Attachment 3.

Literature Review to Assist in Quantification of Expected Benefits of Landscape Water Conservation Best Management Practices (BMPs)

This attachment provides "working notes" and summaries compiled during the literature review effort and are intended to be used as general supplemental information for those desiring more information on various references. In some cases, text was copied electronically from the source document's Executive Summary or Abstract as a means to efficiently and accurately transfer data.

DRAFT--INTERNAL WORKING NOTES

1. **Mecham, B., & Boyd, R. (2004).** ***Case Study: Landscape Irrigation Efficiency of Nine Model Homes.*** **Loveland: Northern Colorado Water Conservancy District.**

General Category: Irrigation, Soils

GreenCO BMP Category: Irrigation Technology, Irrigation Efficiency, Soil Amendment/Ground Preparation

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: Nine single-family model homes in an entry-level housing development were selected for a study to determine if changes in landscape maintenance would produce information on how to better manage lawn watering.

Year(s) Data Collected: Spring 2003

Quantitative/Qualitative: Provides *quantitative* findings of study but with multiple BMPs in place (drip irrigation, soil preparation, and irrigation technology). Provides good background information regarding basis of study

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Drip irrigation and soil preparation had the least amount of excess water usage.
- Improved sprinkler system installation helped conserve
- Landscape appearance began to override the concept of water conservation (looks vs. conservation)
- Lack of communication between all parties involved provided an obstacle to achieving the desired results or reducing water usage.

Limitations: Limited sample size.

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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2. ***Drought Tolerance of Bedding Plant Annuals.* (n.d.). Retrieved from Colorado State University Horticulture and Landscape Architecture: http://www.specialtycrops.colostate.edu/grower_grants/2003/2003_gg_drought_tol.htm**

General Category: Plant Selection, Water Budgeting, Irrigation, Soils Amendment/Ground Preparation

GreenCO BMP Category: Irrigation System Design, Soil Amendment/Ground Preparation

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: As an association of many independently owned garden centers, the Garden Centers of Colorado initiated the X-rated Program to give their customers solutions to drought related problems. The X-rated List is a list of annual, perennials, shrubs and trees that are able to tolerate lower levels of water. The objective of this experiment was to determine how much irrigation water is necessary to maintain healthy bedding plants by being irrigated at five different levels: 100% ET, 75% ET, 50% ET, 25% ET, and 0% ET.

Year(s) Data Collected: Spring and Summer 2003

Quantitative/Qualitative: Provides *quantified* information regarding at what level (100% ET, 75% ET, 50% ET, 25% ET, and 0% ET) certain plants can survive.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A
Summary of Findings Related to Landscape Water Conservation BMPs:

- Provides information on how much irrigation water is necessary to maintain healthy bedding plants.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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3. **Center for ReSource Conservation. (2007).** ***Irrigation Inspection Program: Impacts of Slow the Flow Colorado on Outdoor Water Use.***

General Category: Irrigation, Soils

GreenCO BMP Category: Irrigation System Design, Soil Amendment/Ground Preparation, Irrigation System Installation, Irrigation Efficiency Audits

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: In 2007, the Center for ReSource Conservation (CRC)'s Slow the Flow Colorado Program performed 1256 irrigation inspections across Colorado's Front Range. In an irrigation inspection, a CRC auditor tests a property's irrigation system for efficiency, and recommends an irrigation schedule as well as other improvements that can improve the system's efficiency.

Year(s) Data Collected: 2007

Quantitative/Qualitative: Qualitative information with regards to landscape BMPs. Gives detailed quantitative information regarding before and after audit water usage.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Distribution Uniformity and system operating at incorrect pressure
- 79% of participants that watered at rates above ET prior to the inspection reduced their water usage after the inspection.
- Of the inspected zones, only 12.31% were found to be efficient.

Limitations:

- Does not quantify conservation benefits of individual BMPs.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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4. Aquacraft, Inc.. (2003). *Report on Performance of ET Based Irrigation Controller.*

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: In the Spring of 2000, the cities of Boulder, Longmont, and Greeley, Colorado began a small pilot study of the reliability and effectiveness of the WeatherTRAK ET signal controller. The purpose of this study was to document the performance of the system in actual field conditions at homes of volunteer customers.

Year(s) Data Collected: Between 2000 and 2002

Quantitative/Qualitative: *Quantitative* information regarding how the WeatherTRAK controller works

Cost Data: ☐ N/A ☒ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data:

- The four participants that saved water with the WeatherTRAK system also saved an average of $190 per year in water charges. This was based on the weighted average water rates of $2.40 per kgal in effect in the three cities during 2002.

Summary of Findings Related to Landscape Water Conservation BMPs:

- As a group, the seven sites saved an average of 35,000 gal of water per site compared to their historical use.
- If only the four participants who saved significant amounts of water were included, their average annual savings were 64,000 gallons per site. This shows greater savings potential if the program focuses on high users.

Limitations:

- Some of the study was conducted during the 2002 drought

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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5. **Barta, R. (2004).** ***Stretching Urban Water Supplies in Colorado, Strategies for Landscape Water Conservation.*** **(Barta, 2004)**

General Category: Irrigation, Water Budgeting

GreenCO BMP Category: Irrigation Scheduling, Water Budgeting

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: In response to the suggestion for a consistent comparison of urban landscape water conservation practices, this study examines commonly accepted and emerging strategies for landscape water conservation. The study attempts to enhance the dialogue between the landscape industry in Colorado and the municipalities that supply water for urban landscapes by systematically, and where possible, scientifically defining options for managing urban landscape water use. The study synthesizes existing knowledge on the range of options available for reducing landscape water use; reviews the literature regarding the advantages and disadvantages of each option; and attempts to define a Colorado context for examining urban landscape water conservation strategies.

Year(s) Data Collected: Prior to February 2004

Quantitative/Qualitative: Primarily qualitative

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- "There is not sufficient peer-reviewed literature to scientifically evaluate the effectiveness of urban landscape water conservation strategies."

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

- Use bibliography for additional references
- Summary data provided from other reports

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6. **Western Resource Advocates. (2003).** ***Smart Water: A Comparative Study of Urban Water Use Efficiency Across the Southwest.***

General Category: Xeriscape, Irrigation

GreenCO BMP Category: Xeriscape, Irrigation Technology and Scheduling

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: Western Resource Advocates distributed a comprehensive Smart Water survey to 32 urban water providers throughout the Southwest. The survey contained several dozen questions related to retail water demand in calendar years 1994 and 2001 and asked for water management plans and related materials. A total of 13 water providers including those for major urban areas in Arizona, Colorado, New Mexico, Nevada, Texas, and Utah participated by submitting survey data during the summer and fall of 2002.

Year(s) Data Collected: 2001, 2002

Quantitative/Qualitative: Mostly *qualitative* with a little information describing the quantitative effects of drought restrictions. It does not provide quantitative results for xeriscape and irrigation technology.

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- While gathering conservation program data for this report, WRA discovered a distinct lack of analyses by water providers related to water savings effectiveness and cost-effectiveness of specific conservation programs. Although benefit/cost analysis is a common tool for justifying structural water supply improvements and planning in other areas, this tool is rarely applied to assess the cost-effectiveness of water conservation measures.
- Michelson (1998) conducted a study for AWWARF that reached a similar conclusion. A lack of detailed and consistent program monitoring makes it extremely difficult to perform an objective analysis of program effectiveness.
- The majority of water providers have not assessed the cost-effectiveness of their particular conservation programs. Although detailed benefit/cost analyses are often conducted to justify structural water supply improvements, this level of analysis for water use efficiency measures is virtually non-existent.
- Rebate and retrofit programs:

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- Cash for grass: $1.00 per square foot of landscape converted from turfgrass to Xeriscape
- $50 rain sensor rebate
- $200 soil moisture sensor rebate
- $50 multi-setting irrigation clock rebate
- 50 percent reimbursement of cost for drip irrigation materials and installation

Summary of Findings Related to Landscape Water Conservation BMPs:

- Provides basic climate data for urban areas included in Smart Water report

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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7. **State of California Department of Water Resources. (2008). *Urban Drought Guidebook.***

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology and Scheduling

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: To help local agencies and communities prepare for the possibility of another dry year and possible water supply interruptions, the Department of Water Resources is pleased to publish this updated version of the Urban Drought Guidebook. Drought, climate change, natural disasters, and environmental protections can all affect water supplies. Good planning and preparation can help agencies maintain reliable supplies and reduce the impacts of supply interruptions. We, the U. S. Bureau of Reclamation, and the California Urban Water Conservation Council worked together on the guidebook to provide technical assistance to local water suppliers.

Year(s) Data Collected: Prior to 2008

Quantitative/Qualitative: Primarily qualitative

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- Provides table of water conservation alternatives with the cost-effectiveness on a scale of 1 to 3

Summary of Findings Related to Landscape Water Conservation BMPs:

- Provides estimated savings for certain landscape BMPs, but does not provide basis of savings
- Appendix H: Water Efficient Landscape Websites may be helpful

Limitations:

- Majority is a California based study, but it does reference Denver, Colorado in it as well.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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8. **DeOreo, W. B., Lander, P. W., Qualls, R. J., & Scott, a. J. (1998).** ***Soil Moisture Sensors: Are They A Neglected Tool?***

General Category: Irrigation Technology: Watermark Soil Moisture Sensors and Electronic Modules

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☒ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: The City of Boulder, CO began studying Soil Moisture Sensors as a method of conserving outdoor use water in 1992. The Office of Water Conservation and Department of Public Works installed and monitored over 50 Watermark Soil Moisture Sensors and Electronic Modules on existing irrigation systems throughout the City. These were installed on private homes, association common areas, and public street medians and parks. To date, a total of four project reports, three papers and one master thesis have been prepared on the studies.

Year(s) Data Collected: 1997

Quantitative/Qualitative: A quantitative report based on the Watermark irrigation control technology in Boulder, Colorado

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- The results of this study were quite encouraging from the standpoint of both irrigation efficiency and cost effectiveness. On a seasonal basis, the systems limited applications to an average of 76% of theoretical requirement when all sites are combined.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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9. **AquaCraft. (2002).** ***Performance Evaluation of WeatherTRAK Irrigation Controllers in Colorado.*** **http://www.weathertrak.com/pdfs/studies/Aquacraft_Colorado_WeatherTRAK_Field_Study_Year_1.pdf.**

General Category: Irrigation Technology: WeatherTRAK Irrigation Controllers

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☒ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: Beginning in 2000, the Cities of Boulder, Longmont and Greeley Colorado began a field study aimed at determining the performance of the WeatherTRAK system in actual field use within their service area. A total of 10 sites were selected for the study from a combination of volunteers and high water using accounts. A total of nine residential and 1 office accounts were included in the study. The actual irrigation applications of each system were tracked against the theoretical requirements for the 2001 season, and the results are summarized in this report.

Year(s) Data Collected: 2000-2002

Quantitative/Qualitative: A quantitative report based on the WeatherTRAK Irrigation Controllers

Cost Data: ☐ N/A ☒ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data:

- The 5 participants that saved water with the Weather TRAK system also saved an average of $197 per year in water charges. This was based on weighted average water rates of $2.40 per kgal.

Summary of Findings Related to Landscape Water Conservation BMPs:

- As a group, the 10 sites saved an average of 26,000 gal of water per site compared to their historical use.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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10. Colorado State University Cooperative Extension. (1994). *Best Management Practices for Irrigation Management.* http://www.ext.colostate.edu/Pubs/crops/xcm173.pdf.

General Category: Irrigation

GreenCO BMP Category: Irrigation System Design

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐Government/Agency ☒ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: Best Management Practices (BMPs) for the use of irrigation water can help increase efficiency and uniformity and reduce contamination of water resources. Because each farm is unique, producers must evaluate their systems to determine which BMPs are suitable for their operations. Irrigation management BMPs include irrigation scheduling, equipment modification, land leveling, tailwater recovery, proper tillage and residue management, and chemigation safety.

