References

Associated Landscape Contractors of America. 2003. *Landscape Maintenance Training*. Herndon, VA: ALCA. *(As of 2008, offered by Professional Land Care Network [PLANET].)*

Colorado State University Extension. 2001. Xeriscape Mulches. Plant*talk* Colorado 1905. www.ext.colostate.edu/ptlk/1905. Ft. Collins, CO: CSU.

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Goodspeed, Jerry L. and Larry Sagers. 1990. "Composting." Horticulture Fact Sheet HG/H 08. Logan: Utah State University Extension.

Keane, T. 1995. *Water-wise Landscaping: Guide for Water Management Planning*. Logan: Utah State University Extension.

Kratsch, Heidi A. 2007. "Water-Wise Landscaping: Mulch." HG/Landscaping/2007-01pr. Logan: Utah State University Extension.

Natural Resources Conservation Service, National Association of Conservation Districts and Wildlife Habitat Council. 1998. *Backyard Conservation—Mulching*. Washington, DC: NACD.

28 Drought and Water Shortage Practices for Landscape Management

SBMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

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

NOTE: Should a drought be declared, Salt Lake City, through its Department of Public Utilities will determine, update, and announce Drought Stages. These announcements will include any water-use recommendations or restrictions. For information on drought measures, view the SLC Water Shortage Contingency Plan, at www.slcsaveh2o.com.

Basic Practice Guidelines

Turfgrass Irrigation Practices

1. Base watering decisions on soil moisture content. Though 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, as well as to stress resulting in variations in weather and temperature. Early spring watering can also saturate the soil, reducing the oxygen available to deeper roots, which may result in the death of these deep roots. The loss of deep roots increases susceptibility to drought stress and increases the need for more frequent irrigation.

2. Check the moisture content of the soil with a trowel, shovel, long screwdriver, or soil probe to a depth of 4 to 6 inches for turf areas and 6 to 8 inches for trees and shrubs. In moist soil, the tool will insert easily. If resistance is met, at that interface, the soil is becoming dry. If the soil is dry, water when allowed. 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_O). 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 will help determine the appropriate changes to make to the irrigation schedule. ET and soil sensor technologies are also available and can be added to irrigation controllers to facilitate decisions made regarding water applications and to more accurately determine plant 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);

and/or

- Be difficult to insert the blade of a screwdriver or other such implement from easily penetrating into the soil 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 some diseases.

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 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. Leave lawn clippings in place or apply mulch to the lawn to improve soil quality. See the *Mulching BMP* for more information.

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. However, water waste can still be high at night if irrigation scheduling applies more water than can be absorbed by the soil, which results in water run-off. Prevent water run-off by utilizing a cycle-soak schedule. See the *Irrigation Technology and Scheduling BMP* for more information.

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 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 8:00 A.M. and 8:00 P.M. For further information on watering lawns, see *Lawn BMPs* or go to http://extension.usu.edu/files/publications/publication/HG_517.pdf .

10. To reduce water loss from evaporation, do not water using pressurized spray irrigation systems during windy times. Wind will 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. To ensure the ability to deliver water to trees, shrubs, perennials and other non-turf plants during high temperatures, windy weather, and similar conditions that result in high water loss due to evaporation, consider proving low-flow emitter systems to landscaped, non-turf areas. When placed under mulch layers, low-flow emitters lose little or no water to evaporation or wind.

Irrigation System Maintenance

11. Check, adjust, and repair irrigation equipment on a regular basis, at least weekly and within a day of mowing, when possible. Identify irrigation system leaks and repair them promptly.

12. Each spring as an irrigation system is turned on, check the system for broken, misaligned, and missing spray heads; for uneven water coverage, and leaks. Conduct an irrigation system audit to identify the presence of plugged heads, improper spacing of sprinkler heads, etc., and make necessary corrections. For information on self-auditing irrigation systems, see the *Irrigation Audit BMP*, or visit www.slcsaveh20.com and follow the links to GardenWise Videos and select "*Its Easy to Save Water*" video. Alternatively, call 1.877.728.3420 to schedule a free irrigation audit. Commercial and institutional properties will need to coordinate audit requests through the SLC Water Conservation Program Coordinator. Visit www.slcsaveh2o.com for more information.

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. See *Irrigation System Maintenance BMP* for more information.

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, low-flow 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_O) and precipitation data. See *Irrigation Technology and Scheduling BMP* for more information.

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 BMPs* of this Manual for more detailed guidance.

Lawn Aeration

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

    - Improved water penetration into compacted soils and through thatch and mat layers;

- Improved fertilizer movement to the turf roots;
- Greater levels of oxygen reach the soil in exchange for carbon dioxide and other gases;
- Enhanced turfgrass shoot and root development; and
- Reduced 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. See the *Lawn Aeration BMP* for more information.

General Maintenance for Landscape and Turfgrass

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 several months without water.

22. If unsure what grass is in the lawn, take a sample to the local Utah State University 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 noxious and invasive plants to overtake the lawn or landscape. Apply the proper methods necessary to prevent weed growth such as hand-pulling, maintaining mulch layers, or careful herbicide application. See the *Weeds Management* and *Pesticide and Herbicide Application BMPs* for more information.

24. Carefully inspect the landscape and lawn at least weekly for disease and pest problems, correcting for such 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.
25. Maintain the recommended layer of mulch in non-turf landscaped areas to reduce water loss, moderate soil temperature, and assist in controlling weeds.
26. If changing the plant palette to reduce water demand, or when designing a landscape that is of lower-water demand or drought tolerant, see SLC Plant List and USU Database of Drought Tolerant Plants for more information. Contact information in Resource Section.

Fertilizer Application

27. Conduct a soil test to determine the nutrient needs by sending a soil sample to a reputable soil-testing laboratory. See Resources for testing information.

28. A properly fertilized lawn requires less water. However, 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.

29. Generally, for low-maintenance bluegrass lawns (common throughout the Salt Lake Service Area), apply one pound of nitrogen fertilizer per 1,000 sq. ft. in the spring, late summer, and fall. See the *Fertilizer Application BMP* more detailed guidance.

30. Top-dress the lawn with a thin layer (1/4 inch) of aged compost in the spring or fall to improve soil conditions, which may than lead to a lessened need for chemical fertilizer and reduce water demand.

31. 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 also typically high in salt and adding salt to a lawn increases the need to apply more water.

32. Avoid fertilizing trees and other plants suffering from drought stress as this can increase plant stress, causing plants to weaken and therefore become more susceptible to drought stress, insects, and disease.

Mowing

33. 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 will grow, as long as the soil was prepared deeply.

Landscape Installation

34. If establishing a new lawn, prepare the soil properly; this will increase rooting depth and spread, thus increasing 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 material, not a fine material as a coarse material will last in the soil longer. 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. See the *Soil Amendment/Ground Preparation BMP* for more information.

35. 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 lower-water demanding trees and shrubs when planning new garden areas. View the *SLC Plant List BMP* for ideas and information. Make sure to change the irrigation system accordingly.

Resources

American Landscape and Nursery Association www.anla.org

California Urban Water Conservation Council. 2002. H_2OUSE Water Saver Home. www.h2ouse.net.

Irrigation Association www.ia.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

Center for Irrigation Technology www.californiawater.org.

Irrigation Association. 2006. Smart Water Application™ (SWAT™) Performance Reports (various devices). www.irrigation.org

Salt Lake City Department of Public Utilities Water Conservation Website www.slcsaveh2o.com

U.S. Bureau of Reclamation Water Supply Information www.usbr.gov/main/watersupply.

U.S. Department of Agriculture, SNOTEL (Snowpack Information) www.co.nrcs.usda.gov/snow/snow/index.html.

U.S. Geological Survey National Water Conditions water.usgs.gov/nwc.

U.S. Geological Survey Real Time Stream Flow Conditions for Colorado Website: waterdata.usgs.gov/co/nwis/rt.

USU Database of *Woody Plants for Northern Utah* http://extension.usu.edu/files/uploads/DROUGHT_TOLERANCE_database.xlsx

Utah State University Analytical Laboratories www.usual.usu.edu

References

Cook, Samuel, and Larry Rupp. 2011. *Drought Tolerance: A Database of Irrigation Requirements for Woody Plants of Northern Utah.* Logan: Utah State University Extension.

Denver Botanic Gardens and Colorado State University Extension Plant Select® Website: www.plantselect.org.

Denver Water Conservation and Xeriscape Websites: http://www.denverwater.org/cons_xeriscape/cons_xeriscapeframe.html.

Feucht, J.R. and C.R. Wilson. 2003. *Xeriscaping: Retrofit Your Yard.* Fact Sheet No. 7.234. www.ext.colostate.edu/pubs/garden/07234.html Ft. Collins, CO: Colorado State University Extension.

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Koski, T. 2003. *Winter/Spring (2003) Lawn Management for Colorado Lawns.* http://csuturf.colostate.edu/Pages/summer2003lawnCARE.htm. Ft. Collins, CO: Colorado State University Extension.

McCarty, Patrick, and Curtis Swift. *Coping with Drought: Water Restrictions and the Landscape.* Grand Junction: Colorado State Extension.

Mecham, B.Q. 2003. *Conservation Strategies for Lawn Watering During Drought or Water Shortages* http://www.ncwcd.org/ims/ims_info/Irrigation_Strategies.pdf.

National Drought Mitigation Center, University of Nebraska—Lincoln, The National Drought Mitigation Center Website: www.drought.unl.edu.

Wilson, C.R. and D. Whiting. 2003. *Operating and Maintaining a Home Irrigation System.* Fact Sheet 7.239. http://www.ext.colostate.edu/pubs/garden/07239.html. Ft. Collins, CO: Colorado State University Extension.

29 Snow Removal

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

During the winter, many Green Industry professionals are involved with snow removal for the properties that they manage. Snow removal practices should be conducted in a manner that minimizes adverse impacts to vegetation, soils, and stormwater and source water quality.

NOTE: For obvious safety reasons, snow removal in the Salt Lake Area is important; however, snow removal and management practices can adversely impact vegetation, soils, water quality, and air quality. It is important to be knowledgeable of these potential impacts and choose management measures with the fewest adverse impacts, while still protecting public safety, health, and welfare. In 2010, Salt Lake City tightened its enforcement and penalties for failure to remove snow and ice in a timely manner; see SLC Ord Section 14.20.070 and 14.20.110 for more information.

