BEST PRACTICE 9: Water Efficient Design, Installation, and Maintenance Practices for New and Existing Landscapes

- Programmatic and customer support best practice (utility perspective)
- Customer side best practice - Implemented by water customers with support from water utilities.
- Customer participation – Action by customers required for successful implementation.

Overview

How we design, install, and maintain our landscapes and irrigation systems can greatly impact the amount of water needed to keep the plants alive and healthy. This best practice describes key considerations for maximizing water efficiency through the proper design, installation, and maintenance of new and existing landscapes and irrigation systems. The information presented here is largely based on the work of the Green Industries of Colorado (GreenCO) published in their 2008 BMP guide (GreenCO 2008).

Recent studies suggest that technology alone will not render the level of efficiency desired in urban landscapes (Mayer, et. al. 2009). Irrigation must be addressed with a systems approach that includes design, installation, and maintenance as well as the selection of plant materials and individual irrigation technologies. Education of those operating and maintaining systems should not be overlooked.

Landscape design, installation, and maintenance practices offer a non-regulatory approach to improving outdoor water use efficiency. Proper design and installation can ensure landscapes are capable of thriving on less water. Maintenance practices can help preserve and ensure conservation savings. This best practice is wide ranging and includes many commonly used everyday practices.

The *Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability* (GreenCO 2008) is the fundamental companion document to this best practice. The GreenCO BMPs are richly detailed and provide tremendous detail on the methods and practices for ensuring water efficiency in Colorado landscapes. These BMPs were developed with broad stakeholder support and form the foundation for the best practices described below.

The seven basic principles of xeriscape, developed years ago by Denver Water (and others), remain the fundamental underpinning for conservation-oriented landscapes. These principles are: planning and design, soil improvement, grouping plants with similar water demands, practical turf areas, efficient irrigation, mulching, and appropriate maintenance. In the *Handbook of Water Use and Conservation*, (Vickers 2001) Amy Vickers adds one additional principal to this foundational list: selection of native and low-water-use plants.

Why a Best Practice?

In Colorado, urban landscape irrigation accounts for 50 percent or more of the total annual water demand for a utility.[19] Improving the efficiency of water use on urban landscapes is perhaps the single most important municipal water conservation effort than can be made in Colorado.

State Planning Requirements

Colorado statute requires that all covered entities (water providers that deliver more than 2,000 acre-feet per year) file a water conservation plan with the Colorado Water Conservation Board (CWCB). Entities that do not have an approved plan on file are not eligible to receive grant funding from the State. Under this statute, one of the water saving measures and programs that must be considered in a conservation plan is, "Low water use landscapes, drought-resistant vegetation, removal of phreatophytes, and efficient irrigation." [CRS 37-60-126 (4)(a)(II)].

Applicability

The water efficient landscape design, installation, and maintenance practices described in this best practice apply to both utility customers and landscape professionals who are designers, installers, irrigators, and maintainers of urban landscapes. An irrigator is defined here as anyone that regularly applies utility treated potable water to a landscape through a manual or automatic irrigation delivery system.

Many of the practices and principles described in this best practice will also apply to water utilities for their own irrigation practices and to their efforts to educate and inform their customers.

Implementation

Landscape Design

Whether developing an entirely new landscape or renovating an existing yard, properly planned and designed landscapes can conserve water and protect water quality. For both the do-it-yourself project and the professionally designed landscape, key considerations for water efficient landscape design include:

- Consider site conditions including existing slope, soil, drainage, and plants
- Provide soil most appropriate to the plants
- Use of native and low-water-use plants
- Limit turf areas to those needed for practical purposes
- Group plants according to their water needs (hydrozoning)
- Use efficient irrigation systems
- Mulch over soil and around plants to reduce evaporation

[19] AWWA (1999), Aquacraft (2007), Davis et. al. (2009), Grabow et. al. (2009), Mayer et. al. (2009), McReady (2009), County (2008), Dukes et. al. (2008), GreenCO (2008), Guz (2008), Jakubowski et. al. (2008), Haley et. al. (2007), US BOR (2007), NCWCD (2008), Baum (2005), CSU, (2005), PMSI (2005), Bamezai (2004), Barta (2004), CWRRI (2004), MWDOC (2008, and 2004), DeOreo et. al. (1998), CSU (1994).