Year(s) Data Collected: Prior to 2004

Quantitative/Qualitative: A qualitative report with a little quantitative research

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Table 3. Estimated seasonal consumptive water use for selected crops and sites
- Table 5: Approximate Efficiency of Various Irrigation Application Methods

Limitations:

- Targets agricultural applications rather than urban landscapes

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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11. Colorado Water Resources Research Institute. (2004). *Colorado High Plains Irrigation Practices Guide: Water Saving Options for Irrigators in Eastern Colorado.* http://digitool.library.colostate.edu/view/action/singleViewer.do?dvs=1240332311084~872.

General Category: Irrigation

GreenCO BMP Category: Irrigation Efficiency

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: The Colorado state office of the USDA Natural Resources Conservation Service (NRCS) asked Colorado State University faculty in 2003 to summarize irrigation practices that offer potential water savings at the field or farm level. The purpose of this report is to provide a summary of the documented water savings options for irrigators in Colorado. The report provides a significant amount of detail regarding what options are available for water conservation, how these options are used to conserve water, and expected water savings that can be achieved through various irrigation conservation practices.

Year(s) Data Collected: Prior to 2004

Quantitative/Qualitative: A qualitative report with a large portion of quantitative information

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Provides potential field efficiency ranges for different irrigation techniques

Limitations:

- Targeted to agriculture rather than urban landscapes

Expected Transferability of Findings in Developing Quantitative Estimates: ☐ High ☐ Medium ☒ Low

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12. Colorado State University Extension. (2005). *Irrigation Scheduling: The Water Balance Approach.* http://www.ext.colostate.edu/pubs/crops/04707.html.

General Category: Ways to determine irrigation needs

GreenCO BMP Category:

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description:

Year(s) Data Collected:

Quantitative/Qualitative: A quantitative report that supplies lots of information on how to estimate soil water content.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Provides information regarding crop coefficients; typical available water holding capacities based on soil texture; rooting depths, effective cover and allowable depletion for selected crops

Limitations:

- Agriculturally targeted, as opposed to urban landscape oriented

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

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13. Bauer, J. (2008). ***Lessons Learned from Field Monitoring of Customer-led Programming of SMART Irrigation Controllers*** **. http://www.watersmartinnovations.com/2009/sessions-all.php?year=2008.**

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: A Powerpoint presentation by the East Bay Municipal Utility District that focuses on how necessary and how effective water agency intervention is in the programming and monitoring of the controllers to achieve successful water savings and customer satisfaction

Year(s) Data Collected: July 2006 - June 2007

Quantitative/Qualitative: A qualitative presentation with basic water saving quantification.

Cost Data: ☐ N/A ☒ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data:

- Incentive offer based on the account's average irrigation water use over the past three years.
- Moved to a fixed rebate program that is paid after the inspection.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Customer programmed: 41% water savings
- Gardener programmed: 18% water savings
- Contractor programmed: 41% water savings

Limitations:

- PowerPoint presentation so it lacks detailed background information

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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14. City of Henderson, Nevada. (2008). *Turf Removal Loan Program* . http://www.watersmartinnovations.com/2009/sessions-all.php?year=2008.

General Category: Xeriscape

GreenCO BMP Category: Xeriscape

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: A PowerPoint presentation by the City of Henderson Department of Utility Services that describes the components of the turf removal loan program.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A qualitative presentation with basic water saving quantification.

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- Up front cost: $2-$5 per square foot
- 3-5-7 Plan
  - 3% interest
  - $5000 maximum loan
  - 7 year deferred payment schedule

Summary of Findings Related to Landscape Water Conservation BMPs:

- Southern Nevada Water Authority (SNWA) Water Smart Landscape Rebate Program: Reduce water consumption by 50-70 gallons per square foot of turf converted

Limitations:

- PowerPoint presentation so it lacks detailed background information

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

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15. New Mexico State University. (2008). ***Crop Coefficients for Scheduling Irrigations on Drought Tolerant Landscapes.*** **http://www.watersmartinnovations.com/2009/sessions-all.php?year=2008.**

General Category: Xeriscape

GreenCO BMP Category: Xeriscape

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: A Powerpoint presentation describing a project study with these objectives:

- Establish and maintain a live exhibit of various native or drought tolerant plants that have potential for use in urban landscapes of the western U.S.
- Evaluate the growth and quality of each species under variable levels of irrigation in an effort to formulate (crop) coefficients for these landscapes.

Year(s) Data Collected: 2003-2007

Quantitative/Qualitative: A qualitative presentation with good quantitative study results.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Valuable exhibit of drought tolerant species that have potential for western, semi-arid urban landscapes
- Some valuable insight into the water requirements of xeric adapted species including estimates of baseline K_Ls that can be used for efficient irrigation scheduling

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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16. **Municipal Water District of Orange County. (2008).** ***Effectiveness of Runoff-Reducing Weather-Based Irrigation Controllers (Smartimers).*** **Retrieved from http://www.watersmartinnovations.com/2009/sessions-all.php?year=2008**

General Category: Irrigation
GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: A PowerPoint presentation describing a project study of 4,100 SmarTimers installed in residential and commercial settings throughout Orange County with these objectives:

- Determine effectiveness of SmarTimers
  - across brands
  - Overall-residential and commercial
- Reduce outdoor water use
- Maintain healthy and attractive landscaping
- Reduce runoff and improve water quality

Year(s) Data Collected: 2004-2006

Quantitative/Qualitative: A qualitative presentation with good quantitative study results.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Single Family Residential Installation
  - Savings of 18.3 gpd for 899 water accounts –
  - 439 water accounts (49%) not significantly different
  - 460 water accounts (51%) had significant different water usage – 294 saved, 166 used more
  - Net average savings of 35.7 gpd for SFR participants
- Commercial Accounts:
  - 189 accounts (59%) not significantly different
  - 134 accounts (41%) had significantly different water usage: 98 saved, 36 used more
  - Net average savings of 460 gd

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Limitations:

- The data for this study were not normalized for weather with advanced statistical modeling.
- The results obtained from the retrofit participants in this study were not compared to a control set of similar participants.

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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17. Maddaus, M., Maddaus, W., Torre, M., & Harris, R. (2008). Innovative Water Conservation Supports Sustainable Housing Development. *Journal AWWA*, May. 100 (5), pp. 104-111. http://www.awwa.org/WaterWiser/watch/AWWA_Orlando_PaperonWaterEfficient%20Development.pdf

General Category: Xeriscape, Irrigation

GreenCO BMP Category: Xeriscape, Irrigation System Design

Study Type: ☒ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: To meet stringent regulations on water usage by its residents due to long-term water supply limitations, the developer of the new 600-acre Alamo Creek community in Danville, CA was faced with the challenge of how to build and market a new community while dramatically reducing the amount of water that would normally be consumed. The concept used for the development was a "zero water footprint," essentially offsetting new water requirements by funding water conservation in another part of the EBMUD service area. Plans call for minimizing water use on new lots, while paying a fee to EBMUD to facilitate conservation in other parts of the service area. This is a similar concept to pollutant trading.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A quantitative, planning-level study.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data: Developer pays EBMUD $6,000 per new home to fund conservation projects in another part of the service area, offsetting new demand on a 2:1 basis. Plan is to invest about $ 9 million to save 0.9 mgd from program that EBMUD will undertake that are over and above the current aggressive conservation plan.

Summary of Findings Related to Landscape Water Conservation BMPs:

- An average water usage budget established per lot (for each home) of 320 gallons of water per day, with most of the water reductions coming from lower water usage for landscaping. By comparison, most customers in EBMUD's service area use in excess of 500 gallons of water per day, per residence.

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- The aggressive water savings of 27% will be accomplished through multiple measures indoor and outdoor measures, including these landscape measures:
    - Covenant-required Xeriscape landscaping (estimated overall single family savings 22,000 gal/day, relative to 207,000 gal/day baseline)
    - Low water use landscaping on common areas and street medians
    - Use of ET controllers
    - Use of artificial turf on a soccer field
    - Use of recycled water for all large turf irrigation (much of the savings is due to use of recycled water)
    - Extensive training programs for landscape contractors and home owners
    - Surcharge premiums enforced by the Alamo Creek Homeowners Association to home owners who use more water than budgeted for their individual homes
- A portion of the off-site measures implemented by EBMUD include ET irrigation controllers, with an expected savings of 25%.
- Water savings (indoor and outdoor) are estimated at 20-30%.

Limitations: Data not yet available; planning level information only. In 2007, an 8-10 year buildout was planned.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low (*at present time*)

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18. Ewing Irrigation Products. (2008). ***Action Audits! What You Don't Understand Can Save a Significant Amount of Water.*** **Retrieved from http://www.watersmartinnovations.com/2009/sessions-all.php?year=2008.**

General Category: Irrigation

GreenCO BMP Category: Irrigation Efficiency Audits, Irrigation System Design

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐Government/Agency ☐ University ☐ Manufacturer (Irrigation Distributor)

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: PowerPoint presentation with general information about irrigation efficiency audits and distribution uniformity.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A qualitative presentation with basic quantitative information about water savings with improved irrigation efficiency.

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- Replace spray nozzles with MP Rotator type technology at $12/head

Summary of Findings Related to Landscape Water Conservation BMPs:

- Audits determine uniformity and net precipitation rate which are used to determine a watering schedule
- Las Vegas, NV: Savings on 1 acre of turfgrass = 38,340 gallons/week if DU is increased from 48% to 70% with a weekly water requirement of 2.17”/week

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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19. Rain Bird . (2003). *Irrigation for a Growing World.* http://www.rainbird.com/pdf/iuow/iuow_whitepapers.pdf.

General Category: Irrigation

GreenCO BMP Category: Irrigation Efficiency, Irrigation System Design

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐Government/Agency ☐ University ☒ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____
(Provides case studies throughout the U.S.)

Study Description: At Rain Bird, we feel it is our responsibility to increase awareness of the growing threats posed by global water scarcity. Our white papers, entitled *Irrigation for a Growing World*, are just that, an effort to educate readers on the importance of using water efficiently and ways to incorporate these practices into their daily lives.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A qualitative white paper with brief summaries about various case studies with improved irrigation efficiency.

Cost Data: ☐ N/A ☒ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data:

- Fort Stockton School District-Texas: 75% reduction in water use and a significantly lower water cost of $471 for the month.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Fort Stockton School District-Texas: Following the installation of an automatic irrigation system that distributed water in a uniform and efficient manner, water use on the football field was reduced by just over 1 million gallons, a 75% reduction in water use.
- The City of Bakersfield, California, Parks Division upgraded its outdated, manually operated electromechanical controllers and replaced them with a sophisticated central control system, weather station, ET sensors and other technologies to irrigate the parks and street landscapes at the south end of the city. When compared against the older system still in use in other parts of the city, the upgraded irrigation system saved more than 10 million gallons in one year.

Limitations: N/A

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Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low
Need to research individual case studies

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20. Aquacraft, Inc, National Research Center, Inc, and Dr. Peter J. Bickel. (2009). ***Evaluation of California Weather-Based "Smart" Irrigation Controller Programs.***

General Category: Irrigation
GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: Through this program more than 6,342 smart controllers have been installed in southern and northern California. This report presents results of the impact of 3,112 smart controllers (49.1% of the total) installed at 2,294 sites in northern and southern California. These sites met the fundamental data requirements established for inclusion in this study- 1 full year of pre- and post-installation billing data, corresponding climate data, a measurement of the landscape area at the site, and basic information about the site, controller, and installation.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A quantitative report with detailed background information.

Cost Data: ☐ N/A ☒ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: Installing smart controllers may or may not be cost-effective for a utility or their customers. The determination of cost-effectiveness depends upon the water savings, the avoided cost for water, local retail water rates, the discount rate factor used, and the expected useful life of the product.