Basic Practice Guidelines

1. For obvious safety reasons, snow should be cleared away from fire hydrants so that they remain readily accessible

2. Physical removal of snow and ice by shovels, snowplows, or snow blowers usually does little damage to the landscape as long as snow and ice are not piled directly on landscape plants. The time to plan for snow storage locations that minimize landscape impacts is prior to winter. Salt Lake City has restrictions on the use of mechanized snow removal; see 21A.44.070: General Off-Street Loading Requirements.

3. Many deicing chemicals are salts and can adversely affect plants, soils, and stormwater and surface water quality through either direct contact or through buildup over time. Representative impacts include:

    - Direct contact often occurs when the deicing chemicals accumulate on the plants due to drift during application, or when snow or ice containing the chemical is shoveled or blown onto nearby plants. Because these chemicals are salts, direct contact with the foliage may result in burning due to a rapid dehydration effect. This is most noticeable on evergreens since they will have foliage when deicing chemicals are normally applied. However, buds and twigs of both evergreen and deciduous plants may also be affected.

    - Buildup of de-icing chemicals in the soil may have even more detrimental effects. Repeated application over time (either during a particular winter season or over many seasons) may damage plants by making their roots unable to take up water. Symptoms will include wilting even when the soil is moist, leaf or needle tip burn, stunting or lack of vigor, and/or deficiency symptoms for one or more plant nutrients. The structure of clay soils can be changed to the point that they are unable to support plant life.

- Deicing chemicals can raise the sodium content of the water to above fresh water standards, and as a consequence it increases the TDS. This may impact fresh water resources and the aquatic environment, potentially killing macroinvertabrates, fish, and plants.

4. Deicing chemicals that are considered safer to use around plants include calcium magnesium acetate (CMA) or calcium chloride. As with all chemicals used in the landscape, be sure to read and follow label instructions and do not overapply.

5. The Colorado Department of Transportation (CDOT) has conducted multiple studies on deicing chemicals. The SeaCrest Group (2001) studied three groups of deicers: 1) chloride-based; 2) acetate-based; 3) and sanding materials. The chloride-based deicers included magnesium chloride (FreezGard Zero® with Shield LS®, Ice-Stop™ CI, Caliber™ M1000, Ice Ban™ M50), calcium chloride (Liquidow®, Armor®), and sodium chloride (road salt and Ice Slicer®). The acetate-based deicers include Calcium Magnesium Acetate (CMA®), Potassium Acetate (CF7®), Sodium Acetate (NAAC®), and CMAK™ (a mixture of CMA and Potassium Acetate). Table 1 contains a partial summary of the study findings.

Table 1 Potential Environmental Impacts of Various Deicers (Source: The SeaCrest Group 2001)

Deicer/ Parameter	Inhibited Magnesium Chloride (Liquid)	Caliber + Magnesium Chloride (Liquid)	Ice Ban + Magnesium Chloride (Liquid)	Sodium Chloride/ Ice Slicer (Solid)	Inhibited Calcium Chloride (Liquid)	CMA (Solid/ Liquid)	CMAK (Liquid)	Potassium Acetate (Liquid)	NAAC (Solid)	Sand
Chemicals	Trace metals	Trace metals, phosphorus, ammonia	Trace metals, phosphorus, ammonia, nitrates	Trace metals	Trace metals, ammonia, nitrates.	Trace metals	Trace metals, ammonia, nitrates.	Trace metals	Trace metals, phosphorus	Trace metals
Soil	Improves structure, increases salinity	Improves structure, increases salinity, oxygen depletion	Improves structure, increases salinity, oxygen depletion	Increases salinity; decreases stability	Improves structure, increases salinity	Improves structure; oxygen depletion	Improves structure; oxygen depletion	Improves structure; oxygen depletion	Decreases stability; oxygen depletion	Minimal effects
Water Quality	Increases salinity	Increases salinity; oxygen depletion	Increases salinity; oxygen depletion	Increases salinity	Increases salinity		Oxygen depletion	Oxygen depletion	Oxygen depletion	Increases turbidity
Air Quality	Minimal air pollution	Minimal air pollution	Minimal air pollution	Some air pollution	Minimal air pollution	Minimal air pollution	Minimal air pollution	Minimal air pollution	Some air pollution	High air pollution potential
Aquatic Organisms	Relatively low toxicity	Relatively low toxicity	Moderate toxicity	Relatively low toxicity	Relatively low toxicity	Relatively low toxicity	Moderate toxicity	Moderate toxicity	Relatively low toxicity	Can cover benthic organisms and cause mortality
Terrestrial Vegetation	Chlorides damage vegetation	Chlorides damage vegetation	Chlorides damage vegetation	Chlorides damage vegetation	Chlorides damage vegetation	Minimal damage to vegetation	Minimal damage to vegetation	Minimal damage to vegetation	Effects to vegetation not determined	Can cover vegetation and cause mortality
Terrestrial Animals	Does not attract wildlife	Does not attract wildlife	Does not attract wildlife	Attracts wildlife contributing to road kills	Does not attract wildlife	Not expected to attract wildlife	Not expected to attract wildlife	Not expected to attract wildlife	May attract wildlife contributing to roadkills	May cover burrows of small animals and cause mortality

Note: Trace metals that may be present include arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, and zinc. See http://ttap.colostate.edu/Library/CDOT/CDOT-DTD-R-2001-15.pdf for more information.

6. Highlights of the SeaCrest (2001) study regarding impacts associated with the three categories include:

    a. The chloride-based deicers have been shown to have adverse effects on terrestrial

vegetation. Damage to vegetation from deicing salts has been reported to a distance of 100-650 feet. However, there is a wide range of tolerance of different species of plants to the effects of chlorides. The chloride ions in deicers increase the salinity of the soil near the roadways where they are applied. The magnesium and calcium ions increase the stability and permeability of the soil, whereas sodium ions decrease soil stability and permeability.

b. The acetate-based deicers are organic and have different kinds of effects on the environment than the chloride-based deicers. The acetate ions are broken down by soil microorganisms and may result in oxygen depletion of the soil, which can impact vegetation; however, the acetate deicers CMA and Potassium Acetate (CMAK) are not harmful to terrestrial vegetation at the concentrations typically used on roadways. However, NAAC may potentially have an adverse effect on vegetation because of the presence of the sodium ion, which decreases the stability and permeability of the soil. The depletion of oxygen in the soil from the breakdown of the acetate ion can have a negative effect on plant growth. However, field evidence of this effect is limited.

c. Sand is not a deicer, but has been used for snow and ice control since the early 20th Century because it improves traction. Sand has a negative effect on water quality as a result of the increased turbidity caused by the presence of sand particles in water. The sand gets into the water when the snow melts and enters the storm drain, carrying the sand along. Excessive quantities of sand can smother vegetation.

7. Where practicable, do not use deicers to completely melt snow or ice, but to make their removal easier. Deicers melt down through the ice or snow to the hard surface, then spread out underneath. This undercuts and loosens the snow so shoveling and plowing can be done. For this reason, it is helpful to apply deicers prior to snow events in some cases.

8. Research has shown that the shape of deicing particles affects the speed of their penetration through ice. Uniformly shaped spherical pellets of about 1/16” to 3/16” penetrate ice faster and more efficiently than other shapes. Irregularly shaped particles tend to melt randomly in all directions. Flakes melt as much horizontally as they do vertically.

9. Try to avoid the use of rock salt since this compound is generally most damaging to plants and soils as well as concrete and metal surfaces.

10. Landscape exposure to deicing salts may be unavoidable if the property is adjacent to a street or road subject to frequent salting and plowing. In these cases, it may be possible to select specific plant material that is more resistant to salt accumulation in the soil and salt exposure to the foliage. See Appendix H for salt tolerances of various plants.

11. Do not plow snow directly into streams or wetlands. Snow storage and disposal areas should be located in an area where snowmelt can infiltrate into the ground, filter through a vegetated buffer or be otherwise treated prior to reaching streams and wetlands. Provide adequate storage volume to trap sediment left behind by melting snow and plan regular maintenance to remove accumulated sediment.

12. In areas subject to heavy chemical deicing use, flushing the soil with water after the last

freeze may alleviate burn potential.

13. Year-round practices of proper pruning, watering, and fertilization that promote plant health will also make plants more tolerant to salt exposure. However, for the overall health of the landscape, the goal should be to reduce or minimize the use of deicing chemicals.

14. Re-circulating anti-freeze systems under sidewalks and driveways must be designed in a way that will not negatively impact the groundwater or drinking water aquifers. Designs must be submitted and approved by SLCPU. Propylene glycol is an acceptable re-circulating fluid; Ethylene glycol is not appropriate for use in sensitive drinking water recharge areas. If these types of de-icing systems are proposed for use in the public right-of-way, such as public sidewalks or driveway approaches, a public way permit is required by SLC Engineering Department.

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30 Production Practices for Nurseries, Greenhouses, and Sod Growers

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

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

Basic Practice Guidelines

Plant Grouping, Irrigation Scheduling, and Irrigation Maintenance

1. Manage irrigation to use water efficiently and to minimize transport of chemicals from the soil surface or immediate crop root zone and to conserve water and reduce run-off into stormdrains. 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). Remember to adjust irrigation system timers for the appropriate season. Plants need less water during cool, rainy weather than during hot, dry, windy weather.

   - Group plants together that have the same water requirements (i.e., use hydrozoning concepts in growing fields and for lining out container and BB stock).

   - 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.

   - Keep plant material free of weeds to decrease competition for water.

   - Schedule an annual irrigation audit to identify current and potential problems.

   - Repair or replace broken or leaking hoses, pipes, sprinkler heads and valves.

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

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

   - Consider implementing closed irrigation techniques (water recycling system) whenever water rights, and site and financial constraints allow. (Note: recycled water should be

ozonated or otherwise treated to remove pathogens from the water to prevent spread of disease.)

- Proper backflow prevention devices are necessary to prevent cross-contamination of public water supplies. This is particularly critical if chemigation is used. See the *Backflow Prevention BMP* for more information.

- When designing ball and burlapped (B&B) storage areas, place more drought tolerant species on southern and western sides and the less tolerant species on the northern and eastern sides of the storage areas.

- Use appropriate plant material to create a natural wind break for growing areas.

- When B&B 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. Use shrink wrap to eliminate shock to the plant and therefore reduce water needs when transporting or holding for an extended period of time.