The *Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability* (GreenCO 2008) includes 39 guidelines for landscape design in a detailed BMP. Key elements of this and other GreenCO BMPs are summarized into this best practice.

Site Considerations – "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." (GreenCO 2008) Groundcovers with lower water requirements are a good choice for slopes and hard-to-mow locations. Place lower-water demand plants at the tops of slopes and higher-demand plants at the bottom, in lower-lying drainage areas, near downspouts or in the shade of other plants.

Soil Condition – Evaluate the soil through tests and improve it, if necessary, to promote efficient water use and healthy plants (GreenCO 2008). In order to determine the proper soil amendments to use at a site, inexpensive soil tests like those conducted by the CSU Soil Testing Lab are recommended. The GreenCO BMPs offers useful guidance on soil amendments and testing. In general, the best soil amendments increase water and nutrient holding capacity while improving aeration and water infiltration which is critical to reducing water demands (Davis and Wilson 2005). In Colorado, there are many areas that have very rocky or porous, sandy soils and amendments can be useful in these soils. Another option is to select plants that thrive in sandy soils. Colorado is also known for its heavy clay soils with poor aeration which are found in many urban areas. Adding water to clay soils can cause oxygen starvation in the root zone. Clay soils can limit the growth of some plants, but many native and xeric plans have adapted well to clay soil and in fact prefer it over amended soil as long as it is not over-watered.

Plant Selection – Many plants are capable of thriving without supplemental irrigation. Reducing supplemental water requirements is fundamental to designing landscapes that are water efficient. Consider creating at least one part of the landscape that can thrive on available precipitation without additional irrigation (except during establishment and during unusually dry periods). Key resources to assist in plant selection include the *Annual and Perennial Plant Guide and Rocky Mountain Plant Guide* published by the Colorado Nursery and Greenhouse Association (www.coloradonga.org) and the X-rated gardening website maintained by the Garden Centers of Colorado (www.gardencentersofcolorado.org/xratedgardening2/) (GreenCO 2008).

Practical Turf Areas – "Limiting lawns to functional spaces devoted only to practical uses – for example, recreation and sitting areas – can significantly reduce landscape irrigation needs" (Vickers 2001). Turfgrass is often the plant with the highest water demand in a landscape, but many varieties of grass are now available including some which require less supplemental water. The CSU Turfgrass Program website (http://csuturf.colostate.edu/) offers the latest studies on the advantages and disadvantages of various grass species (GreenCO 2008).

Hydrozoning – Group plants with similar water requirements together. This practice is known as hydrozoning. The reason hydrozoning is so important is because irrigation systems should be designed to apply water evenly across each zone or area. If plants in one zone have different

water requirements, the irrigation system must be adjusted to meet the needs of the highest water use plant in the zone, thus delivering more water than is necessary to meet the needs of the rest of zone.

Efficient Irrigation – Efficient irrigation means applying the minimum amount of water required for a healthy landscape with an acceptable level of appearance. Efficient irrigation practices are important for both manual and automatic irrigators although most of the literature on this subject is devoted to automatic irrigation systems. Automatic irrigation is not required for effective and efficient irrigation and numerous studies have shown that manual irrigators use significantly less water on average than automatic irrigators (Mayer et. al. 1999). However, many people prefer the convenience of an automatic system.

In order to provide efficient irrigation, **"**Properly design, install and maintain irrigation systems to ensure uniform distribution[20] and efficient delivery of water, thereby conserving water and protecting water resources" (GreenCO 2008).

The Irrigation Association (IA) has established the five fundamental best practices for irrigation systems. They are as follows:

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 plant water requirements.

The GreenCO Colorado BMPs provide detailed information and additional resources on this large topic.