Summary of Findings Related to Landscape Water Conservation BMPs:

- The overall results are impressive. In this study, the smart controller sites changed demand by -316,407,600 gallons across California in one year.
- All but one participating water agency achieved overall water savings.
- In this study, 41.8% of the study site increased their irrigation water use after installation of the smart controller. Deficit irrigators are poor candidates for smart controllers and should be pre-screened from utility distribution programs.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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21. Aquacraft, Inc. (2006). ***Post Drought Changes in Residential Water Use.***

General Category: Irrigation, Water Budgeting

GreenCO BMP Category: Irrigation Technology, Water Budgeting

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: During the summer and fall of 2005, Aquacraft was hired by Denver Water to collect water use data in a sample of approximately 100 single-family customers in the Denver Water service area. These data provide important findings about how single-family water demands have changed in Denver between the mid 1990's and 2005.

Year(s) Data Collected: 2005

Quantitative/Qualitative: A quantitative report that provides information about indoor and outdoor water usage.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Annual outdoor use dropped between 1994 and 2004 by an average of 54 kgal. This represents a 53% reduction in outdoor use.
- Prior to the drought, the typical customer irrigated to approximately 85% of net ET, but during the first drought year (2002) this dropped to 70% of net ET, and in 2003, the average irrigation application rate dropped to 50% of net ET.

Limitations:

- It is not clear if the observed reduction in irrigation application rates are durable or will gradually rise to pre-drought levels, but an analysis of the survey results suggest that a portion of these savings may be long lasting.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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22. Merkl, C. (2005). Good Soil A Key to Water Conservation. *Water Wise* , Volume 11, Number 2, Page 6.

General Category: Soils

GreenCO BMP Category: Soil Amendment/ Ground Preparation

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: Generic magazine article about soil preparation with compost.

Year(s) Data Collected: N/S

Quantitative/Qualitative: A qualitative report explaining the benefits of using compost.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- When compost is mixed into the top 4-10 inches of the soil, it improves the physical, chemical, and biological characteristics of the soil in ways superior to any other single product.
- Compost increases the ability of the soil to absorb water. As a general rule, 100 pounds of compost can hold 195 pounds of water.
- Compost also improves water infiltration.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates: ☐ High ☐ Medium ☒ Low

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23. AquaCraft, Inc. (2009). *California Single Family Water Use Efficiency Study.*

General Category: Water Budgeting

GreenCO BMP Category: Water Budgeting

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: The East Bay Municipal Utility District (EBMUD) was one of 10 participants in the California Single Family Water Use Efficiency Study. The goal of this study was to obtain a detailed analysis on the indoor and outdoor water use patterns of a random sample of single family homes in each of the participating agencies. Outdoor water use for the study homes was characterized with respect to the total annual outdoor use, the actual application rte to the landscape in inches and the theoretical irrigation requirements for the home based on the irrigated area by plant type, the local net ET and reasonable irrigation efficiencies based on the type of irrigation system. 83 homes were included in the outdoor analysis.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A qualitative report comparing the actual application rate to the landscape in inches and the theoretical irrigation requirements.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- There is a definite relationship between landscape requirements and actual use.
- There is also a great deal of scatter in the data, and many customers are not adjusting their irrigation to ET requirements.
- People often do not have the information or the interest to spend time calibrating their irrigation systems.
- The average excess over-irrigation use was 15 kgal per lot for the 83 study homes, and 35 kgal for the 35 homes that are over irrigating.
- If these customers are typical of single family customers in the counties, which the statistics show that they are, then the total potential savings in EBMUD from improved irrigation management would be 15 kgal x 306,950 (the number of single family customers in the system). This is

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equivalent to 4604 million gallons, or 14,135 acre-feet of potential water savings per year from improving irrigation applications.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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24. Center for ReSource Conservation. (2007). *Irrigation Inspection Program: Impacts of Slow the Flow Colorado on Outdoor Water Use.*

General Category: Irrigation

GreenCO BMP Category: Irrigation Efficiency Audits

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer ☒ Non-profit

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: This report is intended to summarize the impacts of the Slow the Flow Colorado Irrigation Inspection program on the outdoor (landscape) water use of program participants in the years 2004 and 2005. This report details the methodology and results of the analysis.

Year(s) Data Collected: 2004 and 2005

Quantitative/Qualitative: A quantitative report that compares water usage before the inspection and after the inspection.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- The cost of conducting the number of inspections in the 2005 group (751) was approximately $57,000. Current estimates for the cost of infrastructure associated with the development of water range from $12,000 to $17,000 per acre foot (at a minimum).
- This would indicate that this conservation program is a cost effective method of meeting water supply needs.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Results showed that in 2004, 75% of participants that watered at rates above ET prior to the inspection reduced their water usage after the inspection.
- In 2005, 79% of participants that watered at rates above ET prior to the inspection reduced their water usage after the inspection.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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25. Taylor, L. (2005). Evolution of a Water Budget at Centennial Water and Sanitation District. *Water Wise* , Volume 11, Number 4, Page 5.

General Category: Water Budgeting
GreenCO BMP Category: Water Budgeting

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: The Centennial Water and Sanitation District introduced a water budget system to their residential and commercial customers in 2003. The budget is based on individual customer lot size, not on historical usage or tap size.

Year(s) Data Collected: 2003 - 2005

Quantitative/Qualitative: A brief article demonstrating the impacts of introducing a water budget.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- **2003**: Usage at 100% of water budget amounts; Usage 17% less than historical usage per tap
- **2004**: Usage at 79% of water budget amounts; 11% reduction estimated from mild weather patterns
- **2005**: Usage through August approximately 103% of water budget due to dry July, Single family residential at 99% of water budget, Commercial irrigation (not including Parks District) at 105% of budget with significantly higher overages in dry weather. Observation is that commercial irrigators do not respond to rates in the short term, rather, they are motivated to maintain landscape appearance at any cost.

Limitations:

- Throughout the years, there are customer complaints about large lots with small house, large households, winter irrigation of trees, customers in new homes moving from areas of traditional water rates and those installing new lawns.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

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26. Keesen, L. (2004). The Economics of Water Conservation: Irrigation Technologies. *Water Wise* , Volume 10, Number 4, Page 9.

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: In looking for hard data on cost-effective conservation strategies for outdoor irrigation, the East Cherry Valley Water District sponsored an irrigation system evaluation and renovation program in 1999. The District wanted to find ways to solve water waste from irrigation at a cost that would be appealing to its customers.

Year(s) Data Collected: 1999 - 2000

Quantitative/Qualitative: A brief article with good quantitative information.

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

-

Summary of Findings Related to Landscape Water Conservation BMPs:

- ET controllers were installed at 23 homes, rainfall sensors were installed at 28 homes, and soil moisture sensors were installed at 32 homes.
- Savings from ET controllers: 2001: 1,081 total million gallons saved; 2002: 760 total million gallons saved
- Savings from rain sensors: 2001: 1,391 total million gallons saved; 2002: 810 total million gallons saved
- Savings from soil moisture sensors: 2001: 1,606 total million gallons saved; 2002: 837 total million gallons saved

Limitations:

- Water use and water bills were tracked for two years, 2001 and 2002, which was a serious drought year for many water districts.

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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27. Trout Unlimited, Western Resource Advocates, and Colorado Environmental Coalition. (2005). *Facing Our Future: A Balanced Water Solution for Colorado.*

General Category: Xeriscape

GreenCO BMP Category: Xeriscape

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: Facing Our Future offers a strategic model that will help satisfy the competing demands for water along the Front Range, including those of the environment and river-based recreation, while minimizing reliance on large new dams and projects that divert more water from the West Slope. This strategic model is distinguished from other water management approaches in two primary aspects: (1) it places a higher priority on boosting rates of water conservation and efficiency in water use and management; and (2) it incorporates protection- and even improvement- of environmental values into any and all actions that would boost water supplies.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A qualitative report with quantitative outdoor conservation potential estimates.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- The Technical Appendix shows the savings potential for limited xeriscaping, or full coverage of efficiently-watered bluegrass; moderate xeriscaping; and substantial/full xeriscaping

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates: ☐ High ☒ Medium ☐ Low

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28. Western Resource Advocates. (2008). *Smart Savings Water Conservation: Measures That Make Cents.*

General Category: Xeriscape, Irrigation

GreenCO BMP Category: Xeriscape, Irrigation Efficiency Audits

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: This report provides water utility managers and the public with information that can be utilized to gauge the likely effectiveness of water conservation measures, including the diversity of water conservation measures available, the variety of programs to encourage customers to save water, the water savings that have been achieved, and utility program costs.

Year(s) Data Collected: Varies

Quantitative/Qualitative: A qualitative report with different case studies that demonstrate quantitative water savings and cost.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- Synthetic turf installation in Irvine, CA: Approximate average of $4 per square foot
- Water audits in Albuquerque, NM: assuming the installed water-saving equipment has a life span of 10 years, the utility program cost over the device life span is $42 per cumulative AF saved.
- Xeriscape in Las Vegas, NV: From 2000 to end of November 2007, Southern Nevada Water Authority spent roughly $89 million on incentives for landscape rebates.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Synthetic turf installation in Irvine, CA: Replacing 7,837 square feet of high-water-use grass with synthetic turf saves a total of 149,917 gallons per year.
- Water audits in Albuquerque, NM: The industrial, commercial, and institutional water audit program cumulatively saved 867 AF from 1999 to 2003.
- Xeriscape in Las Vegas, NV: From 2000 to end of November 2007, the cumulative water savings in gallons is 18,028,229,480.

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Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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29. Utah State University Extension Center for Water Efficient Landscaping. (2006). ***Water Check Report and Summary: Summer 2006.***

General Category: Irrigation

GreenCO BMP Category: Irrigation Efficiency Audits

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: The intent of a Water Check is to produce water savings through a free, educational program in which participants learn to irrigate efficiently. The Water Check will provide the participant with an irrigation schedule for their landscape, an evaluation of their irrigation system, and educational handouts on related topics such as low water use landscaping, drip irrigation, and suitable plant lists.

Year(s) Data Collected: 1999-2005

Quantitative/Qualitative: A quantitative report with lots of charts showing the change of water use after a Water Check.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- The average annual cost of residential water checks from 1999-2005: $123/check
- The average annual cost of large water checks from 1999-2005: $472/check

Summary of Findings Related to Landscape Water Conservation BMPs:

- West Jordan: Overall, there has been a net savings of water by the Water Check participants. When using 2001 as a baseline year (253,000 gallons per household), in 2003 (first year after water check), there was a 15% decrease in use, and 20% decrease in use in 2004.
- Salt Lake City Public Utilities: Again, using 2001 as a baseline year (199,000 gallons per household), in 2003 (first year after Water Check) there was a 17% decrease and a 34% decrease in 2004.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates: ☐ High ☒ Medium ☐ Low

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30. Western Resource Advocates. (2007). *Front Range Water Meter: Water Conservation Ratings and Recommendations for 13 Colorado Communities.*

General Category: Xeriscape, Irrigation, Education, Soils

GreenCO BMP Category: Xeriscape, Irrigation Efficiency Audits, Soil Amendment

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: This Front Range Water Meter report, which provides an up-to-date snapshot of how Colorado Front Range cities compare across many water conservation categories, including rates of per capita use, breadth and depth of implementation of conservation programs, water loss, conservation funding, and many others. The Water Meter's scoring criteria provide a thoughtful and useful basis for comparison and a "score" for each utility. The Water Meter also provides a specific set of recommendations for how each utility can improve its conservation portfolio.