- Heal-in mix for B&B plants should either be fully composted or inert material such as sand or its equivalent. This is necessary to prevent competition for water and nutrients and to maintain a lower soil temperature for the roots.

Integrated Pest Management

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: When selecting crops and plant varieties, whenever possible, select varieties that have few or reduced problems with insects and diseases.

    - 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.

        - To reduce disease problems, do not extend the period of leaf wetness beyond 12 hours.

  - 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 appropriate 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 the 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: Use the IPM controls described above plus beneficial insects and other biological controls whenever possible.

Chemical Management and Application

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 (if water rights obligations allow).
- 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.

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PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

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31 Water Management Practices for Nurseries, Greenhouses, Sod Growers, and Holding Yards

BMP Type			
Design			X
Installation			X
Maintenance/Operations			X
Green Industry Relevance			
ASLA		GCC	X
ALCC		ISA	X
CALCP		RMSGA	X
CNGA	X	GCSAA	X

Description

Manage production and holding areas to promote the efficient use of water, reduce run-off, and protect stormwater and source water protection. Water is a critical resource, and conserving that resource not only places the nursery industry in a leadership position, but also helps to save money. Water is typically the largest utility cost and offers the greatest opportunity for reduced operation costs.

This BMP has been adapted in part from "Coping with Drought: Water Conservation Methods for the Greenhouse by Laura Pottorff, Regional Commercial Greenhouse Specialist, Colorado State University 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 whenever feasible by all growers and in holding yards. 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. As inventory is sold, consolidate plant material to maximize benefit of water used, and adjust sprinklers accordingly.

4. 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.

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

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

7. Manage leaching from containers or pulse-irrigated containers. If fertilizer levels are

reduced and the electrical conductivity monitored, the necessity for leaching may be reduced. If pulse-irrigation is used with less fertilizer and the monitoring of the electrical conductivity, leaching may potentially be obtained on occasion with far less wasted water than the 10 percent recommended by many textbooks.

8. 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 may become difficult to "wet" after becoming excessively dry and therefore may require excess water. Wetting agents may be added to avoid these problems and repeated pulse-irrigation may reduce the amount of water needed to "wet" the soil.

Step 2: Examine and Improve Efficiency of Irrigation System

9. 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.

10. 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.
    - 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. If hand watering, supply all hoses with positive pressure nozzles to avoid water waste when hose is not in use. Regularly inspect nozzles, gaskets, and hoses for leaks; make replacements as necessary and in a timely manner.

12. 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.

13. 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.

14. 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.

15. 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

16. 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 Utah, it is important to consider water rights constraints when adopting these systems.

17. 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.

18. 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.

19. If utilizing collected water, adequate backflow prevention systems must be installed and properly maintained. See *Backflow Prevention BMP* for more information.

20. 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.

21. 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.

Resources

American Landscape and Nursery Association www.anla.org

Irrigation Association www.ia.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

Center for Irrigation Technology www.californiawater.org.

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32 Practices for Retail Nurseries, Greenhouses, Garden Centers, and Sod Suppliers

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

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

Basic Practice Guidelines

Plant Selection, Organization, and Labeling

1. Group plants together that have the same water requirements (i.e., use hydrozoning) and water accordingly. Include plant hydrozone information in plant and nursery signage to inform customers.

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

3. Offer plants with lower water requirements or those adapted to local conditions and appropriately identify them in displays. Consider displays that feature plants from the *SLC Plant List*, and provide collateral material to customers. For brochures, lists, and other material, contact the Water Conservation Office, SLC Dept of Public Utilities.

4. 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.

5. Be properly educated about the water requirements of plants when communicating with the public and recommend plants with lower water requirements, or those adaptive or 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. Be aware of which plants, though low-water in the region from where they are shipped, may not be low-water here, and amend plant tags accordingly. Consult the *SLC Plant List* of the Utah Plant Tag Program for more information.

6. To maintain the health of turf stock, bring in only those quantities which may be sold in a reasonable period of time. Select turf varieties that are well suited to the region, and use less water and pesticides.

Irrigation

7. 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.

8. Properly educate retail employees on the water needs of plant stock so that both over-watering and under-watering are minimized.

9. Upgrade irrigation equipment to improve application efficiency.

10. Promptly repair leaking irrigation equipment—including hoses, bibs, and couplings. Install positive pressure nozzles on all nursery hoses; don't leave hoses running on the ground or unattended

11. 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.

12. 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.

Plant Pests and Diseases

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

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

Chemicals

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

16. Offer a range of pest, weed, and disease control measures to your customers, and provide information regarding the energy, water quality, and environmental impacts of choices.

17. 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.

Resources

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PLANET Professional Landcare Network www.landcarenetwork.org

Salt Lake County Extension Office at http://extension.usu.edu/saltlake, for weed identification

TPI Turfgrass Producers International www.turfgrasssod.org

Utah Nursery and Landscape Association www.utahgreen.org

Utah Plant Pest Diagnostic Lab. http://utahpests.usu.edu/uppdl/

Utah State University Cooperative Extension Utah Pests News
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33 Park, Golf Course, Cemetery, and Other Large Landscape Design and Management

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Large landscaped areas such as parks, golf courses, cemeteries, and campuses should be well designed and properly managed to be an aesthetically-pleasing environmental amenity and to minimize water waste, excessive chemical use, and runoff to waterbodies or stormdrain systems.

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

Large landscaped areas such as parks, golf courses, cemeteries , and campuses present significant opportunities to implement the various SLC BMPs at a large scale, with potential for significant water conservation and water quality benefits. The basic practice guidelines categorized into design, construction, and maintenance practices.

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, the site manager, and public utilities representative. 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. Additionally, contact the following for applicable permit requirements:

    - SLCDPU Stormwater: SWPPP Permit; Riparian Permit; pond or pool draining

    - SLCDPU Cross Connection Group: backflow prevention issues

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; and
- 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 detention facilities such as retention ponds and detention basins. Such features should be designed in accordance with SLC Stormwater Standards.

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. Any construction or landscaping that occurs within a riparian corridor is required to meet the provisions of 21A Riparian Corridor Overlay. See www.slch2o.com for more information.

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, limit the quantity of runoff, and help protect wetland and sensitive areas from fertilizer and pesticide contamination.

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. Refer to SLCDPU Engineering Review staff for guidance; 801.483.6727.

8. Stream crossings in Salt Lake City require a Riparian Corridor Permit, Salt Lake County Flood Control Permit, and a 404 Permit issued by the State DEQ and/or the US Army Corp of Engineers.

9. Man-made wetlands may be incorporated into site designs to enhance water quality where soil and hydrologic conditions are appropriate. Such design features require long-term maintenance plans.

10. Large landscape design should be based on advanced irrigation design principles. Water application rates should correspond to consumptive use requirements. Water budgets should be developed during the design phase and tracked as part of routine maintenance. Advanced irrigation technology using weather stations and centralized control systems should be used.

11. Irrigation should be designed such that distinct turf-types, turf function, and use levels are irrigated separately to maximize water-savings and use-reduction opportunities. Typically, tees and greens need the most water, and roughs and naturalized areas the least, with fairways somewhere in the middle. Non-turf areas should be on separate zones from turf, and consideration should be made to matching zones to site microclimates (i.e., separating sunny and shady areas).

12. Stormwater reuse and rain catchment should be considered when environmentally, legally (e.g., water rights) and agronomically feasible. For rainwater harvesting, view the Utah State Dept of Water Rights restrictions and requirements.

Construction

13. 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.

14. 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).

15. Protect existing specimen trees, and follow guidelines as established in 21A.48.135: Tree Protection.

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

17. 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. See *Soil Amendment/Ground Preparation BMP*.

18. Appropriate sediment control measures should be implemented to prevent off-site transport of pollutants in accordance with SLC Ground Disturbance Permit Requirements. See Appendix A for more information.

Maintenance

19. Integrated Pest Management (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.

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

21. 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, and may cause increases in certain plant diseases.

22. 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.

23. A landscape management plan for turf and non-turf plants that considers irrigation, fertilization, IPM, and environmental constraints is vital to evaluate ongoing maintenance and operation.

24. 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.

25. 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. Refer to the Pesticide, Fertilizer, and Other Chemical Storage, Handling, and Disposal BMPs.

26. Record keeping is important to document changes in landscape quality for both turf and non-turf plants, recording overall plant appearance and vigor, pest levels, and water quality. A computerized database or spreadsheet is recommended.

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

28. Monitor the site to identify strengths and weaknesses of existing bmp management. Results should be used to revise management strategies. The best-designed BMPs will fail without regular maintenance including regular monitoring, repairs and other adjustments.

Drought Management Strategies

29. During drought, golf courses and other large landscapes must be prepared to implement management strategies that reduce water use, while protecting investment in their landscapes, which may include:

    - Elimination of irrigation in selected areas
    - Reducing irrigation of rough areas
    - Hand-watering tees and portions of fairways
    - Adjusting fertilization practices
    - Reducing fairway irrigation
    - Raising mowing height
    - Modifying the existing irrigation system

Resources

American Landscape and Nursery Association www.anla.org

Audubon International http://www.audubonintemational.org/programs/acss/golf.htm.

Audubon International offers the Audubon Cooperative Sanctuary Program (ACSP), which is a certification program that helps golf courses protect the environment and preserve the natural heritage of the game of golf. Visit http://www.audubonintemational.org/programs/acss/golf.htm.

Center for Irrigation Technology www.californiawater.org.

Environmental Institute for Golf http://www.eifg.org/

Golf Course Superintendents Association http://www.gcsaa.org/

Irrigation Association www.ia.org

Irrigation Association http://www.irrigation.org/certification/default.aspx?pg=cgia_program.htm

Irrigation Association certification program for Golf Irrigation Auditors http://www.irrigation.org/certification/default.aspx?pg=cgia_program.htmguidance.

Irrigation Association. 2006. Smart Water Application™ (SWAT™) Performance Reports (various devices). www.irrigation.org

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

U.S. Bureau of Reclamation's (2007) report: *Weather and Soil Moisture Based Landscape Irrigation Scheduling Devices*, which evaluated the performance of weather-based controllers from 20 different manufacturers and soil-moisture, based products for eight manufacturers. See www.usbr.gov/waterconservation/docs/Controller2006.pdf for the evaluation results

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34 Landscape Features in Low Impact Development

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Properly design, install, and maintain landscape features serving stormwater runoff water quality treatment and volume reduction functions. Low Impact Development (LID) designs seek to approximate pre-development runoff hydrology by allowing storm runoff to infiltrate into the landscape rather than routing urban runoff directly into the storm sewer. Landscaping can be used to help minimize directly connected impervious area, which can both reduce required runoff treatment volumes (the "water quality capture volume") and provide water quality benefits such as filtering pollutants from runoff. Green Industry professionals need to understand sound design practices associated with LID, as well as understand special maintenance requirements that may be needed on such properties.