Mulch – Mulches are placed on the soil surface to reduce evaporation. GreenCO recommends using organic mulches to "reduce water loss through evaporation" and "to reduce soil loss due to exposure to wind and runoff and to suppress weeds and to provide a more uniform soil temperature" (GreenCO 2008). Use of mulch should be specified as part of a comprehensive water efficient landscape design.

Other benefits of mulch include:

- The reduction of weeds that compete with plants for moisture and soil nutrients
- Erosion control by allowing rainfall to be absorbed before running off
- Reducing soil compaction from rainfall and overhead irrigation
- Regulation of soil temperatures and reduction of damage to plants from freezing and thawing of the root zone
- Delineation of hydrozones

[20] Distribution uniformity is defined as the measure uniformity of irrigation water over an area (IA 2010).

It is important to select mulches that are appropriate for the hydrozone and plant type. Organic mulches break down with time and in so doing enrich the soil and improve the texture of the soil near the surface. Many plants selected for use in the landscape benefit from these characteristics of organic mulch.

Plants that have adapted to living under xeric conditions often perform better with the use of inorganic mulches. Many of these plants prefer soil without the addition of organic matter and have characteristics that enable them to thrive in poor soil with little or no irrigation. In fact the moisture retained by organic mulches can result in their early demise. The heat absorbed by inorganic mulch encourages plant growth and helps to reduce competition from weeds.

Other Design Considerations – Additional design considerations for maximizing landscape water efficiency include:

- In mountain areas in particular, wildfire hazards must be considered in any landscape design.
- Hardscapes are an often neglected element of landscape design. Hardscapes have no water requirement and as such form an important part in landscapes created to be water efficient.
- Wind can dramatically impact irrigation particularly if the sprinkler head creates a fine mist. In windy areas, sprinkler heads that produce larger drops of water should be considered.
- Water features including ponds, fountains, waterfalls, etc. are notoriously water wasteful even if designed to be re-circulating. Evaporative losses and unavoidable leaks place water features outside the boundary of good water efficient landscape design.

Landscape Installation

When installing a new landscape or replacing an existing landscape, minimize erosion and control sediment leaving the site during landscape installation, follow the landscape design plan carefully, and provide proper care of the landscape during installation (GreenCO 2008).

Sediment and erosion control practices summarized below, are detailed extensively in the *Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability* (GreenCO 2008).

- Protect existing plants and trees that are not to be impacted by the installation.
- Protect drainage areas from runoff.
- Comply with applicable stormwater permit requirements.
- Phase construction to limit exposed land.
- Properly store and if necessary cover topsoil and soil amendments (i.e. not in the street).
- Take special care with planted slopes to slow water runoff.
- Properly handle, store, and dispose of all chemicals, fertilizers and pesticides.

A significant portion of the installation best practices revolve around soil preparation because proper soil preparation can substantially reduce irrigation requirements by increasing water holding capacity.

Assuming that a water efficient landscape design has been completed, the installation process involves carefully following the design plan while minimizing impacts to neighboring properties and ecosystems and maintaining the health of existing plants and trees that are not to be impacted by the installation. GreenCO has identified the following areas for consideration during landscape installation (GreenCO 2008):

- Perform soil analysis to determine what amendments and fertilizer may be necessary.
- Properly amend soil as needed and till to a depth of 4 to 6 inches.
- Sow seeds at proper time of year and mulch seeded areas adequately to retain moisture.
- Maintain health of plants in containers prior to planting in the ground.
- Irrigate adequately and appropriately during the establishment period. Length of establishment varies with different plants.
- Conduct regular, routine inspections of new plantings and attend to any detected problems as soon as possible.

Irrigation System Installation[21]

Each irrigation system should be installed in accordance with design specifications as well as any applicable manufacturer specifications, local code requirements, and the fundamental principles of efficient and uniform water distribution (GreenCO 2008).

The irrigation system installation best practices, summarized below, are detailed extensively in the *Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability* (GreenCO 2008).