Year(s) Data Collected: 1999-2005

Quantitative/Qualitative: A detailed report with qualitative and quantitative information regarding each of the Front Range cities in Appendix A.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- Each city has their own respective conservation budget and funding

Summary of Findings Related to Landscape Water Conservation BMPs:

- Four cities- Aurora, Boulder, Denver, and Colorado Springs- took top honors. Four more- Broomfield, Erie, Louisville, and Longmont- are making tremendous progress in achieving greater water efficiency. Five more cities- Berthoud, Evans, Fort Morgan, Fort Lupton, and Loveland- are relatively small but fast-growing cities that have substantial room for improvement, which is important because they will soon be home to many new Colorado residents.
- Denver, Aurora, and Colorado Springs are home to the three largest water utilities in Colorado. While not having the fourth largest utility in the state, Boulder has many conservation and efficiency measures in place that are comparable to those seen at bigger utilities. All four have demand-side management programs that are

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- Appendix A provides Detailed Individual Utility Summaries

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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31. Northern Colorado Water Conservancy District. (n.d.). *Turfgrass Irrigation Management*. Retrieved from http://www.ncwcd.org/ims/scheduler.asp

General Category: Maintenance: Turf, Water Budgeting

GreenCO BMP Category: Turf Management, Water Budgeting

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: The Turf Irrigation Management Program is used for audits, scheduling, ET calculation using high and low temperatures, and water budgeting. It provides an Excel spreadsheet that calculates ET and makes a water budget based on input parameters.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A quantitative Excel workbook that calculates ET.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- This spreadsheet can be used for any site where an irrigation audit has been performed, or can be performed.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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32. Keesen Water Management. (1998). *The Meadows.* Retrieved from http://www.keesen.com/successes.htm

General Category: Irrigation

GreenCO BMP Category: Irrigation System Design,

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: In 1994, Keesen Water Management performed an irrigation system evaluation for the Meadows Metropolitan District 37-acre streetscape. In 1996, they were contracted to develop Irrigation Design and Maintenance Requirements for The Meadows. These guidelines were filed with Douglas County and became a requirement for all future development.

Year(s) Data Collected: 1996-1997

Quantitative/Qualitative: A brief overview of the irrigation design and maintenance requirements. Report provides basin qualitative information with a table showing water savings.

Cost Data: ☐ N/A ☒ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data:

- 1997 net water savings of $51,407

Summary of Findings Related to Landscape Water Conservation BMPs:

- 1997 net water savings: 25,449,000, or 28 inches

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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33. Sovocool, K. A. (2005). *Xeriscape Conversion Study, Final Report* . http://www.snwa.com/assets/pdf/xeri_study_final.pdf.

General Category: Xeriscape

GreenCO BMP Category: Xeriscape

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: Recognizing the need for more exacting (and locally applicable) savings estimates, Southern Nevada Water Authority conducted a study that could yield quantitative savings estimates of what a xeriscape conversion facilitation program could yield under real world conditions. The experimental study involved recruiting hundreds of participants into treatment groups (a Xeric Study and a Turf Study Group and control groups), as well as the installation of submeters to collect per unit area application data. Data on both household consumption and consumption through the submeters was collected, as well as a wealth of other data.

Year(s) Data Collected: Began in 1995; multi-year study

Quantitative/Qualitative: A detailed, quantitative report comparing the water use for a Xeriscape Study Group, Turf Study Group, and a non-contacted Comparison Group.

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:
See the report for detailed cost analysis, including payback periods.

- Tracking of the costs residents incurred when converting their landscapes from turf to xeric landscape revealed that at the time of the study, the average conversion cost was $1.55 per square foot across all of the conversion projects for which data was available. The average cost for those who did the work themselves was $1.37 per square foot, and for those employing a contractor, it was $1.93 per square foot. All of these costs are probably higher today due to inflation and a strong market for conversion projects.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Results show a significant average savings of 30% (96,000 gallons) in total annual residential consumption for those who converted from turf to xeriscape. The per-unit area savings as revealed by the submeter data was found to be 55.8 gallons per square foot (89.6 inches precipitation equivalents) each year. Results showed that savings yielded by xeriscapes were most pronounced in summer.

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The major conclusions of this research are as follows:

1. Xeriscape conversion projects can save vast quantities of water at single-family residences. Homes in this study saved an average of 96,000 gallons annually following completion of an average-size conversion project. This is a savings of 30% in total annual consumption; a finding in line with those yielded by other research studies in this region.

2. Over the long timeframe of this study, total yearly savings have neither eroded nor improved across the years. On average, household consumption drops immediately and quickly stabilizes.

3. There is an enormous difference in application of water to locally used turfgrasses and xeric landscape by residents. On average, each year residents applied 73.0 gallons per square foot (117.2 inches) of water to grow turfgrass in this area and just 17.2 gallons per square foot (27.6 inches) to xeric landscape areas. The difference between these two figures, 55.8 gallons per square foot (89.6 inches) is the theoretical average savings yielded annually by having xeriscape in lieu of turf in this area. This is a *substantial* savings (76.4%) when considered in the context of the available residential water conservation measures. A sub-study of other commercial properties with xeriscape found the average application to xeric areas by these customers to be essentially equivalent to that observed for the residential customers.

4. Over the course of a year, the difference in application between turf and xeric areas varies in a predictable bell-shaped-curve manner, with the greatest difference occurring in summer. This is because turf irrigation peaks to a much greater extent in summer than xeric irrigation. The difference in irrigation between these two types of landscape varies from as little as 1.56 gallons per square foot for the month of December, on up to 9.62 gallons per square foot for the month of July.

5. In comparing irrigation application to the reference evapotranspirational rate (ET_o), it was found that on average application to turf exceeded ET_o in every month except March, exceeding it the most May through November. In contrast, xeric application remained well below ET_o year round.

6. The author experimented with using a locally invoked “rule-of-thumb” which holds that xeric plantings require about a third of the evapotranspirational rate as needed for turf. In comparing this developed reference, $0.33(ET_o)$, to application, it was found that these values were, in absolute terms, somewhat close month to month and very close over the entire year. In comparing this developed reference to application, it was found that xeric application was below $0.33(ET_o)$ half the year and above it the other half of the year (September-February).

Relative to questions about irrigation management and the potential for further efficiency gains, findings associated with conclusions 4 through 6 and subsequent analyses led the author to the suggest that (i.) the greatest absolute savings from assorted improvements in irrigation will be realized in the summer, but (ii.) the most

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readily obtained efficiency improvements (i.e., not requiring capital outlays) yielded from better controller management may be obtained September through January, as this is the period when a lot of residents fail to successfully decrease irrigation in response to lower irrigation requirements (for both types of landscape).

8. Multivariate regression modeling was used to help discover some of the factors associated with variability in water consumption at single-family residences. These are:

i. The amount of turf at the residence (positive correlation).

ii. The property value of the residence (as indicated by the local assessor's office; positive correlation).

iii. The age of the residence (positive correlation).

iv. The total income of the property's residents (positive correlation).

v. Whether or not the turfgrass present at the residence is Fescue (a locally popular cool-season grass; positive correlation). As a side-result from one of the multivariate analyses, Bermuda grass may be receiving approximately 59 gallons per square foot per year – certainly less than the application for the much more common cool-season grass in this study. Some variables which were significant in many other incarnations of the model (but not the final model) include parcel size, surface area of open water for pools and spas, the total number of occupants living at the residence, and total landscapeable area.

9. A similar approach was used to identify some of the factors associated with variability in irrigation application to monitored xeric areas. These are:

i. The total canopy coverage within the xeric area (positive correlation).

ii. The average per-station flow rate of the installed irrigation system serving the xeric area (positive correlation).

iii. The size of the xeric area (positive correlation).

iv. The property value of the residence (positive correlation).

v. Parcel size (inverse correlation).

vi. Whether or not the irrigation system was exclusively a drip irrigation system (i.e., not composed of microsprays, bubblers, other higher flow emitters, or combinations of emitters; inverse correlation). V

ii. Whether or not the resident responsible for managing irrigation at the home is knowledgeable about enforcement of local provisions prohibiting outdoor water waste (inverse correlation).

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Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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34. Western Resource Advocates, Colorado Environmental Coalition, and Western Colorado Congress. (2004). *Water Rate Structures in Colorado: How Colorado Cities Compare in Using this Important Water Use Efficiency Tool.*

General Category: Water Budgeting

GreenCO BMP Category: Water Budgeting (Rate Structure)

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: In late June of 2004, we gathered water rate data from twelve municipal water utilities on the Front Range of Colorado and fourteen municipal water utilities on the Western Slope. This sampling provides a good cross-section of water providers along Colorado's Front Range, both in terms of geographic distribution and community size. Although the variation in rate structures used across Colorado can be seen as a rough indication of how each city prioritizes water conservation, each utility has a different water supply situation and different costs associated with these supplies. Therefore, rate structures can be expected to vary somewhat regardless of each city's commitment to conservation.

Year(s) Data Collected: 2004

Quantitative/Qualitative: A comprehensive report summarizing the rate structures used in throughout Colorado. It provides detailed quantitative information regarding type of rate structure and associated costs.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- Table 1 lists the components of each rate structure that was implemented by these water providers as of June 22, 2004 in these water service areas.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Many cities with water rate structures that accurately reflect the value of water and the costs of obtaining new water supplies have lower per capita water use and can stretch existing water supplies further.
- The *increasing block rate structure* most effectively encourages efficient water use.
- Increasing block rate structures can maximize efficiency if the block volumes are individually customized to the specific water needs of each customer. This is called a *water budget rate structure*. Under this design, each customer is assigned a monthly allotment of water based on the

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customer's lot size, irrigable area, climate conditions, and household occupancy. In most cases, the monthly allotment, or budget, provides enough water for each customer to sustain normal indoor uses as well as basic landscape irrigation needs. If the customer exceeds the monthly water budget, the excess water use is charged at notably higher unit prices (as with the standard increasing block rate structure).

- The majority of the water providers in the analysis sample applied some form of an increasing block rate structure (Aurora, Boulder, Colorado Springs, Denver, Fort Collins, Highlands Ranch, Longmont, Thornton, and Westminster). This widespread use was not the case just a few years ago when uniform rate structures were more common. We can be encouraged by the fact that many Front Range cities are taking steps towards promoting efficient water use through their rate structures.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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35. Environmental Protection Agency. (2002). *Cases in Water Conservation: How Efficiency Programs Help Water Utilities Save Water and Avoid Costs.*

General Category: Water Budgeting, Education, Xeriscape, Irrigation

GreenCO BMP Category: Water Budgeting (Rate Structure), Public Education, Xeriscape, Irrigation Efficiency Audits

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☒ Other _17 different cities in the U.S._

Study Description: These case studies feature the efforts and achievements of 17 water systems. These systems range in size from small to very large, and their efficiency programs incorporate a wide range of techniques for achieving various water management goals. In every case, the results are impressive.

Year(s) Data Collected:

Quantitative/Qualitative: A comprehensive report that goes into detail for 17 various cities throughout the U.S. regarding their approach to water conservation and their results.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- These case studies illustrate some of the tangible results achieved by water conservation programs implemented at the local level. Many of these accomplishments have broader relevance to other communities facing similar water resource management and infrastructure investment issues.
- Each city has seen impressive results in water conservation.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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36. Bureau of Economic and Business Research. (2005). Water Use and Residential Rate Structures in the Intermountain West. *Utah Economic and Business Review*, Volume 65, Numbers 3 & 4.

General Category: Water Budgeting

GreenCO BMP Category: Water Budgeting (Rate Structure)

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: This report examines water use in 25 Intermountain metropolitan areas with a focus on water delivered through public water supply systems. Water rate schedules for the utilities that serve half the population of the 25 areas are discussed and future water sources for metropolitan areas within Utah are noted.