Basic Practice Guidelines

1. LID techniques are consistent with several sustainability principles such as "valuing all water on the site" and "maintaining or regenerating healthy hydrologic processes." Runoff is treated as a site resource, rather than a waste product targeted for quick disposal. By directing runoff through vegetated areas, plants can take advantage of natural rainfall and runoff pathways, and downstream water bodies benefit from reduced runoff rates, volumes and pollutants.

2. LID practices should be identified early in the site development planning process for the most creative implementation and to ensure compliance with local drainage criteria, since some LID practices are new approaches that may not have fully defined design criteria in some communities.

Stormwater Practices

Landscape-related LID practices include a variety of engineered stormwater BMPs (also called Integrated Management Practices) that are specifically designed and located to minimize the quantity of urban runoff and improve its quality. Representative LID BMPs are summarized in Table 1. The remainder of this BMP fact sheet focuses on a relatively small-scale infiltration-based practice commonly described as porous landscape detention or a bioinfiltration cell. However, proponents of LID emphasize that LID is a design philosophy that incorporates many design considerations. Porous landscape detention is just one tool in the LID toolbox. Of paramount importance for any stormwater-related feature is the protection of the public safety, health, and welfare. This should be kept in mind during planning, design, installation, and maintenance. Those designing LID sites should recognize that it may be necessary to combine traditional stormwater management facilities for flood control with LID techniques in order to

meet local government stormwater runoff criteria.

Porous landscape detention in an Aurora parking lot. (Photo Courtesy of Michelle Delaria, CASFM photo database, http://www.casfm.org/stormwater_committee/

Table 1 Representative LID Practices and Functions
(Note: the general descriptions below are NOT design criteria; instead, they are brief descriptions to increase awareness regarding the practices.)

Practice and Description	Considerations/ Implications for Green Industry Professionals
Porous Landscape Detention (PLD) (also called bioretention cells, infiltration planters, and rain gardens): An engineered vegetated landscape area underlain by a sand bed, often equipped with an underdrain pipe, that receives runoff from site development. A shallow surcharge area above the vegetation allows temporary storage of a runoff design volume (typically called the water quality capture volume) and then gradually infiltrates into the underlying sand filter prior to infiltrating into the ground or exiting via an underdrain pipe.	*See more detailed discussion of Porous Landscape Detention based on Urban Drainage and Flood Control District (UDFCD) criteria following this table.* Check local government requirements for setbacks of PLD from building foundations. Removal of PLD from an existing development or modification of design specifications is not allowed. Proper maintenance of PLD features is essential to their long-term function. Proper design, installation and maintenance of the growing media and filter layers are essential to avoid clogging and standing water. Be sure to follow local design criteria to avoid these problems.
Contained Planters/Rain Gardens: These landscape features are similar to porous landscape detention except they are typically fed	Plants selected for rain gardens should be relatively self-sustaining, with minimal needs for supplemental irrigation, fertilizer,

Practice and Description	Considerations/ Implications for Green Industry Professionals
by roof downspouts or direct precipitation and are constructed in above-ground structures (planters) with underdrains to the ground surface. A variation on the rain garden is a tree planter in ultra urban areas.	pesticides, etc. Appropriate soils and planter sizing are important to the long-term health of the plants.
Porous/Permeable Pavement: Porous or permeable pavement enables parking lot, street, and driveway runoff to infiltrate into the ground rather than runoff into the gutter. Various forms of this practice include modular block pavement, cobblestone block pavement, reinforced grass (turf rings) pavement, poured porous concrete pavement, porous asphalt pavement, and others. Also see UDFCD 2007 or Ferguson (2005).	When designing hardscape features as part of landscape, consider permeable materials that enable infiltration into the soil. It should be noted that Porous Pavement is not an appropriate BMP in all climates. Complications in Utah include the limited ability to plow or salt the surface during winter conditions and treat for sediment in the summer. Snow plows and salt treatment tend to damage the surface and subsurface of the pavement. In addition, air-borne sediment tends to settle out of the air during the Utah summers and blocks the porous nature of the pavement, resulting in a maintenance intensive BMP. The EPA fact sheet for porous pavement recommends vacuuming the pavement four times a year, among other maintenance tasks. Prior to utilizing this BMP, the designer should carefully weigh the maintenance obligations, and the extent that the pavement will need to be treated for snow and ice before pursuing this type of system.
Replacement of Roadside Curb/ Gutter with Grass Ditches: Rather than immediately routing runoff from roads into the storm sewer, which increases runoff rates and volumes, grass ditches or swales can be used to convey road runoff. Some adaptations of this practice use a slotted curb and gutter or curb cuts to route runoff to the grass swale or ditch.	Lawn care professionals may maintain roadside ditches. Since these ditches drain to rivers, streams, and other waterbodies, it is important to carefully apply or minimize use of fertilizers, pesticides, and herbicides. Sediment may accumulate in roadside ditches, particularly after winter deicing, requiring shoveling and disposal of sediment to maintain the ditch capacity. If erosion or gullying is identified, it should be corrected as soon as possible through implementation of a variety of erosion and sediment control measures (e.g., erosion control logs and/or mats, check dams,

Practice and Description	Considerations/ Implications for Green Industry Professionals
	revegetation, etc.) Vegetated roadside ditches in the Salt Lake Area may also be affected by snow removal practices. See the *Snow Removal* BMP for more information.
Disconnected Downspouts: Rather than connecting roof downspouts directly into storm drains, they should be day lighted to the ground surface in areas that maintain positive drainage away from building foundations.	Downspouts can be directed towards planting beds and other landscape features that benefit from the additional runoff. While disconnecting downspouts is fundamental to reducing directly connected impervious area, it is also essential to be mindful of potential problems that moisture from roof downspouts in the backfill zone around building foundations can cause, especially in areas with soil that have potential for swelling. Roof downspouts should be directed to discharge to pervious areas that do not have the potential to cause foundation moisture problems. This can often be accomplished by using downspout extenders. Recommendations contained in the development's geotechnical reports should be followed.
Vegetated or Grass Swales (also called biofilters): Vegetated swales provide natural conveyance of stormwater providing filtering and some infiltration of stormwater runoff. Typical swales are shallow grass-lined channels with relatively wide, flat bottoms designed for shallow flow near the source of storm runoff. Some communities have also implemented modifications to grass swales as "vegetated street swales" that incorporate a combination of porous landscape detention and traditional swale features. These facilities are typically narrow depressions that have vegetated surfaces underlain by a rock trench and geotextile fabric. Other variations of this practice include swales with wetland vegetation. See the City of Portland or the Low Impact Development Center for examples.	Grass swales should be maintained in healthy condition by proper irrigation, mowing, fertilization and weed control to maximize the filtering role of the grass and to reduce potential for erosion (i.e., avoid bare patches of soil). Proper soil amendment to enable infiltration and plant rooting should be implemented. In some cases, soils must comply with engineered design criteria. Depth and sideslopes of swales should be designed with public safety in mind. During installation, be sure to comply with engineering specifications for the swale design.
Vegetated or Grass Buffers: Grass buffers, sometimes called biofilters or buffer strips, are vegetated areas designed to accept sheet flow	Maintenance of buffers includes maintenance of irrigation systems, appropriate mowing and periodic sediment

Practice and Description	Considerations/ Implications for Green Industry Professionals
provided by flow spreaders which accept flow from an upstream development. Vegetation may take the form of grasses, meadows, forests, etc. The primary mechanisms for pollutant removal are filtration, infiltration, and settling.	removal. Fertilizer and herbicides should be used only to the extent necessary to maintain plant health and controls weeds.
Green Roofs: Green roofs, also known as vegetated roof covers, eco-roofs, or nature roofs, are multi-beneficial structural components that help to mitigate the effects of urbanization on water quality by filtering, absorbing or detaining rainfall. They are constructed of a lightweight soil media, underlain by a drainage layer, and a high quality impermeable membrane that protects the building structure. The soil is planted with a specialized mix of plants that can thrive in the harsh, dry, high temperature conditions of the roof and tolerate short periods of inundation from storm events. See the LID website (www.lidstormwater.net/greenroofs/greenroofs_home.htm) or the Green Roof (www.greenroofs.com/) for more information.	Experience with green roofs in Utah is currently limited. The new EPA headquarters has a green roof that is being monitored. Green Industry professionals involved with design, installation, and maintenance of green roofs should recognize special considerations will likely be required for plant selection, irrigation, maintenance, and other factors.
Infiltration Facilities: A variety of infiltration facilities may be incorporated such as infiltration trenches, sand filters, infiltration basins, percolation trenches, and dry wells.	
Minimizing Directly Connected Impervious Area: This is a site layout and design consideration that breaks up the flow of runoff across impervious surfaces by incorporating permeable, landscape-oriented features.	
Preserve Natural Features: During the site design process, natural features providing significant water quality and environmental functions such as wetlands, riparian corridors, and other multiple-benefit natural landscape features may be preserved.	Natural features preserved at a site will have different landscape maintenance requirements than traditional, manicured lawn areas. Ask the owner for guidance on such areas. Maintenance may be limited to infrequent mowing, weed control and pruning.
Tree Planting/Preservation: Trees intercept rainwater in their canopy and reduce the water running off from a site. The shading effect of trees can help to reduce water temperatures in runoff. Appropriate tree placement can reduce both summer cooling and winter heating. Place	Generally, large trees with small leaves are most effective at intercepting rainfall. Some communities such as Portland, OR have implemented aggressive tree planting goals and offer development tree credits

Practice and Description	Considerations/ Implications for Green Industry Professionals
deciduous trees on west and south sides; evergreen trees on north side.	toward stormwater treatment requirements when trees are planted as part of development. Also see www.caseytrees.org/programs/planning-design/gbo.html for study results in the Washington, D.C. area.
Preservation of Soils with High Infiltration Capacity and/or Use of Soil Amendment to Improve Infiltration: LID designs may set aside areas with soils with high infiltration capacity (Type A and B soils) to facilitate infiltration of development-generated site runoff. Alternatively, LID designs may incorporate soil amendment to improve infiltration, based on the results of soil tests.	If soils with high infiltration rates are being protected at a development site, keep heavy machinery off of the area to avoid soil compaction during development. If design plans call for soil amendment to improve infiltration, follow specifications for soil amendment. Topsoil removed from graded areas can be stockpiled for later use on a site.