- Installation should not commence until all underground utilities are located and marked.
- Install the irrigation system in accordance with design specifications. Any alteration or deviation from the design should be approved in advance by the designer.
- The design and installation should both be completed by reputable professionals. (Please see best practice on certification of landscape professionals for additional information.)
- Ensure the water supply and pressure at the point of connection meet design criteria.
- On-the-ground reality often differs from plan drawings. Carefully review all site plans against what can be observed at the site to minimize conflicts between buildings, hardscape, plants of differing sizes, and sprinkler head placement.
- Alert the property owner and designers about unusual or unexpected site or soil conditions.
- Existing plants that do not receive supplemental irrigation may rely heavily on drainage for water to grow. Ensure that site drainage has not been altered.
- The irrigation designer (or other qualified inspector) and local authorities should perform at least one field observation during installation to ensure adherence to design specifications and local codes and to check for proper installation and function of the backflow prevention assembly, main line, pipes, valves, sprinklers, control wire, irrigation controller, and soil sensor(s) or rain shutoff device.

[21] This section of the best practice applies largely to in-ground automatic irrigation systems, although many of the same principles apply to manual irrigation systems as well.

- Furnish “as-built” record drawings to the owner of the system.
- Test the irrigation system to verify that the system meets the design criteria and delivers water uniformly in each zone.
- Create an irrigation schedule to meet the water requirements of the plants with minimal runoff. Understand that the establishment schedule will differ from normal operational schedule. Re-evaluate the irrigation schedule regularly to ensure efficiency and adequacy.
- Perform a thorough inspection of the system after installation and perform an irrigation efficiency evaluation of the site using established IA procedures after one year of operation of the new system (see Best Practice 10). Make any necessary repairs and adjustments.

Landscape Maintenance

To ensure optimum water efficiency, practice regular and appropriate maintenance for the landscape including (but not limited to): spring clean-up, mowing, aeration, pruning, weeding, mulching, fertilization and attention to the irrigation system (GreenCO 2008).

The landscape maintenance best practices, summarized below, are detailed extensively in the *Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability* (GreenCO 2008).

- Remove dead or dying plants and all weeds that compete with healthy plants for available water. Clean up plant litter and remove weeds before they go to seed.
- Replace or replenish mulch in areas where it has deteriorated.
- Aerate turf in the spring and in the fall, if needed, to eliminate compaction and improve the turf’s ability to take up moisture, nutrients and air.

Irrigation System Maintenance and Operation

Automatic irrigation systems must be maintained regularly to ensure efficient performance and uniform distribution of water. In Colorado, this minimally includes a check-up in the spring when the system is turned on and a winterization before the first hard freeze. During the irrigation season, the irrigation schedule should be modified to accommodate changing plant water needs and repairs should be made as required.

The irrigation system maintenance best practices, summarized below, are detailed extensively in the *Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado: Moving Toward Sustainability* (GreenCO 2008).

- Establish a systematic maintenance schedule for inspecting, testing and reporting on performance conditions of the irrigation system.
- Check, adjust and repair irrigation equipment on a regular basis, ideally on a weekly schedule and within 24 hours of mowing, whenever possible.
- The person mowing the property is often in the best position to identify broken or misaligned heads, overly wet areas, and other potential problems. As part of day-to-day maintenance, staff should understand the irrigation system basics and be able to recognize system problems.

- Set mower height appropriately.
- Identify irrigation system leaks and repair them promptly.
- Where applicable, post irrigation schedules, zone location map and other relevant programming information in or near each controller (or clearly identify where information is kept).
- Employ a certified landscape irrigation auditor at least once every five years to conduct a thorough and comprehensive check for efficiency of water application.
- Make adjustments whenever irrigation water falls or runs onto hard surfaces such as sidewalks, streets or driveways.
- Check for leaks. 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.
- 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.
- 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. Time of day can affect pressure. Pressure measurements should be made at the same time of day the irrigation is likely to occur. Install pressure reducing valves (PRVs) 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 ideal, but not required in all areas.
- 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.
- Install a master valve. This prevents leakage from the irrigation system when the system is not in use.
- Verify that sprinklers are properly adjusted—check the nozzle, arc, radius, level and altitude 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.
- Test all repairs.
- Ensure that the replacement hardware used for system repairs matches the existing hardware, and is in accordance with the design.
- As plants mature, trim or remove vegetation as required to preserve system performance.
- Re-program automatic controllers (if necessary) to meet the seasonal plant needs.