Year(s) Data Collected: Published in March/April 2004

Quantitative/Qualitative: A concise report summarizing water use in 25 Intermountain metropolitan areas and quantifying the water rate schedule used.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- The highest marginal rate, or the rate for the last drip of water consumed during a billing period, ranges from less than $1 per 1,000 gallons to over $7 per 1,000 gallons.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Provides water rate schedules for largest utilities in selected metropolitan areas
- Most of the utilities have an increasing rate structure, with the per unit charge for water increasing as the amount of water used increases.
- Seasonal rates are imposed by five of the 38 utilities. Salt Lake City and Colorado Springs utilities have flat rates during the winter months and an increasing rate structure during the summer months.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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37. Kenney, D., Christopher, G., Klein, R., Lowrey, J., & Reidy, K. (2007). *Residential Water Demand Management: Lessons From Aurora, Colorado.*

General Category: Water Budgeting, Irrigation

GreenCO BMP Category: Water Budgeting (Rate Structure), Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: The investigation of residential water demand featured in this paper focuses on the City of Aurora, Colorado, a rapidly growing Denver suburb of approximately 309,000 residents served exclusively by a single municipal provider: Aurora Water.

Year(s) Data Collected: 1997-2005

Quantitative/Qualitative: A quantitative and statistically-based report that shows results for those items under utility control: price, restrictions, rate structures, and rebates.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- In summer 2002, Aurora transitioned from a flat rate to an increasing block rate (IBR) pricing structure, with all households subject to the same rates and block widths. Soon thereafter, Aurora began to refine their IBR structure by tailoring the size of each block width on a household by household basis.
- Rebates up to 50% of total cost for those for outdoor technologies, such as sprinkler system upgrades.
- Aurora Water customers wanting a Water Smart Reader (WSR), an in-home device that intercepts radio signals from an individual's water meter, displaying real-time information about levels of water consumption, area assessed a charge of $30 (roughly half the cost of providing the product.)

Summary of Findings Related to Landscape Water Conservation BMPs:

- Overall, our findings are consistent with the literature in demonstrating that residential water demand is largely a function of price, the impact of non-price demand management programs, weather and climate, and most likely, demographic characteristics of households and the homes they occupy.

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Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

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38. U.S. Bureau of Reclamation. (2007). *Reclamation Managing Water in the West: Weather and Soil Moisture Based Landscape Irrigation Scheduling Devices.* http://www.usbr.gov/waterconservation/docs/SmartController.pdf.

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology and Scheduling

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☒ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☒ Other _____

Study Description: This report includes information on smart irrigation control products by 28 companies that were available as of June 2007. Three additional companies have been added and one companies' products are no longer available in the U.S. Previously reported product information (models, pricing, etc.) has been updated and minor revisions have been made throughout the document. It is Reclamation's intention to continue to update the report as often as needed in an attempt to keep all information current.

Year(s) Data Collected: Up to 2007

Quantitative/Qualitative: A detailed report that provides information regarding the different smart irrigation control products available including: description, operational features, prices and warranties, installation, and water savings.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- Provides cost of each smart irrigation control products.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Most of the product descriptions in this report discuss water savings. In some cases, water savings associated with various studies and demonstration projects are discussed. In most cases the water savings discussed are as reported by the manufacturer.
- Each product provides water savings data.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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39. Institute of Applied Research and Water Resource Institute. (2007). *Statewide Market Survey: Landscape Water Use Efficiency, Final Report.*

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology and Scheduling

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☒ Manufacturer

Data Type: ☐ Site-specific ☒ Regional (California) ☐ Summary ☒ Other _____

Study Description: Researchers surveyed homeowners and landscape property managers, those who control the irrigation water applied to managed properties, about their irrigation behaviors and attitudes about water conservation measures. Over 1300 surveys were conducted in six regions of California.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A qualitative report based on survey findings that gives recommendations based on survey results.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Residential Survey Findings:
  - 89% with sprinkler systems have an automatic timer, 12% have weather based controllers
  - 41% said "appearance" was what matters most regarding their lawn and garden
  - 55% did not know how many gallons of water is used in the landscape
  - 76% said they would buy water efficient plants if they were to buy new plants
  - 81% said that offering cast for reducing lawn size and replacing it with more water efficient plants would work (35%) or might work (43%)
  - 87% said that offering rebates for weather-based controllers would work (59%) or might work (28%)
- Managed Property Findings:
  - 98% said that conserving water is important
  - 78% use water efficient plants

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- 49% expressed interest in finding a landscaper knowledgeable about water saving techniques and plants and would listen to their local water district regarding water conservation
- 52% would attend a free weekend workshop
- 71% would pay more for a water saving technology if it would save them time and money in the future.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low
Good resource to know what water conservation measures show interest by residents and managed properties

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40. American Water Works Association. (2006). *Water Conservation Programs- A Planning Manual, Manual of Water Supply Practices M52.*

General Category:

GreenCO BMP Category:

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☒ Other _____

Study Description: The manual provides 6 chapters of information regarding how to assess the need for conservation and describes the pros and cons of establishing a program in more detail; a process to set conservation program goals, qualitatively and quantitatively; methods to assess and reduce water losses; how to estimate water savings from conservation measures, benefits, and costs; and describes what is necessary to develop and carry out a water conservation program.

Year(s) Data Collected: N/A

Quantitative/Qualitative: Provides detailed information regarding how to quantify water savings.

Cost Data: ☐ N/A ☒ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data:

- Chapter 4 goes into great detail about how to calculate water savings by providing formulas and specific details on how to calculate water savings, which will result in cost savings from water conservation.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Appendix A provides case studies of successful programs

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low
Great information on how to implement a water conservation plan

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41. AquaCraft, Inc. (2009). *California Single Family Water Use Efficiency Study.*

General Category: Water Budgeting

GreenCO BMP Category: Water Budgeting

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: 10 participating agencies in the California Single Family Study were studied to obtain a detailed analysis on the indoor and outdoor water use patterns of a random sample of single family homes in each of the participating agencies.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A qualitative report comparing the actual application rate to the landscape in inches to the theoretical irrigation requirements.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- **San Diego County Water Authority:** The actual application should be around 81 of the ET based on the average landscape ration, but the actual applications averaged 219% of the theoretical requirements, while the median application ratio was only 87% of the theoretical requirements. 11% of the homes were applying more than 5 times the irrigation requirements. There was a total of 1976 kgal of excess water used during the study year. This averages approximately 36.6 kgal per home.
- **Redwood City:** The actual application should be around 89% of the ET based on the average landscape, and the actual applications averaged 120% of the theoretical requirement, while the median application ratio was 73% of the theoretical requirement. This shows that the water customers in Redwood City are generally doing a fairly good job of managing their irrigation uses, and most customers are irrigating below their requirements.
- **Sonoma County Water Agency:** The results of the outdoor analysis show that there was a total of 334 kgal of excess water use during the study year.

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- **Las Virgenes Water District:** The results of the outdoor study show that there was a total of 7855 kgal of excess water use during the study year. This averages approximately 135 kgal per home.
- **Los Angeles Department of Water and Power:** The results of the outdoor analysis show that there was a total of 2974 kgal of excess water use during the study year in the 97 homes. This averages approximately 30 kgal per home.
- **Irvine Ranch Water District:** On average the single family accounts in this study group were applying 285% of the amount of water that based on the best science should be necessary to maintain their landscapes.
- **City of San Francisco:** The results of the outdoor analysis show that there was a total of 141 kgal of excess water use during the study year by the 18 homes in the study group that were irrigating. This averaged approximately 2.8 kgal per study home.
- **City of San Diego:** The results of the outdoor analysis show that there was a total of 724 kgal of excess water use during the study year for outdoor purposes. This averages approximately 17 kgal per home.
- **City of Davis:** The results of the outdoor analysis show that there was a total of 1558 kgal of excess water use during the study year. This averages approximately 31 kgal per home.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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42. Dickinson, M. A. (2000). ***Water Conservation in the United States: A Decade of Progress.***

General Category: Water Budgeting, Education

GreenCO BMP Category: Water Budgeting, Public Education

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: This report summarizes the California experience of discussing the role that water use and efficiency and conservation could play. In 1989 the urban water community and the environmental community began to negotiate what the terms of 'water efficiency" might be and how it might best be done statewide. By September 1991, the document was ready for ratification by all parties concerned. To date, the "Memorandum of Understanding", has now been signed by 228 signatories. The Memorandum of Understanding includes a list of fourteen BMPs for water conservation and a schedule for their implementation.

Year(s) Data Collected: N/A

Quantitative/Qualitative: A qualitative report with information regarding BMPs to be implemented.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- The cost of each BMP varies widely, and these costs are in the process of being documented in a current Council study. On average, the collective implementation produces water for about $300 per acre-foot.

Summary of Findings Related to Landscape Water Conservation BMPs:

BMP completion requirements:

- Large Landscape Conservation Program and Incentives: prepare water budgets for 90% of all commercial and industrial accounts with dedicated meters; provide irrigation surveys to 15% of mixed-metered customers.
- Public Information Programs: provide active public information programs in water agencies to promote and educate customers about water conservation.
- School Education Programs: provide active school education programs to educate students about water conservation and efficient water uses

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- Conservation Pricing: eliminate non-conserving pricing policies and adopt pricing structures such as uniform rates or inclining block rates, incentives to customers to reduce average or peak use, and surcharges to encourage conservation.
- California's investment in conservation will yield approximately 1.4 million acre-feet.

Limitations:

- Does not quantify individual BMP water savings

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

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43. Kenney, D., Christopher, G., Klein, R., Lowrey, J., & Reidy, K. (2007). *Residential Water Demand Management: Lessons From Aurora, Colorado.*

General Category: Irrigation

GreenCO BMP Category: Irrigation Scheduling

Study Type: ☒ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: In this study the experiences of municipal water providers serving the following cities along Colorado's northern Front Range were tracked: Aurora, Boulder, Fort Collins, Lafayette, Louisville, Thornton, and Westminster. Denver Water was also tracked. This paper documents the various approaches they used and evaluates if voluntary and/or mandatory restrictions were effective in reducing water consumption and if so, to what extent.

Year(s) Data Collected: 2000, 2001, 2002

Quantitative/Qualitative: A quantitative report that summarizes the calculated effectiveness of water restrictions, both voluntary and mandatory, over the study period.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- In every city or provider region, conservation programs featuring mandatory restrictions were associated with significant savings in water use. Net savings ranged widely from 13 percent in Aurora to 53 percent in Lafayette.
- The performance of voluntary restrictions was, with a few exceptions, disappointing.
- This study indicates that outdoor watering restrictions, particularly mandatory programs, are an effective means of reducing water demand during drought periods among Colorado's Front Range municipalities.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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44. Smart Waer Application Technologies. (n.d.). *"Smart" Controller Efficiency Testing for Climate-based Controllers.* Retrieved from http://www.irrigation.org/SWAT/Industry/default.aspx?pg=tested_climate.asp

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☒ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description: The Irrigation Association has developed an independent third party testing protocol specific to "smart" climatologically-based controllers. Currently the protocol is administered through the Center for Irrigation Technology (CIT), an independent testing laboratory, applied research facility and educational resource center based at California State University, Fresno. The objective of this protocol is to evaluate how well current commercial technology has integrated the scientific data into a practical system that meets the agronomic needs of turf and landscape plants.

Year(s) Data Collected: Varies: 2006-2009

Quantitative/Qualitative: Several "smart" controllers have completed IA-SWAT protocol testing and results have been released by the manufacturer. The SWAT Performance Reports provide detailed quantitative results.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Out of 18 smart controllers that were tested, the following controllers had 0% irrigation excess (how much irrigation water was applied beyond the needs of the plant material):
  - Calsense ET2000e-24-GR-RB with RB-1 Tipping Rain Bucket
  - Irritrol Smart Dial
  - Rain Bird ET Manager with ESP-TM Controller
  - Rain Master RME Eagle (RMEGEG)
  - SMG Superior Controls Sterling 8 Controller w/ Water2Save
  - Toro Intelli-Sense

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- Water Optimizer
- WeatherTRAK

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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45. Sharvelle, S., Azar, M. N., Stromberger, M., & Roesner, L. (2009). *Graywater Irrigation as a Means to Meet Water Demands in Arid Regions.*

General Category: Irrigation

GreenCO BMP Category: Irrigation Using Nonpotable Sources

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____
Provides information for households in California, Colorado, and Texas

Study Description: Graywater irrigation systems offer many benefits, however the use of such systems has not become widespread due to concerns about safety issues. While some states have begun to legalize and regulate the practice of graywater reuse for residential landscape, little guidance based on scientific data has been provided for the safe operation of graywater irrigation systems. We selected three households where graywater has been applied for irrigation for more than five years to include in this study located in California, Colorado, and Texas.