Aurora parking lot runoff directed to a grass swale through a slotted curb (left). Bioswale in a Colorado Springs parking lot (right). (Photos Courtesy of Michelle Delaria, CASFM photo database, http://www.casfm.org/stormwater_committee/).

Porous Landscape Detention ("PLD" or Bioretention Cell)

1. UDFCD (2007) provides a detailed design procedure, design details, and design spreadsheet that address the following design elements for PLD: basin storage volume based on a 12-hour drain time, surface area and maximum water quality capture volume (WQCV) depth, sand/peat media specifications for growing media, granular sub-base and underdrain requirements, and impermeable membranes (for use in Type D soils), or geotextile liners. These design criteria are not repeated herein and can be downloaded from the UDFCD

website www.udfcd.org.

2. Vegetation selected for PLDs in the Salt Lake Area may be either irrigated bluegrass or natural grasses with shrub and tree plantings. UDFCD recommends that the PLD's infiltrating surface be vegetated with drought tolerant native grass species that do well in sandy soils. A PLD provides a natural moisture source for vegetation, enabling green areas to exist with reduced irrigation needs. Table 2 lists recommended seed mix for sites that will not be irrigated after the vegetation has been established and includes wildflower seed to provide a more natural and diverse appearance. All seed needs to be well mixed, broadcast seeded, followed by hand raking to cover seed, followed by an application of 800 lbs/acre[1] of Biosol to improve germination. The seeded area should be hydro-mulched with 2,500 lbs/acre of virgin wood fiber hydro-mulch and 150 lbs/acre of organic tackifier. If standing water, snow/frozen ground are present, then seeding should be delayed until these conditions subside.

3. Do not use trees and shrubs on the flat surface of the PLD because roots can damage geotextile liners and will interfere with restorative maintenance. Tree and shrubs may be used on sideslopes if they are place at least 6 inches above the flat surface and have geotextile liners placed between them and the flat PLD surface.

4. Do not use sod in PLD installations.

5. If the PLD surface will be irrigated, do not place sprinkler heads on the flat surface. If the seed mix in Table 2 is used, be sure to reduce the water applied according to the needs of the plants.

6. PLD facilities should not be placed close to building foundations or other areas where expansive soils are present, although a properly designed and installed underdrain and impermeable liner may ameliorate some of this concern. The use of downspout extensions that direct roof runoff to PLD areas at adequate distances from building foundations and backfill zones is another alternative.

7. PLD facilities remove pollutants in stormwater through settling, filtering, adsorption and biological uptake of constituents. Additionally, infiltration and evaporation reduce runoff volumes. Installation at sites with naturally moderate to high infiltration rates (Type A or B soils) may be less expensive that facilities located in Type C and D soils, where more extensive engineered features (e.g., underdrains and liners) are required. Percolation tests at a depth equal to and deeper than the bottom depth of the PLD are needed to determine what types of engineered features are required.

[1] Most PLD facilities are several hundred square feet to a few thousand square feet in size, accepting drainage from areas less than one acre. The application rate is given in terms of acres for simplicity and should not be confused with facility size.

Table 2 UDFCD-recommended Seed Mixes for PLD

COMMON NAME	SCIENTIFIC NAME	VARIETY	PLS Lbs per Acre	Ounces per Acre
Sand bluestem	Andropogon hallii	Garden	3.5	
Sideoats grama	Bouteloua curtipendula	Butte	3	
Prairie sandreed	Calamovilfa longifolia	Goshen	3	
Indian ricegrass	Oryzopsis hymenoides	Paloma	3	
Switchgrass	Panicum virgatum	Blackwell	4	
Western Wheatgrass	Pascopyrum smithii	Ariba	3	
Little bluestem	Schizachyrium scoparium	Patura	3	
Alkali sacaton	Sporobolus airoides		3	
Sand dropseed	Sporobolus cryptandrus		3	
* Pasture Sage	Artemisia frigida			2
* Blue aster	Aster laevis			4
* Blanket flower	Gaillardia aristata			8
* Prairie coneflower	Ratibida columnifera			4
* Purple prairieclover	Dalea (Petalostemum) purpurea			4
Sub-Totals:			27.5	22
Total lbs per acre:			**28.9**	

8. Maintenance of PLD during the first year includes temporary irrigation and mowing to control annual weeds. Mowers should be rotary and the tractor small enough not to rut the soil and damage the vegetation. Mow when the site is relatively dry. If needed, spot treat with approved herbicides to control noxious weeds. Be sure to reseed bare areas after the first growing season.

9. Routine maintenance following the first growing season includes replacement of mulch in the spring and fall. By removing and disposing of old mulch, sediment accumulation in the PLD can also be removed, prolonging the life of the structure. Clogging of the facility with silt and eroded clay soils is a possible problem to keep in mind.

10. Typical opportunities for incorporating PLD into a site include parking lot islands/medians, street medians, roadside swale features, and site entrance or buffer features. PLD sites typically receive drainage from relatively small areas such as a single lot or parking area. A slotted curb opening or curb cut into a depressed landscape area is often a key sign that the landscape is engineered to provide stormwater benefits. When landscape maintenance crews encounter such features, they should consult with the property owner regarding any special maintenance considerations and should not “re-landscape” or remove such facilities.

11. Rainwater harvesting is a LID BMP and is allowed in Utah, but there are restrictions and permitting requirements. Visit www.waterrights.utah.gov for more information.

Providing proper soil amendment to enable infiltration of runoff is a LID technique, unlike this photo where infiltration is not occurring below turf (left). The U.S. EPA Region 8 headquarter in Denver has installed a green roof that includes drought tolerant vegetation and drip irrigation (right). (Photos from EPA Region 8 website: http://www.epa.gov/region8/greenroof/

Resources

Green Roof www.greenroofs.com

Low Impact Development Center www.lidstormwater.net

U.S. Environmental Protection Agency, Green Roof www.epa.gov/hiri/strategies/greenroofs.html

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35 Design, Planting, and Maintenance of Engineered Drainage Structures

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Proper design, construction, and maintenance of engineered drainage structures, such as swales, rock-lined channels, detention basins, retention ponds, and wetlands, will ensure proper function and reduce run-off pollutants to the stormwater drainage system.

While not all engineered drainage structures utilize plants, vegetation can serve multiple purposes, including stabilizing structures to prevent excessive erosion and removing pollutants from stormwater. Because of the semi-arid nature of Utah's climate, prevalence of introduced noxious and invasive plants, and the variety of soil types, prompt implementation of a vegetation plan is critical if vegetation is to be successful.

Basic Practice Guidelines

When landscaping engineered drainage structures, Green Industry professionals should work closely with the engineer responsible for the structure 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 maintenance 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 structure have differing moisture regimes that should be taken into consideration. Different plant forms (e.g., grasses, shrubs, and trees) may need to be limited to specific areas to enable proper functioning of the structure. Do not plant trees and shrubs below the high water elevation as they can reduce the hydraulic capacity of the structure, increase maintenance requirements, and cause the plugging of downstream bridges and culverts when plants are 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. See the *SLC Plant List* for recommended grasses.

5. Plantings should not include cattails and other invasive or aggressive species 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 and rushes.

6. 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 or on-site sources, whenever possible.

Site Preparation

9. For vegetated drainageways, side slopes should not exceed 3:1 (three horizontal units to one vertical unit) to reduce hazards from mowing and irrigation runoff.

10. All areas to be planted should have sufficient topsoil to support the selected plants. Native topsoil should be stripped and saved for this purpose whenever a site is graded. See *Landscape Installation and Erosion and Sediment Control BMP*. Conduct soils tests on the stockpiled soil to determine what amendments or fertilizers, if any, are needed. See Resources for information on soil testing.

11. The upper soils in areas to be seeded should not be compacted and should be in a friable condition.

12. When necessary for plant establishment, 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. Conduct soils tests prior to amending or fertilizing soil. See Resources for information on soil testing.

Planting and Seeding

13. Avoid flow to drainage structure until vegetation is established to reduce sediment-laden runoff. If utilization of drainage structure is necessary, institute temporary BMPs to reduce sediment-laden runoff.

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

15. 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.

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

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

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

19. All seeded areas should be mulched and the mulch should be adequately secured. See *Mulching BMP*.

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

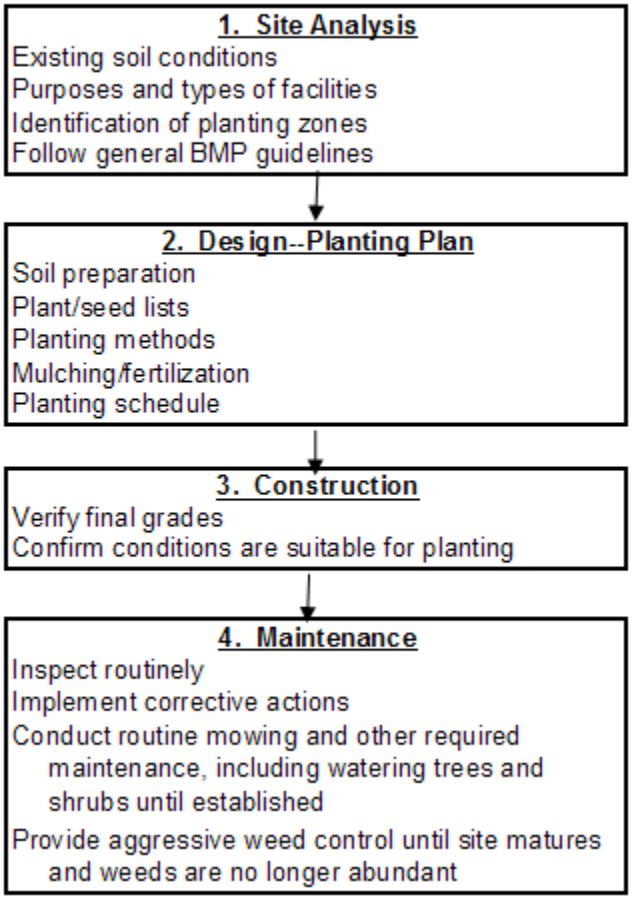
21. All containerized nursery stock should be kept in a live and healthy condition prior to installation.