Water Savings and Other Benefits

A well designed, installed, and maintained landscape and irrigation system should use substantially less water than a poorly maintained landscape and irrigation system on a similar property.

Range of Likely Water Savings: Varies

The water savings achievable from well designed, installed, and maintained landscapes and irrigation systems are not well quantified. For some landscapes the savings will be substantial, on the order of 30 – 50%, but for others there may no measurable savings achieved and in some cases water use may even increase as a result of changes made to the landscape or irrigation system.

The 2004 YARDX study of Xeriscape sponsored by Metro Water Conservation, Inc. of Denver and the U.S. Bureau of Reclamation, in partnership with nine water utilities examined water use from 1997 through 2002 and compared outdoor water use for traditional (pre-existing) and waterwise landscaping along Colorado's Front Range. The YARDX study found that water efficient landscapes could consistently obtain water savings of 30%, and up to 50%, over traditional landscaping (Medina and Gumper 2004).

The water saving benefits of implementing the recommendations of this best practice will be experienced over many years and likely cannot be accurately measured without great effort. From a water savings perspective the key is that only the necessary amount of water is applied to the landscape and over irrigation is eliminated. A recent study in California found that eliminating over irrigation in sites that had historically over irrigated would reduce outdoor use in single-family homes by about 30%, or about a 15% reduction in total use (DeOreo et. al. 2010). It is estimated that full implementation of the recommendations in this best practice resulting in the elimination of over-irrigation will result in outdoor water savings in the range of 10 – 40% (and total savings in the range of 5 – 20%) over the period of time the landscape remains in place compared with a similar poorly designed, installed, and maintained landscape.

How to Determine Savings

For existing landscapes that are upgraded and improved using the recommendations of this best practice, water savings can be measured by comparing weather-adjusted billed consumption data from pre- and post-completion time periods. For new landscapes that are designed and installed implementing the recommendations from this best practice, it may be possible to determine water savings by comparing water use against similar, neighboring sites that did not implement the recommendations of this best practice. However, this type of analysis must be carefully designed to yield reliable results.

Savings Assumptions and Caveats

Although irrigation accounts for approximately 50% of urban water use in Colorado, the extent of over irrigation and inefficient irrigation is not well understood. The 1999 *Residential End Uses of Water* study found that homes in Denver applied about 85% of the net ET requirement for turfgrass on average while homes in Boulder applied about 68% (Mayer et. al. 1999).

Water savings are achieved by eliminating over-irrigation and by reducing irrigation demands by changing plant materials and improving landscaping practices. If over-irrigation is not occurring, there is little potential to save through irrigation efficiency improvements. Although some people believe over-irrigation is rampant in Colorado, the available data and studies do not support this notion. Over-irrigation is only a problem in a relatively small percentage of properties in any utility service area. Fortunately, it is possible to identify over-irrigators using historic consumption data and a measurement (or even an estimate) of the landscape area. Using landscape area and billed consumption, the amount of water applied over the course of a year can be calculated and compared against the net ET rate (net ET) for the same time period. Sites with an irrigation application greater the net ET are the best candidates for irrigation demand reductions.

Goals and Benchmarks

A reasonable goal or benchmark for landscape irrigation can be calculated for any site in Colorado assuming climate data and the landscape area are available. The Theoretical Irrigation Requirement (TIR) for a site can be calculated using the following equation:

Theoretical Irrigation Requirement (TIR) (inches) = (ET_o x kc) – Effective Precipitation

Where:

ET_o = Gross annual ET (inches)[22]

Effective Precipitation = effective precipitation (inches) which is the useful amount of precipitation stored in the soil in a 24-hour period.

k_c = ET adjustment factor or crop/landscape coefficient (a default value of 0.8 is a recommended starting point and upper limit for a water efficient landscape. Many landscapes, particularly those featuring the principles of xeriscape and/or water wise plantings, should have a lower k_c ranging from 0.5 to 0.7.[23]

In Colorado, expect TIR values to range from 10 to 30 inches depending upon the ET_o rate, amount of precipitation and the water requirements of the plants in the landscape.