Year(s) Data Collected: Soil samples have been collected and analyzed at households where graywater has been applied for irrigation for at least five years.

Quantitative/Qualitative: Provides detailed qualitative soil sample results for the various study locations.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- If graywater is used for irrigation of a typical residential landscape, it could supply about 30% of the demand, and with increasing emphasis on xeriscape in the semi-arid West, it has the potential to supply 100% of the irrigation demand in some areas.
- Pathogen indicator organisms were measured in soil samples to assess their fate after graywater application. No clear trend of an effect of graywater irrigation was observed. However, it is notable that pathogen indicators were generally not found to be higher in soils irrigated with graywater than control soils irrigated with freshwater.

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Limitations:

- Only some states, including California, Arizona, and New Mexico have legalized the graywater practice.
- The use of graywater systems is not viable for most homeowners in Colorado. Currently, the treatment, disposal, and potential use of graywater is regulated by the State of Colorado Guidelines On Individual Sewage Disposal Systems and applicable county Individual Sewage Disposal System (ISDS) regulations. The Colorado Department of Public Health and Environment (CDPHE) does not currently separate graywater from blackwater in its regulations. Consequently, surface applications require permitting and monitoring. Application of graywater from systems discharging 2,000 gallons or more per day requires a permit from the CDPHE; smaller systems require permits from your local health department.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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46. Grabow, G. L., Dukes, M., & Thapa, B. (2009). ***The use of Soil-water Sensors in Turf Irrigation Control- How Effective are they?***

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☒ Regional ☐ Summary ☐ Other _____
Florida and North Carolina

Study Description: Several studies involving soil-moisture sensors have been done in Florida and one study in North Carolina is near completion, These studies have looked at soil-water sensor based systems of various manufacturers in similar settings; have compared results between different moisture setting thresholds; have contrasted water usage with ET based controller systems; and have monitored root zone soil-water status in plots irrigated by soil-water based systems.

Year(s) Data Collected: N/A

Quantitative/Qualitative: Provides both qualitative and quantitative information comparing soil-water based controller systems with ET controller systems.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Soil-water sensor controller systems have conceptual advantages in irrigation control since they integrate all elements of a soil-water budget into the soil. Studies have shown that these systems consistently reduce water use when compared to standard controller systems set to irrigation of historical ET or historical gross irrigation requirement.
- In a study conducted in Utah, the use of a simple automated device for overriding a standard electronic irrigation clock by monitoring soil-water can result in an average of 10% savings in water use and can still maintain healthy green lawns compared to a system without a rain sensor.
- In Florida, most SMS systems saved significant amounts of water when compared to time-based irrigation schedules typically used

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by homeowners. They recorded "wet weather" savings of 69% to 92% for three of the four systems tested and "dry weather" savings of 28% to 83% while maintaining turfgrass quality at acceptable levels.

- In a study that evaluated three commercially available ET controllers, found water savings as much as 40% compare to the theoretical gross irrigation requirement, and water wastage by as much as 63% depending upon the season.

Limitations:

- One argument against the soil-water based systems has been the perceived problems with representativeness of sensor location and repeatability of the sensor systems.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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47. Cardenas-Lailhacar, B., Dukes, M. D., & Meaks, L. (2009). *Irrigation Rain Sensors Accuracy.*

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____
University of Florida Agricultural and Biological Engineering Department turfgrass research facility in Gainesville.

Study Description: The objectives of this research were to evaluate two expanding disk rain sensor types, Mini-Click (MC) and Wireless Rain-Click (WL), with respect to: a) the accuracy of their set point with respect to rainfall depth, b) the number of times in irrigation bypass mode, and c) the duration in irrigation bypass mode. Four treatments with four replications each were established. For the MCs, three set points were established: 3, 6, and 13 mm thresholds. The dry-out ventilation windows of the MCs and WLs were kept completely open.

Year(s) Data Collected: January 1, 2006 – July 31, 2007

Quantitative/Qualitative: Provides quantitative information evaluating the two expanding disk rain sensor types

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Accuracy tests results suggested that the 3-MC responded close to its set point (73%), but 6-MC and 13-MC resulted in lower accuracies (30 and 58%).
- Replicates at a particular set point were variable, sometimes responding properly according to their settings, sometimes not detecting rainfall events five or more times their set points, and sometimes even shutting off several hours after the rain had stopped.
- Most of the time, treatments remained in bypass mode for less than 24 hours, and almost all treatments dried out in less than 48 hours during this testing period.

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Limitations:

- After more than two years of continuous operation these devices still have the ability to bypass irrigation cycles during rainy weather; however, their accuracy appears to be degrading with time.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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48. Davis, S. L., & Dukes, M. D. (2009). *Preliminary Results for Bench Testing of Evapotranspiration-based Irrigation Controllers in Florida.*

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____
University of Florida Agricultural and Biological Engineering Department turfgrass research facility in Gainesville.

Study Description: The objectives of this study are to duplicate the soil water balance calculations specified by the smart water application technologies (SWAT) test and recreate the SWAT bench test in a humid region using ET controllers previously tested under the SWAT protocol in an arid climate. Three brands of ET controllers previously tested under the SWAT protocol by CIT were installed. The controllers are as follows: Weathermatic SL1600 with SLW20 weather monitor, Toro Intelli-sense duplicates utilizing the WeatherTRAK ET Everywhere Service, and ETwater Smart Controller 100 duplicates.

Year(s) Data Collected: The ET water controllers began the SWAT test on September 14, 2008 with manufacturer permission and testing ended on January 11, 2009. The Weathermatic controller began the SWAT test on September 23, 2008. The Toro WORS and Toro WRS controllers began testing on October 23, 2008.

Quantitative/Qualitative: Provides detailed qualitative information on the materials and methods of how the daily moisture balance to simulate the water dynamics of a landscape plant system is calculated. Quantitative information is provided for whether the controllers have accurate irrigation scheduling capabilities.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Cumulative totals for rainfall and ET over the study period were lower than the historical average, averaging 56% and 40%, respectively. The combination of low ET and rainfall suggests that

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irrigation wouldn't generally be required and plan material would be dormant during most of the time period.

- The results found during the 2008 SWAT test showed that the ET controllers generally scored well in SWAT performance scores of scheduling efficiency and irrigation adequacy.
- The controllers resulted in slightly lower scores, mainly concerning scheduling efficiency, than what was published from the original SWAT test. Scheduling efficiency results were lower than the original published results by 2.5% for the ETwater controllers, 14% by the Toro controllers, and 5.6% by the Weathermatic.

Limitations:

- Since controller programming is extremely important to obtaining good SWAT results, manufacturers program the controllers based on how to get a good score rather than using the landscapes described in the protocol.
- It is likely that manufacturers would have opted not to publish these results as a SWAT score and restarted the test with minor adjustments.
- The SWAT testing protocol should be clearly outlined and detailed enough for results to be reproducible if it will continue to be used as an industry standard. However, the testing procedures are not reproducible based on the current form of the protocol document.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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49. McCready, M., & Dukes, M. D. (2009). ***Evaluation of Irrigation Scheduling Efficiency and Adequacy by Various Control Technologies Compared to the Theoretical Irrigation Requirements.***

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____
Plant and Science Research and Education Unit in Citra, Florida

Study Description: A variety of commercially available technologies for reducing residential irrigation water use are available to homeowners. These technologies include soil moisture sensors, rain sensors and evapotranspiration (ET) based controllers. The purpose of this research was to evaluate the adequacy and efficiency of the irrigation schedules for each control device with an irrigation schedule developed using a theoretical soil water balance.

Year(s) Data Collected: There were four treatment periods during April 22, 2006 to June 20, 2006 (SP06); September 23, 2006 to December 15, 2006 (F06) and May 1, 2007 to August 31, 2007 (S07).

Quantitative/Qualitative: Provides detailed qualitative information on the materials and methods of how the daily moisture balance to simulate the water dynamics of a landscape plant system is calculated. Quantitative information is provided for comparing the adequacy and efficiency of the irrigation schedules for each control device.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- In general, adequacy of irrigation for all treatments improved in the fall months compared to the spring months of testing.
- Simply using adequacy alone or efficiency alone was not a good indicator of the accuracy of an irrigation schedule.
- Some treatments received high efficiency scores but very low adequacy scores because irrigation was not sufficient for plant needs.
- Tables in back of report provide detailed quantitative results.

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Limitations:

- There were some limitations for the experimental treatments compared to the SWB. The SWB was allowed to irrigate whenever soil moisture dropped to RAW and it only irrigated to FC. The experimental treatments were scheduled for irrigation on specific days of the week (1, 2 or 7 d/wk) and irrigation depth was programmed into the time, with the exception of TORO.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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50. McCready, M., & Dukes, M. D. (2009). ***Evaluation of Irrigation Scheduling Efficiency and Adequacy by Various Control Technologies Compared to the Theoretical Irrigation Requirements.***

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____
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Study Description: A variety of commercially available technologies for reducing residential irrigation water use are available to homeowners. These technologies include soil moisture sensors, rain sensors and evapotranspiration (ET) based controllers. The purpose of this research was to evaluate the adequacy and efficiency of the irrigation schedules for each control device with an irrigation schedule developed using a theoretical soil water balance.

Year(s) Data Collected: There were four treatment periods during April 22, 2006 to June 20, 2006 (SP06); September 23, 2006 to December 15, 2006 (F06) and May 1, 2007 to August 31, 2007 (S07).

Quantitative/Qualitative: Provides detailed qualitative information on the materials and methods of how the daily moisture balance to simulate the water dynamics of a landscape plant system is calculated. Quantitative information is provided for comparing the adequacy and efficiency of the irrigation schedules for each control device.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

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- Tables in back of report provide detailed quantitative results.

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Limitations:

- There were some limitations for the experimental treatments compared to the SWB. The SWB was allowed to irrigate whenever soil moisture dropped to RAW and it only irrigated to FC. The experimental treatments were scheduled for irrigation on specific days of the week (1, 2 or 7 d/wk) and irrigation depth was programmed into the time, with the exception of TORO.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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51. O'Brien, B. (July/August 2008). SOIL: Not Just a Four-Letter Word. *Colorado Green* , Volume 24, No 4.

General Category: Soils

GreenCO BMP Category: Soil Amendment/Ground Preparation

Study Type: ☒ Journal ☐ Private Study ☐ Book ☐Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: A journal article explaining how good soil preparation is the foundation for healthy, sustainable landscapes.

Year(s) Data Collected: N/A

Quantitative/Qualitative: Qualitative information regarding the necessity of using soil amendments

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- "Proper soil amendment with deep tillage will improve the soil's water-holding properties and is the first step in my list of things to do to improve irrigation efficiency and management in the landscape." –Brent Mecham
- More and more Colorado cities are requiring or strongly recommending soil amendment.
- Denver Water announced its new soil amendment rule (effective August 2008) for all new residential and commercial construction within the city and county. Proof of soil amendments must be submitted prior to meter sets. For the most part, the rules include testing, addition 4 to 6 inches or organic matter and tilling to a minimum depth of 4 to 6 inches.
- "Since Aurora's lawn permit ordinance was enacted in the mid '80s, he has witnessed healthier lawns that use less water."- Kevin Reidy, water conservation supervisor with the City of Aurora
- "I have witnessed improvements in the overall health and quality of landscapes since the rule was implemented in 2002." – Natalie Stevens, marketing technician with the City of Greeley

Limitations:

- Not all sites will require amendment, specifically those designed to preserve natural habitats and those designed with the use of native plants.