22. Containerized trees and shrubs should be installed properly to ensure success. See *Planting BMPs*.

23. Live stakes, poles, and willow bundles should be installed when dormant.

24. 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.

Revegetation Process Flow Chart
(Source: UDFCD 2001)



Maintenance

24. Sites should be routinely inspected following planting to implement follow-up measures to increase success. Immediate attention to a problem (e.g., noxious and invasive plant 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 become established, normally the first year.

26. Noxious and invasive plant infestations should be managed using appropriate physical, chemical, or biological methods as soon as possible. When using chemical weed control, only herbicides with aquatic labeling should be applied. If drainage way is in the watershed, see 17004.375: Herbicide, Pesticide, and Fertilizer Restrictions. See *Pesticide and Herbicide BMPs.*

27. Areas of erosion should be repaired and stabilized.

28. Planted trees and shrubs should be watered as needed year round.

Resources

Soil Testing: Utah State University Analytical Laboratories www.usual.usu.edu

References

Don Godi and Associates. 1984. *Guidelines for Development and Maintenance of Natural Vegetation*. Denver, CO: Urban Drainage and Flood Control District.

Don Godi and Associates. 1993. *Design Workbook for Establishment of Natural Vegetation*. Denver, CO: Urban Drainage and Flood Control District.

36 Riparian Buffer Preservation

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Preserve or restore buffers of 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, stream bank stabilization, and stream temperature control.

Land development along the Wasatch Front and in areas adjacent to our critical watershed lands 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), riparian habitat, and wildlife habitat. Preserving undeveloped riparian corridors in our mountain valleys is an important commitment to help protect water quality and aquatic life.

INCENTIVES: The RCO offers incentives for projects that propose to day-light conduit-enclosed sections of qualifying streams as part of their landscaping plans. Contact the SLCDPU Development Engineer for more information.

Basic Practice Guidelines

Permitting and Setbacks

PERMIT INFORMATION: Before beginning any work in areas adjacent to a riparian corridor, consult SLC Code 21A.34.130: Riparian Corridor Overlay District (RCO) for regulations and guidelines and contact the SLCDPU Development Engineer for permit information.

1. Permits are required to make modifications within riparian setback areas. The RCO setback area is from zero to one-hundred (0 to 100) feet as measured horizontally from the annual high water elevation along the creek or Jordan River. Contact SLCDPU Development Engineer for more information regarding Riparian permits. The following represent riparian setback zones:

    - Zone A, 0- 25 feet is a no disturb area; grading, mechanical equipment are not allowed.
    - Zone B 25 -50 ft allows minimal grading, paths, small patios, but no new structures.
    - Zone C 50 -100 feet allows re-grading and structures but has some commercial / industrial limitations, such as no commercial parking lots, some types outdoor material storage may be limited, septic drainfields, etc.

Note: Features such as erodable soils, unstable stream bank conditions, steep slopes, the presence of a wildlife migration corridor, poor vegetative cover, property usage involving hazardous materials, etc., may warrant larger setbacks.

Modifications include planting; plant removal; reseeding; and construction of paths, structures, bridges, and fences, or any other act that alters the riparian corridor physically or visually.

2. Cordon off areas of non-disturbance within riparian setback areas.

Existing and Introduced Vegetation

3. Protect and retain existing appropriate riparian vegetation whenever possible. Consider enhancing the existing setback area by planting site-appropriate, native plants. Make the natural riparian area an integral part of the site design. A permit is required to alter the vegetation within the setback.

4. Inappropriate plants should be removed and replaced with appropriate species. See Riparian Corridor Study List of Plants www.slch2o.com. A permit is required to remove vegetation from within setback areas.

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

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

Drainage

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

8. Clearly specify landscape maintenance practices that are acceptable within setback areas. 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 and invasive plants with approved herbicides.

Resources

Salt Lake City Riparian Corridor Study and Plant List
www.slcgov.com/Utilities/ud_riparian_corridor_stream_study.htm

Salt Lake City Plant List www.slcsaveh2o.com

References

Castelle, A.J., A.W. Johnson and C. Conolly. 1994. Wetland and Stream Buffer Size Requirements —a Review. *Journal of Environmental Quality* 23(Sept/Oct): 878-82.

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Leff, S.F. 1998. Rationale, Strategies and Resources for Restoring and Protecting Streamside Corridors. *River Voices*, 9:1.

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Welsch, D. 1991. *Riparian Forest Buffers*. FS Pub. No. NA-PR-07-91. Radnor, PA: U.S. Department of Agriculture, Forest Service. Forest Resources Management.

37 Employee Education

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Educate Green Industry employees, both those engaged in the public and private sectors, on water quality and water conservation practices.

UNLA has landscape and irrigation certification programs that are available for nursery and landscape employees and professions. Visit www.utahgreen.org.

Basic Practice Guidelines

General Knowledge

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 and appropriate and efficient irrigation systems on the impacts of water use reduction, water waste reduction, stormwater, and source water quality.

2. 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). See *Appendix I* for a list of representative certification and training programs

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

4. Encourage active participation in local, state, regional, and national Green Industry organizations to keep up with current water efficiency technology and trends, such as the Utah Nursery and Landscape Association.

5. Provide information to your employees of training and certification opportunities.

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

7. Provide bilingual educational materials, as needed.

Sprinkler Systems

8. Train employees to identify irrigation problems (e.g., broken hoses, etc.) and designate an employee (or employees) to verify and correct irrigation problems. This is applicable to all industry segments.

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

Chemicals and Equipment

10. Train employees to identify and report mishandling of chemicals, garden debris, equipment fuels, or other actions which may have a detrimental effect on water use or waste, and stormwater and source water quality.

11. Emphasize the importance of always reading and following 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 safety Data Sheets (MSDSs) are and be familiar with commonly used chemicals as required under the Community Right-to-Know laws. For more information on application, storage, and handling of chemicals, refer to the *Pesticides and Herbicides BMPs*.

Water Quality and Conservation

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

13. Make water conservation, stormwater quality, and source water protection a priority for employees. Awareness campaigns and incentive programs can be helpful in changing attitudes and actions.

Resources

American Nursery and Landscape Association (ANLA) www.anla.org.

American Society of Landscape Architects (ASLA) www.asla.org

Golf Course Superintendents Association (GSAA) www.gcsaa.org/

International Society of Arboriculture (ISA) www.isa-arbor.com/

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

Irrigation Association (including irrigation BMPs): www.irrigation.org

Irrigation Training and Research Center, Cal-Poly State University, San Luis Obispo, California

www.itrc.org

Professional Landcare Network (PLANET) http://www.landcarenetwork.org

Salt Lake City Riparian Corridor www.slcgov.com/Utilities/ud_riparian_corridor_stream_study

Salt Lake City Water Conservation www.slcsaveh2o.com

Salt Lake City Watershed Protection www.keepitpure.com

Trees Are Good www.treesaregood.com/

Turf Resource Center www.turfgrasssod.org.

U.S. Composting Council www.compostingcouncil.org

U.S. Environmental Protection Agency, Greenscapes Program www.epa.gov/greenscapes/.

U.S. Environmental Protection Agency, WaterSense Program www.epa.gov/WaterSense.

U.S. Green Building Council www.gbci.org/ or www.usgbc.org/.

Utah Nursery and Landscape Association (UNLA) www.utahgreen.org

References

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Irrigation Association Water Management Committee. 2005. *Turf and Landscape Irrigation Best Management Practices.* www.irrigation.org. Falls Church, VA: Irrigation Association.

38 Public and Customer Education

BMP Type	
Design	
Installation	
Maintenance/Operations	

Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Model and teach water conservation, stormwater pollution prevention, and source water protection to all consumers of green industry products, property owners, and property managers, including industry professional and homeowners.

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. Set the example for the public by implementing the SLC BMPs and demonstrating that practices that conserve water, reduce water waste, use water efficiently, and protect water quality result in attractive landscapes providing environmental benefits and cost saving, in many cases.

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

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

4. Emphasize the value of conservation-oriented watering practices and the benefits of sustainable landscaping principles to clients and customers. For example, clearly communicate the basic principle that proper irrigation saves water, money, and promotes healthier plants. Educate customers and clients that Xeriscape™ is a group of management practices and is not a particular plant palette or garden design style. Reinforce that any landscape can be water-wise and stormwater smart.

5. Provide technical assistance to the public in converting existing landscapes into those that incorporate sustainable landscape 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 meeting 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 water-wise demonstration projects, etc. Nurseries and garden centers can provide displays featuring water-wise demonstration gardens or hands-on demonstrations on creating water-wise landscapes.

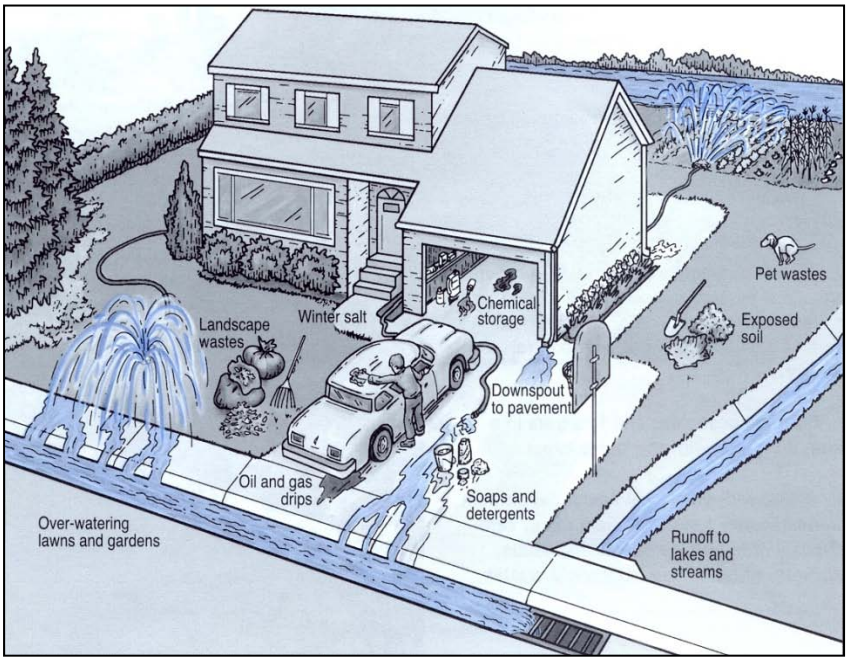
8. For lawn care professionals, offer clients a water audit service to improve efficiency of water use. This would include evaluating sprinkler systems for proper coverage, replacing damaged heads, realigning heads, teaching owners how to program their controllers, preparing watering schedules based 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 proper operation . At a minimum, owners should know how to run the controller and change watering times and duration (minutes) based on weather and seasonal conditions, and how to shut off sprinklers to respond to daily weather 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. Know which plants are actually water-wise in this region, and don't depend on the growers labels. Convey the correct information to consumers.