Other Benefits

In addition to water efficiency, well-designed and maintained landscapes also improve stormwater management, provide recreation opportunities, offer habitat to local wildlife, provide aesthetic benefits, and help reduce non-point source pollution through reduced runoff (GreenCO 2008). Well designed and maintained landscapes are also healthier and look better.

[22] ETo is more formally defined as "the rate of ET from a hypothetical reference crop with an assumed crop height of 0.12 m (4.72 in), a fixed surface resistance of 70 sec m^{-1} (70 sec $3.2ft^{-1}$) and an albedo of 0.23, closely resembling the ET from an extensive surface of green grass of uniform height, actively growing, well-watered, and completely shading the ground". http://edis.ifas.ufl.edu/ae256

[23] The GreenCO landscape BMPs offer an detailed information about crop coefficients in Appendix E - http://greenco.org/bmp_downloads/BMP_Manual_Appendices.pdf.

Xeriscape plants also provide drought flexibility. In times of drought and mandatory water restrictions, low-water using plants may survive better and therefore reduce replacement costs.

Costs

Utility Costs

There are no utility costs associated with customers implementing the recommendations of this best practice. Some utilities have developed programs to encourage water wise landscapes and efficient irrigation by offering classes, rebates (for turf removal or purchase of low-water requirement plants), or by providing low interest loans for water wise landscape projects. These utility programs are likely to only be cost effective in communities with expensive new water supply projects that might be avoided or delayed through conservation.

Customer Costs

Landscaping costs vary enormously depending upon what work is being done, who is doing it, and the condition of the existing landscape. A local Colorado landscape professional reviewed 18 professional xeric landscape installations that her company performed over the past three years and found tremendous variability in the per square foot costs. The cost data below is provided for informational purposes and to illustrate the possible range of customer costs associated with a professionally installed xeriscape. Please understand that prices will vary and may be more or less than those presented here.

Site Preparation

Most landscape projects require that the existing landscape be removed to make way for the new landscape to be installed. The costs for site preparation varied from $0.43/SF to $3.75/SF with most site prep work falling between $0.60/SF and $1.40/SF (Peck 2010).

Installation Costs

Installation costs depend largely upon the level of planting vs. hardscape and irrigation (i.e. no system, new system, or rehab of existing system).

Least Expensive

The least expensive installations are only plantings (no hardscape), using mostly shrubs and some sod or seeded turfgrass areas. Low cost installations do not have in-ground sprinklers and drip irrigation (if installed) is accomplished by attaching drip lines to a hose bib. An estimated cost for a basic installation such as this is approximately $4.00/SF (Peck 2010). Lower cost installations are also possible. The “Garden in a Box” program offered by Boulder’s Center for Resource Conservation in 2010 provided plant materials for under $3/SF (Woodward 2010).

Lower Mid-Range

The next tier of water efficient landscapes have more extensive shrub plantings with drip irrigation, limited turf area (less than 25% of total area) with in-ground irrigation, and some perennial flowers and ground covers (less than 20% of total area). These landscape installations often include some boulders and/or flagstone walkways or stepping stones (less than 10% of total area). Most of these landscapes were renovations of entire suburban lots,

and the costs were fairly consistent at $8 - $9.50/SF. The size of the plants installed can impact the cost and Peck explained that these installations all used 1 gallon shrubs instead of 5 gallon shrubs along with flats of perennial flowers and ground covers instead of 1 gallon plants whenever possible.

Upper Mid-Range
Landscapes that are similar to the lower mid-range but which include more hardscape and larger sized plants cost $14 - $18/SF to install.

Most Expensive
There is really no upper limit to the amount of money that can be spent on a landscape, but landscapes with extensive hardscape, large boulder placements, flagstone patios and walkways, and elaborate irrigation systems cost in range of $22 - $24/SF to install. Peck reported that installing flagstone mortared over concrete was significantly more expensive than installing dry laid flagstone.