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Depending on the existing soil conditions, soil amendment could have adverse effects and actually do more harm than good.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

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52. Shedd, M., Dukes, M. D., & Miller, G. L. (2007). *Evaluation of Evapotranspiration and Soil Moisture-based Irrigation Control on Turfgrass.*

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐Government/Agency ☒ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____
Plant Science Research and Education Unit in Citra, Florida

Study Description: A variety of commercially available technologies for reducing residential irrigation water use are available to homeowners. These technologies include soil moisture sensors, rain sensors and evapotranspiration (ET) based controllers. The purpose of this research was to evaluate the effectiveness of these various technologies based on irrigation applied and turfgrass quality measurements.

Year(s) Data Collected: Treatments were implemented in the spring and fall seasons of 2006. The spring treatments started on April 22, 2006 and ended June 30, 2006 (71 days), and the fall treatments began on September 23, 2006 and ended December 15, 2006 (84 days).

Quantitative/Qualitative: Provides detailed qualitative information on the materials and methods of how the daily moisture balance to simulate the water dynamics of a landscape plant system is calculated. Quantitative information is provided for evaluating the effectiveness of the various technologies.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Even though both seasons were relatively dry, all of the technologies tested managed to reduce water application compared to the 2-WORS (without rain sensor) treatment, with some treatments also maintaining acceptable turf quality.
- The highest overall water saving with high quality turf were seen in the ET-based treatments and the 2-DWRS (a deficit replacement schedule that was 60% of the 2-WRS)
- ET-based treatments managed to use between 36% and 59% less water than the control treatment 2-WORS.

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- Time-based treatments in the spring showed that the frequency may have an impact on quality of turf, with more frequent irrigation to a shallow depth providing higher quality but not necessarily higher water savings.

Limitations:

- These experiments were performed during two relatively dry seasons when the treatments were expected to produce little water savings.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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53. Diamond, R. A. (2003). ***Project Review of the Irvine ET Controller Residential Runoff Reduction Study.*** *****how does this compare against IRWD 2004 Study******

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____
Five similar neighborhoods in Irvine, California

Study Description: The Residential Runoff Reduction Study (R3) had four primary purposes. The initial purpose was to develop and expand the application and use of pager-signal technology to manage irrigation water for residential homes and larger dedicated landscape areas. Secondly, the study was intended to evaluate the effectiveness of an education program consisting of landscape maintenance information and a suggested irrigation schedule on both water use and runoff. The third study goal was to determine the connection between proper water uses in the landscape and the quantity and quality of dry weather runoff that enters the urban storm drain system. Finally, the study was intended to gauge the acceptance of water management via the ET controllers and whether this style of water management affected the overall appearance of landscape.

Year(s) Data Collected: 18-month study period

Quantitative/Qualitative: Provides quantitative results for water savings.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- The ET controller retrofit group homes received a site evaluation and installation of an ET controller to manage the irrigation system. Also, the residents of these homes received information regarding environmentally sensitive landscape practices.
    - Water conservations savings from the ET controller group was 41 gallons per day.
    - There was a 49% direct reduction in water runoff (pre and post) in the ET controller area during the dry-season periods.

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    - 72% of participants indicated that they liked the controllers. This group also found that the controller irrigation either maintained or improved the appearance of the landscape.
- The second group was referred to as the educational group. This group received the same environmental landscape practice information as the ET controller group, plus a suggested water schedule each month.
    - The educational group residential customers saved 26 gallons per day.
    - Direct pre and post runoff from the educational group increased 36% while runoff increased 72% in comparison to the control group.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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54. Olmstead, S. M., & Stavins, R. N. (2007). ***Managing Water Demand: Price vs. Non-Price Conservation Programs.***

General Category: N/A

GreenCO BMP Category: N/A

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: This paper offers an analysis of the relative merits of price and non-price approaches to water conservation. As economists, we emphasize the strong empirical evidence that using prices to manage water demand is more cost-effective than implementing non-price conservation programs. Price-based approaches also have advantages in terms of monitoring and enforcement. In terms of predictability and equity, neither policy instrument has an inherent advantage over the other. As in any policy context, political considerations are also important.

Year(s) Data Collected: N/A

Quantitative/Qualitative: Provides qualitative information comparing price vs. non-price conservation programs to manage water demand

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- On average, in the United States, a 10% increase in marginal price of water can be expected to diminish demand in the urban residential sector by about 3 to 4 percent.
- Estimates of the water savings attributable to non-price demand management policies such as watering restrictions and low-flow fixture subsidies vary from zero to significant savings.
- More stringent mandatory policies (when well-enforced) tend to have stronger effects than voluntary policies and education programs.
- Where water savings have been estimated from non-price approaches, they are usually smaller than expected, due to behavioral responses.
- Price-based approaches to water conservation are more cost-effective tan non-price approaches.
- The gains from using prices as an incentive for conservation come from allowing households to respond to increased water prices in the manner of

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their choice, rather than by installing a particular technology or reducing particular uses, as prescribed in non-price approaches.

- Non-price demand management policies require monitoring and enforcement, since they are easy to violate.
- Raising water prices can be politically very difficult; perhaps as a result, water demand management through non-price techniques is the overwhelmingly dominant paradigm in the United States.

Summary of Findings Related to Landscape Water Conservation BMPs: N/A

Limitations:

- In specific cases, non-price water conservation programs can only be compared with price increases if water suppliers have a measure of the benefits of non-price conservation programs. In compiling this report, we were unable to find any estimates of the impacts of these types of water conservation policies in New England, and few such estimates exist, even for very expensive programs, across the United States.
- Water conservation in this reference is generic and not landscape BMP specific

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

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55. Environmental Protection Agency. ***Water-Efficient Landscaping: Preventing Pollution and Using Resources Wisely.*** **http://www.epa.gov/WaterSense/docs/water-efficient_landscaping_508.pdf.**

General Category: Irrigation

GreenCO BMP Category:

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: This booklet describes the benefits of water-efficient landscaping. It includes several examples of successful projects and programs, as well as contact, references, and a short bibliography.

Year(s) Data Collected: N/S

Quantitative/Qualitative: Provides qualitative water-efficient landscaping information with generic quantitative information.

Cost Data: ☐ N/A ☒ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data:

- Residents of Glendale, Arizona, can receive a $100 cash rebate for installing or converting more than half of their landscapable area to non-grass vegetation.
- In Las Vegas, Nevada, homeowners can receive up to $1,000 for converting their lawn to Xeriscape, while commercial landowners can receive up to a $50,000 credit on their water bill.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Las Vegas, Nevada: Preliminary results of a five-year study show that residents who converted a portion of their lawns to Xeriscape reduced total water consumption by an average of 33 percent.

Limitations: N/A

Expected Transferability of Findings in Developing Quantitative Estimates: ☐ High ☐ Medium ☒ Low

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56. Clary, J., O'Brien, B., & Calomino, K. (2006). *Working Together to Promote Landscape Water Conservation.*

General Category: Irrigation, Water Budgeting, Education

GreenCO BMP Category: Xeriscape, Irrigation Design, Irrigation Technology, Water Budgeting, Public Education

Study Type: ☒ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: To assess how builders are going about promoting and/or implementing water conservation and water-quality protection, several homebuilders were contacted to participate as case studies. The three builders selected included Engle Homes, McStain Neighborhoods, and Village Homes. The goals of the studies were:

1. Assess what water conservation practices builders are implementing.
2. Share these approaches with the broader builder community to demonstrate how water conservation and water-quality protection can be integrated effectively into builder practices.

Year(s) Data Collected: N/S

Quantitative/Qualitative: Provides qualitative information for each case study with general quantitative information.

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- **Engle Homes**: There are five alternative backyard Xeriscape designs that buyers can request to have Engle's subcontractors install, hire their own subcontractor, or use the designs for their own landscaping.
- Table 2 provides summary costs for alternative backyard xeriscape designs.

Summary of Findings Related to Landscape Water Conservation BMPs:

- **Engle Homes:** As part of Engle's Water-Wise Program, it created a water-wise booklet with Valerian LLV to provide buyers with information regarding Xeriscape, soil preparation, hydrozoning, efficient irrigation, mulching, appropriate maintenance, and drought-tolerant plants.
- Engle Homes completes front yard landscaping in most of its projects. The water-wise standards for these installations include the following:
    - Soil amendments added (3 cubic yards per 1,000 square feet)

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    - Irrigated turf limited to 50% to 60% of the total landscape area
    - Balance of yard planted in drought-tolerant bedding areas and rock or wood mulches
    - Use of drought-tolerant trees and shrubs
    - Drip irrigation zones installed for shrub beds
    - Rain sensors installed as standard to curtail irrigation during natural precipitation
- **McStain Neighborhoods:** In 2003, McStain Neighborhoods developed a guidance document called the "McStain Neighborhoods Water Conservation Standards for Common Area and Open Space Landscapes."
- In order to promote long-term landscape water conservation, McStain has developed both landscape maintenance and irrigation system maintenance specifications so that expectations are clearly defined for contractors.
- **Village Homes:** When Village installs individual lot landscaping, it strives to provide water conservation-oriented specifications for irrigation systems, soil amendment, and/or landscape design.
- Village has recognized the importance of homeowner education with regard to the critical role that landscaping practices play in a development, both in terms of community enjoyment and protection of water quality.

Limitations:

- **McStain Neighborhoods:** Because McStain's projects following these standards are still in the early phases of development, performance data and potential water cost savings were not available for inclusion in this report. (As of September/October 2006)

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

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57. Vickers, A. (2001). *Handbook of Water Use and Conservation*. Amhurst: Water Plow Press.

General Category: Irrigation, Water Budgeting, Education

GreenCO BMP Category: Xeriscape, Irrigation Design, Irrigation Technology, Water Budgeting, Public Education

Study Type ☐ Journal ☐ Private Study ☒ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: Comprehensive handbook on water conservation, with substantial information on landscape water conservation.

Year(s) Data Collected: Prior to 2001

Quantitative/Qualitative: Both

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

Summary of Findings Related to Landscape Water Conservation BMPs: **Good general reference for background**. Several specific case studies provided.

Limitations: General reference book

Expected Transferability of Findings in Developing Quantitative Estimates: ☐ High ☒ Medium ☐ Low

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58. Mecham, B. (March 2003). ***Conservation Strategies for Lawn Watering During Drought or Water Shortages.***

General Category: Xeriscape

GreenCO BMP Category: Xeriscape,

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: A brief study with conservation strategies with accompanying options that could be used to reduce irrigation demand that are based on the typical growing season of April 1 to October 31 and assume near normal rainfall.

Year(s) Data Collected: N/S

Quantitative/Qualitative: A quantitative report that shows the amount of water reduced based on different conservation strategies.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- **Conservation Strategy #1 at 10% landscape irrigation reduction**:
  - A 10% reduction in irrigation run times- **Reduction: 10%**
  - Irrigation May 1 to September 30- **Reduction: 15%**
- **Conservation Strategy #2 at 20% landscape irrigation reduction:**
  - A 20% reduction in irrigation run times- **Reduction: 20%**
  - Irrigation April 23 to October 7 at 1" per week- **Reduction: 24%**
- **Conservation Strategy #3 at 30% landscape irrigation reduction:**
  - Irrigation May 1 to September 30 at 1" per week- **Reduction: 28%**
  - Irrigation May 1 to June 30 at irrigation requirement, NO irrigation July 1 to July 30, Irrigation August 1 to October 15 at irrigation requirement- **Reduction: 32%**
- **Conservation Strategy #4 at 40% landscape irrigation reduction**:
  - Irrigation May 1 to October 15 at 0.75" per week- **Reduction: 35%**

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- Irrigation May 1 to June 30 at 1” per week, NO irrigation July 1 to July 31, Irrigation August 1 to October 15 at 1” per week- **Reduction: 43%**
- Irrigation April 15 to June 15 at irrigation requirement, NO irrigation June 15 to August 15, Irrigation August 16 to October 31 at irrigation requirement- **Reduction: 44%**
- Water budget or water diet- **Reduction: 40%**

Limitations:

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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59. Keesen, L. (2009). Next Steps After an Audit are Implementing Changes For Less Water Use and Long Term Sustainability.