12. Emphasize the fact that reading the label when applying pesticides, herbicides, and fertilizers is critical—over-application and misuse of these chemicals can damage plants, harm people, and negatively affect the water quality in our creeks, rivers, and lakes.



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.

13. Emphasize the critical importance of proper ground preparation prior to planting and laying sod. Many new homeowners have poor quality soil as a result of construction 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.

Resources

American Nursery and Landscape Association (ANLA) www.anla.org

American Society of Landscape Architects (ASLA) www.asla.org

Golf Course Superintendents Association (GSAA) www.gcsaa.org/

International Society of Arboriculture (ISA) www.isa-arbor.com/

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

Irrigation Association (including irrigation BMPs): www.irrigation.org

Irrigation Training and Research Center, Cal-Poly State University, San Luis Obispo, California www.itrc.org

Professional Landcare Network (PLANET) http://www.landcarenetwork.org

Salt Lake City Riparian Corridor www.slcgov.com/Utilities/ud_riparian_corridor_stream_study

Salt Lake City Water Conservation www.slcsaveh2o.com

Salt Lake City Watershed Protection www.keepitpure.com

Trees Are Good www.treesaregood.com/

Turf Resource Center www.turfgrasssod.org.

U.S. Composting Council www.compostingcouncil.org

U.S. Environmental Protection Agency, Greenscapes Program www.epa.gov/greenscapes/.

U.S. Environmental Protection Agency, WaterSense Program www.epa.gov/WaterSense.

U.S. Green Building Council www.gbci.org/ or www.usgbc.org/

Utah Nursery and Landscape Association (UNLA) www.utahgreen.org

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39 Woody Shrub Selection, Planting, and Care

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

A woody shrub is a plant that maintains live, though sometimes dormant, wood year long. This BMP covers deciduous and evergreen shrubs. Some plants that are thought of as perennials, such as Russian sage, are also woody plants. Properly plant and maintain shrubs to maximize plant health.

Note: Woody shrub, shrub, and woody plants are used interchangeably in this text.

Basic Practice Guidelines

Selection

1. When selecting shrubs, and all plants, be sure to consider:

    - Soil type, drainage, pH, fertility and volume available to support root growth.

    - Susceptibility to insects and disease, keeping in mind species diversity for protection against plant loss during insect or disease outbreaks.

    - Appropriateness for climate (hardiness) and water requirements, remembering that summer heat needs to be considered as well as winter cold. See *SLC Plant List* for relative water requirements of various species.

    - Mature size and location relative to underground and overhead utilities and power lines.

    - Mature size relative to buildings, windows, walks, driveways, and other shrubs.

2. Consider selecting lower water demanding native or introduced adaptive species compatible to the planting site's climate, soil, site features, uses, and landscape design. See *SLC Plant List* for recommendations; also see Appendix H for a list of the relative salt tolerances of various shrubs.

3. When purchasing shrubs from a nursery, try to find out where the stock was grown. Stock originating from the South and West Coast may be less hardy than stock grown in northern nurseries.

Planting

4. Plant shrubs so that the root collar (root crown) is one to two (1 to 2) inches above grade to help in better establishment and long-term health of the shrub. Planting holes should be shallower than the root ball for this to occur. See the *Tree Planting BMP* for more detail.

5. Avoid soil interface problems by utilizing the native soil to backfill planting holes and by avoiding amending the backfill. If the soil is to be amended, ideally an entire planting area is amended, and not simply the area around planting holes, to enhance root penetration into indigenous soil and to avoid creating larger "containers" in planting area. Do not amend the soil beneath the root ball. Place root balls on firm, undisturbed soil. Also score root balls and the sides of the hole to aid in transition. Do not fertilize during planting or during the first year.

6. Shrubs planted near streams and drainages should be selected and installed according to information in the Riparian Corridor Study (see www.slch2o.com for details).

Irrigation Design and Watering

7. For more details on irrigation design, installation, and maintenance see *Irrigation System Design*, *Irrigation System Installation*, and *Irrigation System Maintenance BMPs*.

8. When planning irrigation for shrubs, shrub borders, or mixed borders, zone them separately from turf where possible to provide deep, less frequent waterings. All construction covered under 21A.48.055 must hydrozone. See *SLC Plant List* and *Irrigation BMPs* for more information.

9. Regular, appropriate watering of shrubs is important because moisture stress is a precursor to many diseases and insect problems. Shrubs may not show stress for several years after being under-watered or suffering from drought damage. It is also important to keep in mind that too much water can also cause problems by causing roots to rot and decreasing the availability of oxygen in the soil.

An Under-watered Plant Has:

- Dull leaves
- Drooping leaves
- Dropping leaves
- Leaves with brown centers

An Over-watered Plant Has:

- Yellowing leaves
- Leaves with browntTips
- Leaves with brown centers

10. Shrubs require water two grow. The amount of water needed depends on the species of shrub and the conditions in which it is planted. This includes winter watering for newly planted shrubs, particularly evergreens, when snow is absent. See SLC Plant List for more information on watering requirements for specific shrubs.

11. Root systems can spread two to four times wider than the height of the shrub. Most of the shrubs roots are in the top 24 inches of the soil, depending on soil type. Apply water within the dripline, so it moistens the critical root zone to a depth of at least 12 to 18 inches. For evergreens, water should also be applied 3 to 5 feet beyond the dripline. Apply water to

many locations under dripline. If a deep root fork or needle is used, insert the device no deeper than 8 inches into the soil.

12. Apply water so that it does not spray onto the leaves of the shrub, to avoid encouraging mildews and other diseases.

13. During prolonged dry periods in the fall and winter (October through March), some species may need watering one to two times per month. Water only when temperatures are above 40 degrees and no snow cover exists and when there is no snow or rain.

14. The frequency of watering applications should be determined based on the weather and the site's micro-climate. To determine if a shrub or an area of shrubs needs watering, check the soil moisture by plunging a six to eight (6 to 8) inch screw driver into the soil. If it enters with relative ease, the soil is moist and requires no water. Where the screw driver meets resistance is where the soil begins to dry. At this point, a visual assessment of the plant can assist in determining if watering is required.

Mulching

15. Apply organic mulch within the dripline at a depth of 4 inches to conserve moisture. Leave a space between the mulch and trunk or crown of the shrub to discourage pest damage to the root collar. Mulch materials may include wood chips, bark, leaves, and evergreen needles. Gravel and other rock mulches can increase ambient air temperature so first determine if the shrub requires the extra heat. See the SLC Plant List for information regarding mulch recommendations.

16. Maintain the mulch layer consistently through the year to help reduce moisture lose from the soil; inhibit weeds; and reduce dust and erosion.

Weed and Pest Control

17. Maintain a healthy landscape to help prevent disease and insect issues from becoming problematic and causing plant decline.

18. To decrease the chance that weeds, pests, and diseases may become a problem, do the following:

    - Select the right plant for the right place, and provide it with ample room to grow
    - Avoid over- or under-watering
    - Avoid over-fertilizing
    - Maintain a three to four inch layer of mulch to inhibit weeds and to moderate soil temperature and moisture levels

- Be present in the landscape frequently and observe and note the over-all health of plants; be proactive when problems first appear
- Control pests, disease, and weeds early, beginning with mechanical measures, if possible
- Use the least toxic control measures first
- Learn to live with imperfection

19. Many shrub species are harmed by herbicides used in the lawn. Shrubs already stressed by drought can be harmed by a heavy application of herbicide in the root zone.

20. For information on the use, storage, and disposal of landscape chemicals, see the following BMPs:

- *Fertilizer Application*
- *Pesticide and Herbicide Application*
- *Pesticides, Fertilizers, Chemical Handling*

Pruning

21. Properly prune young shrubs to establish good structure and minimize the potential for damage from snow and wind.

22. Prune shrubs 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.

23. Shearing shrubs increases maintenance as the practice encourages erratic and irregular growth; may increase the incidence of pest infestation due to a lack of air circulation and sunlight into the center of the plant; and can increase the plants water demand.

24. Prune shrubs utilizing one of the two following practices: selective pruning and renovation pruning. (INSERT GRAPHICS)

25. The timing of pruning should be based on seasonal conditions and the type of plant. Spring blooming shrubs should to pruned immediately after blooming, while summer blooming shrubs may be pruned in late spring. Knowing if a shrub blooms on old or new wood helps in making the determination of when to prune.

Resources

International Society of Arboriculture, Rocky Mountain Chapter Website: www.isarmc.org

References

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40 Backflow Prevention

BMP Type			
Design			X
Installation			X
Maintenance/Operations			X
Green Industry Relevance			
APA		UCFC	
ASLA		UNPGA	
GCSAA		UNPS	
ITP		UWCF	

Backflow preventers are used to protect the culinary water system from contamination hazards inherent in irrigation systems and are required by state regulations (Utah Plumbing Code as adopted and amended and Salt Lake City Ordinances Chapter 21A.26).

Description

For backflow prevention purposes there are two general categories or types of irrigation systems utilizing backflow prevention devices and assemblies: first, systems utilizing SLC culinary water only; and second, systems utilizing culinary and non-potable water or culinary water from other sources for irrigation. Systems utilizing solely non-potable water require no backflow protection.

1. Water Sources and Backflow Prevention

SLC Culinary Water as Sole Source

Irrigation systems utilizing culinary water have four options for backflow protection of which three are commonly used.

The first and preferred method is to install atmospheric vacuum breakers (AVB), one per zone downstream of the control valve for each zone and at an elevation at least six (6) inches higher than the downstream piping or the highest sprinkler head on the system, whichever is highest. This is the least expensive backflow preventer of the four but requires one AVB per zone. This type of backflow protection requires no annual testing which is an advantage because of no ongoing costs (Diagram 1.1).