Resources and Examples

Resources

Handbook of Water Use and Conservation, Amy Vickers, 2001, Water Plow Press, Amherst, MA

Xeriscape Plant Guide, 1999, Fulcrum and Denver Water and AWWA, Denver, CO.

Xeriscape Handbook: A How-To Guide to Natural, Resource-Wise Gardening, Gayle Weinstein, 1999, Fulcrum Publishing.

Waterwise Landscaping with Trees, Shrubs, and Vines: A Xeriscape Guide for the Rocky Mountain Region, California, and the Desert Southwest, James M Knopf (Editor), Maureen McIntyre (Illustrator), 1999, Charisma Books.

The Xeriscape Flower Gardener: A Waterwise Guide for the Rocky Mountain Region, Jim Knopf, 1991, Johnson Books.

Dry-Land Gardening: A Xeriscaping Guide for Dry-Summer, Cold-Winter Climates, Jennifer Bennett, 1998, Firefly Books.

Residential Landscape Architecture: Design Process for the Private Residence, Norman K. Booth and James E. Hiss, 1998, Prentice Hall.

Landscaping : Principles and Practices : The Residential Design Workbook, Ferrell Bridwell, 1997, Delmar Publishing.

Landscape Plants for Western Regions: An Illustrated Guide to Plants for Water Conservation, by Bob Perry, Land Design Publishing, 1992 (Out of Print – Only Available Used or Library Loan)

Examples

There are numerous water efficient demonstration gardens across Colorado, but a few locations stand out as offering exceptional examples of water wise plantings and irrigation methods.

Northern Colorado Water Conservancy District – Berthoud
Northern Water's Conservation Gardens contain more than 700 plants and 60 turfgrasses that thrive in Colorado's arid climate. The gardens are located behind the Northern Water headquarters building at 220 Water Ave, Berthoud, CO 80513. The gardens and the adjoining Colorado-Big Thompson Project Interpretive Area are free and open to the public seven days a week April through September during daylight hours. For more information visit: www.ncwcd.org/ncwcd_about/gardens.asp

Aurora Municipal Xeriscape Garden
The Aurora Municipal Center (AMC) Xeriscape Garden is a high plains garden made up of six acres of rolling hills and beautiful plants. The garden is located at the northwest corner of Alameda Parkway and Chambers Road and is open from dawn to dusk daily. Built in 2002 to serve as an example of low-water use landscaping, the garden includes a variety of plants clearly labeled so visitors can take ideas home and use them in their own yard. Signs also explain the seven steps of xeriscape. The garden requires very little water and when irrigated, is watered with reclaimed water (nonpotable water) from Aurora's Sand Creek Wastewater Reclamation Plant. For more information visit: www.auroragov.org/AuroraGov/Departments/AuroraWater/WaterConservation/OutdoorWater/042655?ssSourceNodeId=658&ssSourceSiteId=621

Colorado Springs Utilities Conservation and Environmental Center
Located at 2855 Mesa Road in Colorado Springs and open Monday through Friday, 8 a.m. through 5 p.m., the Colorado Springs Conservation and Environmental Center includes an extensive water wise demonstration garden. For more information visit: www.csu.org/residential/environment/cec/item1034.html

Denver Botanic Gardens
The Denver Botanic Gardens maintains a large collection of native and low water use plants. They also offer trainings in topics such as "Rocky Mountain Gardening" which includes instruction in water wise landscaping. www.botanicgardens.org/

Denver Water Xeriscape Demonstration Garden
Denver Water's xeriscape demonstration garden showcases over 200 plant types on two-thirds of an acre. The garden features interpretive signs and literature. It is also the oldest xeriscape garden in the country. The garden is located at 1600 West 12th Avenue, Denver, CO 80204. www.denverwater.org/Conservation/Xeriscape/

Colorado WaterWise
Colorado WaterWise's website features 11 Xeriscape gardens in Colorado, including photos, features, websites and location. For more information visit: http://coloradowaterwise.org//index.php?option=com_content&task=category&sectionid=10&id=64&Itemid=239.