The second option is the pressure vacuum breaker (PVB) installation including another variation called the spill-resistant vacuum breaker (SVB). The PVB and SVB can be used interchangeably. The PVB or SVB backflow preventer is more expensive than the AVB mentioned above, but can be installed ahead of all zones of the system. However, it must be installed at least twelve (12) inches above the ground and twelve inches above the downstream piping or the highest sprinkler head of the entire system, whichever is highest. This valve is required to be tested at least annually, or as required by the Department of Public Utilities (Diagram 1.2).

The third option is to install a reduced pressure backflow preventer (RP). An RP can also be installed ahead of all zones of an irrigation system. It must also be installed where it is not subject to flooding and at least twelve (12) inches above the surrounding ground but does not have to be above the highest head of the irrigation system. It is the most expensive of the other three types and is also required to be tested at least annually, or oftener as required by the Department of Public Utilities. . Chemical addition such as fertilizers or pesticides may only be injected or pumped into an irrigation system downstream of an RP (Diagram 1.3).

The fourth option is the installation of an air-gap (AG) tank. Pumping is required because city water pressure is lost through the air-gap. This type of system is one of the most expensive to install and operate since electrical connections must be made and pumps must be maintained. Chemical addition such as fertilizers or pesticides may only be injected or pumped into an irrigation system downstream of the air-gap tank or added to the air-gap tank. This type of backflow prevention is rarely, if ever, used for irrigation systems utilizing culinary water as a sole Source (Diagram 1.4).

SLC Culinary Water and Other Culinary Sources

This type of installation requires either an air-gap tank as outlined in diagram 1.5 or an RP as outlined in diagram 1.6.

SLC Culinary Water with Non-potable Sources

This type of installation requires either an air-gap tank as outlined in diagram 1.5 or an RP as outlined in diagram 1.6. A disadvantage to the RP installation is the annual or more often testing requirement and the requirement to disconnect the potable water source downstream of the RP whenever the non-potable source is being used; see Utah Code Annotated 19-4-112, (d).

Non-potable Water Sources

These systems do not require backflow prevention controls provided that there are no connections to any culinary line.

2. Testing

Testing: Initial, annual, or as required testing for the PVB/SVB and RP types of backflow prevention installations will be done as per Section 312.10 of the International Plumbing Code, as amended and adopted by the State of Utah and in the Utah Public Drinking Water Regulations section 309-105-12 (4). SLCDPU will usually notify each customer at least annually when testing is due. Testing must be accomplished by a currently certified backflow assembly technician. A list of the currently certified technicians or testers is available from the Utah State Department of Environmental Quality web site www.drinkingwater.utah.gov/documents/compliance/backflow_technicians_by_name.pdf. Failure, to complete the required test will result in the termination of water service to the premises in accordance with SLC code (insert reference).

3. Submittals: Backflow Prevention Plans

Irrigation systems utilizing culinary water either alone or in tandem with non-potable water must state the type of system being proposed on the plan documents, including the type of backflow prevention devices, and their location and an outline of the sprinkler zones being supplied water from the backflow prevention devices.

Besides the items mentioned in the proposed ordinance the following information should be included on the submittal:

a. General site information, including the location of all culinary water services to the property.

b. The location of any non-culinary sources of water proposed to be used on the site for irrigation, including rainwater, gray water, other recycled water, non-potable pressurized irrigation water, ponds, lakes, rivers, streams, cisterns, wells, ditches, etc.

c. The location and elevation of any hills, berms, water features, swales, rain gardens, terracing or other landscaped areas as well as the location of any areas to be temporarily irrigated.

d. The location and description of all chemical application apparatus such as fertigation, chemigation, or fertilizer injection equipment, etc.

e. An explanation outlining the reasons for proposing a particular type of backflow preventer

f. A drawing of the proposed irrigation and backflow preventer winterization and seasonal shut-down features.

4. Review Procedure and Certificate of Occupancy

I. An irrigation system with AVB's will not be approved until the proper installation has been verified by inspection at the completion of the irrigation system installation.

   a. Property owners are required to submit a completed annual certification that no changes have been made to the system and that it is functioning as designed (see AVB Annual Certification form in appendices).

II. An irrigation system with testable backflow preventers such as PVB/SVB's and RP's will not be approved until proper installation, certified test, and operation has been submitted to SLCDPU.

5. Standards

Design and installation of backflow prevention devices & assemblies: Backflow preventers shall meet the requirements of the Utah Department of Environmental Quality as outlined in the "List

of Approved Devices and Assemblies" and in the "State of Utah Cross Connection Guide" as to approved devices and assemblies and their installation; see website http://www.drinkingwater.utah.gov/documents/rules_ddw_version/R309-105_9-24-09.pdf.

I. Irrigation system design should preferentially utilize atmospheric vacuum breakers where potable water is the sole source of water supply. See diagram 1.1 "Landscape and Irrigation - Typical Residential and Commercial Recommended Installation" in Appendix 1.

II. Irrigation systems utilizing non-potable or non-culinary sources in addition to a culinary source shall utilize the air-gap backflow prevention method (diagram 1.5), or the reduced pressure backflow preventer (diagram 1.6), ahead of any connections to the irrigation system. Design shall be in accordance with recognized standards as shown in diagrams 1.5 and diagram 1.6 and shall be in conformance with the Plumbing Code as amended and adopted by the State of Utah.

III. Installation of backflow preventers for the irrigation system shall be in accordance with manufacturer's requirements and the Plumbing Code as amended and adopted by the State of Utah. The Utah Public Drinking Water Regulations requirements to protect the drinking water shall prevail in all cases as may be determined by the Department of Public Utilities. (R309-105-12 (1)"The water supplier shall not allow a connection to his system which may jeopardize its quality and integrity."

6. Inspection, Maintenance, Testing, and Enforcement

I. Pre-occupancy inspection shall be made before final approval of the installation is given. Approval will require a certification from the installer that the system is in compliance with the plans and requirements and shall contain test reports of backflow preventers requiring initial and annual testing. Backflow preventer installations shall be in compliance with the drawings in the appendix. Backflow preventers requiring test shall be tested and certified as properly operating by a currently certified (Utah certified) technician before final approval. Test results shall be reported on test forms provided by SLCDPU (see appendix) and submitted in a timely manner

II. Maintenance: Maintenance and testing shall be performed to correct any deficiencies shown to exist after inspection of installation or after testing of backflow preventers.

Backflow preventer repair parts shall be manufacturer's original equipment replacement parts. Irrigation system repairs & parts shall be of a quality acceptable to the Department. Backflow preventer installations shall be protected from vandalism, tampering freezing, etc.

III. Test reports shall be submitted annually on approved forms during the anniversary month of the original approval date & other dates as determined by the Department of Public Utilities. Failed test reports shall be submitted to the Department of Public Utilities within five (5) days of the failed test. Failure to test may result in termination of water

service. Failure to submit test reports in a timely manner will result in actions being taken against the tester, in accordance with Drinking Water Rules 3-9-305-6, and may result in tester being removed from approved tester list.

IV. Enforcement: Termination of water service to the premises may result due to inability, refusal, neglect, or failure to correct any deficiencies found during inspections or failure to submit reports on annual or as-required tests of backflow preventers in a timely manner to the SLC Department of Public Utilities.

Resources

Salt Lake City Department of Public Utilities www.slch2o.com Cross Connection Division 801.483.6795

41 Retrofitting an Existing Irrigation System

BMP Type			
Design			
Installation			
Maintenance/Operations			
Green Industry Relevance			
AIA		L/I.UNLA	
ASLA		UCFC	
ISTMA		UNPGA	
ITP.UNLA		UWCF	

Description

Even an established landscape with an existing irrigation system can be made more efficient with a little effort and some readily available irrigation components. This BMP is intended to offer general guidance, and does not address all aspects of irrigation retrofitting.

Basic Practice Guidelines

1. Replace sprinkler heads with more efficient multi-stream/multi-trajectory spray heads (see Resource Section for example). This is particularly important on irrigation zones that use both fixed spray heads and rotor-type heads, which have different precipitation rates and therefore increase inefficiency.

2. Purchase spray heads that throw water the needed distance, measured as a radius. Do not purchase heads that spray an area larger than needed.

3. Avoid overlap between sprinkler heads; if there are redundant heads on a zone, or on adjacent zones, identify those heads and either adjust to produce no flow or cap the head by replacing the spray head with a nozzle cap.

4. Adjust spray arc angles to cover needed areas only; avoid spraying water onto buildings, drives, walks, or into gutters.

5. Install nozzle heads designed for parking strips or corners, as appropriate.

6. Make certain that nozzle heads clear surrounding vegetation. If choosing to keep turfgrass longer between mowing, consider swapping 4-inch pop-ups with 6-inch pop-ups to ensure uniform distribution of irrigation water.

7. When eliminating turf areas to reduce water demand with alternative landscape, check to make certain that the spray heads watering that turf area are on a separate zone to ensure that the new low-water plantings don't get watered with the remaining turf.

8. Some high-efficiency irrigation components are eligible for rebates from the Central Utah Water Conservancy District. See the Resources Section for contact information.

9. Check to see that no sprinkler zone waters both turf and non-turf areas. If such zones exist, separate the watering by either converting the turf to non-turf landscape, or by capping the heads supplying water to either the turf or non-turf portion, and modifying the sprinkler system to water that portion by adding a zone or modifying an existing zone.

10. Consider replacing spray heads in shrub and perennial areas with low-flow emitters, such as drip. Be certain before beginning that the zone being converted only supplies water to that

area. Do not combine spray heads with low-flow components on a single zone.

Resources

American Landscape and Nursery Association www.anla.org

California Urban Water Conservation Council. 2002. H_2OUSE Water Saver Home. www.h2ouse.net.

Irrigation Association www.ia.org

Irrigation Training and Research Center, Cal-Poly State University, San Luis Obispo, CA. www.itrc.org.

National Turfgrass Evaluation Program www.ntep.org

PLANET Professional Landcare Network www.landcarenetwork.org

TPI Turfgrass Producers International www.turfgrasssod.org

Central Utah Water Conservancy District http://www.cuwcd.com/rebates/

Mp3 Rotator Spray Nozzle http://www.hunterindustries.com/products/mprotator/

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