General Category: Irrigation

GreenCO BMP Category: Irrigation Efficiency Audits

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: A PowerPoint presentation with brief information on an East Cherry Creek Valley Water District sponsored Irrigation System Evaluations and Pilot Program of Greenfield/Liverpool.

Year(s) Data Collected: 2000

Quantitative/Qualitative: Quantitative information regarding the water savings of the Greenfield/Liverpool streetscape system evaluation

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

- **Greenfield:** Renovation cost: $11,100; payback 4.7 years; Total water savings: $7,155 (3-year)
- **Liverpool:** Renovation cost: $7,492; payback: 2.9 years; Total water savings: $11,379 (4-year)

Summary of Findings Related to Landscape Water Conservation BMPs:

- New spray heads were installed with 4-inch pop-up height, check valves and pressure control
- New nozzles were installed to better control the spray
- Check valves were installed in rotors
- Rain and freeze sensors were installed on controllers
- Goal was to beat 30-inches annually or lower
- Greenfield:
    - 2001 usage went down from 61.7 to 50.1 inches
    - Three year savings of 2.7 million gallons or 8 acre-feet.
- Liverpool:
    - 2000 usage went down from 63.0 to 30.0 inches
    - Down 53% first year
    - Four year savings of 4.5 million gallons or 14 acre-feet

Limitations: N/A

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Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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60. Medina, Jonnie G., and Julia Gumper, 2004: YARDX: Yield And Reliability Demonstrated in Xeriscape: Final Report. Metro Water Conservation, Incorporated, Littleton, CO, 140 p. www.coloradowaterwise.org

General Category: Xeriscape

GreenCO BMP Category: Xeriscape

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description: The YARDX project is one of five field projects of Reclamation's National Xeriscape Demonstration Program (NXDP) established to study the benefits of installing Xeriscape under differing climatic and other potentially impacting conditions.

Year(s) Data Collected: 1997-2002

Quantitative/Qualitative: Quantitative

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

Summary of Findings Related to Landscape Water Conservation BMPs:

Abstract Extracted from Report:

Metro Water Conservation, Inc. (MWCI) of Denver, Colorado, in partnership with the Bureau of Reclamation, conducted a water conservation study known as the Yield And Reliability Demonstrated in Xeriscape (YARDX) project to estimate the benefits of water-conserving landscaping known as Xeriscape. Benefits to be assessed were seasonal water savings, landscape installation, and annual maintenance costs. Seven municipalities from Fort Collins, Colorado, to Colorado Springs, Colorado, participated in the study. The YARDX project is one of five field projects of Reclamation's National Xeriscape Demonstration Program (NXDP) established to study the benefits of installing Xeriscape under differing climatic and other potentially impacting conditions.

YARDX was conducted from 1997 through 2002. The project included seven field demonstrations, each with some differing attributes, including Xeriscape application type (retrofits or new starts), application level (high or moderate water savings designs), yard size, irrigation method, socio-economic level, and soil

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type. In seven demonstrations, control groups of traditional high water use turf were established with similar characteristics to Xeriscapes, except for landscape type. Participants had to install Xeriscapes, except at one demonstration. All participants had to maintain them with no major revision during the study period. Xeriscape participants were provided a small rebate to join the study, and were given education on installing and maintaining Xeriscapes. One demonstration involved comparison of older, established Xeriscapes, with comparable control landscapes.

Data analysis of historical water use established the need for sample sizes of approximately 30 properties studied over 4 growing seasons, to have at least a 90-percent chance of detecting a 30-percent change in water use at the 5-percent significance level. The demonstrations yielded high-quality data that generally enabled the estimation of water savings and annual maintenance costs.

Xeriscape installation costs ran a modest $0.90 to $1.45 per square foot, with homeowners in the project contributing a substantial amount of labor. Demonstrations obtained water savings from 18 to more than 50 percent over control samples. Results indicated that relatively consistently, water savings in the 30-percentile range could be obtained for properly designed and maintained Xeriscapes. Annual maintenance costs ranged from $0.34 to $1.33 per square foot. For cost estimation, homeowner labor was computed at $18 per hour. Generally, the maintenance cost of the Xeriscapes sampled, compared to the non-Xeriscaped properties, was found to be less than controls during the plant establishment years, but somewhat more during the plant maturation years. This suggests that as Xeriscapes age, they gradually require more maintenance, compared to traditional landscapes.

Xeriscape participants overwhelmingly expressed satisfaction with their landscapes and would freely recommend this type of landscaping to others. The information gained in the YARDX project should provide an additional alternative in dealing with water conservation needs in the Colorado Front Range.

Limitations: The final year of data collection 2002 was influenced by drought.

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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61. Colorado Springs Utilities. (n.d.). Residential Irrigation Equipment Rebates. Retrieved June 15, 2009, from Colorado Springs Utilities: http://www.csu.org/residential/greenback/rebates/irrigation/item1117.html

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other

Study Description: Rebate program information, including estimates of savings associated with various irrigation technology rebates. Source of data not specified on website.

Year(s) Data Collected: N/A (Information retrieved from website in June 2009.

Quantitative/Qualitative: Semi-quantitative

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

Water Savings to Customers:
Weather-based irrigation controllers: $50/yr estimated savings
Matched precipitation nozzles: save the average customer nearly $25 each year
Sprinkler heads with check valves: a savings of at least $30 each year.

Rebate Program allows up to $200/customer

Summary of Findings Related to Landscape Water Conservation BMPs:

Weather-based irrigation controllers: …can reduce irrigation water usage by an average of 16%" Elsewhere, "Studies suggest irrigation savings of about 20 percent or more can be expected. Actual savings is dependent of previous watering habits and weather, but a reasonable range is 10 to 30 percent. It can also reduce runoff by more than 50 percent."

Rain Shutoff Device: Savings is dependent on the frequency and volume of rainfall and watering, but a reasonable range in Colorado Springs is 5 to 10 percent of irrigation use.

Sprinkler heads with check valves: Savings is dependent on a number of factors including the number of cycles run, but 5 to 10 percent of irrigation use is conservative.

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Matched precipitation nozzles: Savings is dependent on a number of factors, but research suggests that 10 to 20 percent is possible.

Other CSU fact sheets state that prior to mandatory water restrictions in 2002, SF residential use was 122 gpcd. In 2006, usage had decreased to 96 gpcd, attributable to watering restrictions, regional drought awareness, favorable weather conditions and water conservation programs.

Limitations: Source of estimates assumed to be other literature or vendors.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low (estimates general and basis is unknown at this time)

DRAFT--INTERNAL WORKING NOTES

62. Broustis, D. (2008). Moving Toward Water Use Metrics (and Benchmarks), Seattle Parks and Recreation. *WaterSmart Innovations '08. Las Vegas, NM, October*. http://www.watersmartinnovations.com/2009/sessions-all.php?year=2008

General Category: Irrigation, General

GreenCO BMP Category: Irrigation, Landscape

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ **Government/Agency** ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☐ **Other**

Study Description: Presents suggested approach to development of water use metrics/benchmarks. May provide a template for consideration in Colorado

Year(s) Data Collected: N/A

Quantitative/Qualitative: Designed to facilitate quantitative evaluation of data

Cost Data: ☐ **N/A** ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: ***none***

Summary of Findings Related to Landscape Water Conservation BMPs:

Selected notes clipped directly from Powerpoint Presentation:

Residential: Outdoor benchmarks limited, data not as good
Multifamily: Submetering results in lower use
Irrigation: Weather-based control reduces use
GPCD vs. g/sq ft
Recommendations:

- Develop relevant metrics based on end use
  - Housing: People are more important than square footage
  - Commercial: Square footage may be appropriate
  - Irrigation: Consider weather, area and landscape type
- Agree upon standardized metrics
  - Residential
    - Gallons per capita per day
- Commercial
  - Set assumptions and methods for addressing each sector
  - Address odd uses
- Establish a clearinghouse for information

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- Encourage end users (and possibly utilities) to populate databases
    - Poor or inaccurate utility records may confound data from utilities
- Proposed Water Use Indices (WUI)
    - WUIirr: inches/irrigated sq. ft. or CCF/1,000 irrigated sq. ft.
- Current irrigation "benchmarking"
    - Weather-based control to reduce use
        - Doesn't necessarily optimize opportunities
- Water budgets(calculation methodology should be standardized)
- But how to compare actual use from year to year?
    - Annual variability of +/-15%...or more
- Irrigation use tells only part of the story if it isn't weather normalized
    - ET isn't the be all/end all of efficiency
    - ET alone doesn't correct actual consumption for annual variability
        - Rain and actual water use vs. presumed ET need
- Weather-corrected irrigation benchmarking proposed using Irrigation Utilization Index (IUI)
    - WUIIrr = inches/irrigated square foot (non-weather adjusted)
    - IUI = Average WUIIrr * (Current need/Average need)
    - Using IUI, ET and rain in a given year can be compared to an average or baseline use
        - Tells if current water use is higher or lower than anticipated
- Stumbling Blocks:
- Databases are not as sexy as HETsand rain barrels
- Residential year-round irrigation data hard to separate from indoor use
    - Outdoor use could confound data
    - Seasonal irrigation: could be segregated
    - Inconsistent/inaccurate fixture consumption "in the field" could skew results
    - Useful to know to address concerns and minimize use
- Commercial odd uses skew comparisons
    - Accurately and consistently handling odd uses
- Commercial irrigation could be difficult to categorize
    - Difficult to categorize the wide range of landscape options
    - But could drive end users to efficient choices
- Recommendations to standardize metrics, utilize existing knowledge, seek simplicity/consistency, designate one or more information warehouses, populate database/share information

Limitations:

Expected Transferability of Findings in Developing Quantitative Estimates:

☐ **High** ☐ Medium ☐ Low

DRAFT-INTERNAL WORKING NOTES

63. Isaman, V. (2008). Topsoil, Compost and Water Quality Guidelines for Landscaping Help Reduce Irrigation Demands. *WaterSmart Innovations '08. Las Vegas, NM, October*. http://www.watersmartinnovations.com/2009/sessions-all.php?year=2008

General Category: Soil Amendment

GreenCO BMP Category: Soil Amendment

Study Type: ☐ Journal ☒ Private Study ☐ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☒ Other

Study Description: Presentation on benefits of composting.

Year(s) Data Collected: N/A

Quantitative/Qualitative: Qualitative

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- Premise: The most state of the art irrigation controllers, Eto based weather systems, devices and sensors will not compensate for inherent landscape deficiencies…
- Benefits of Compost:
  - Improve soil structure resulting in increased water infiltration rates
  - Increase water-holding capacity
  - Increase nutrient holding capacity
  - Improve the micro-organism environment
  - Improve root growth through reducing compaction
  - Improve tilth (the 'workability' of the soil; clays don't stick, sands don't fall apart)
  - Reducing erosion (by increasing soil infiltration and water holding)

Limitations: Quantitative water conservation estimates not provided

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☐ **Low**

DRAFT-INTERNAL WORKING NOTES

64. Martien, L. (2008). Conservation Audits of Denver Public Libraries. *WaterSmart Innovations '08. Las Vegas, NM, October*. http://www.watersmartinnovations.com/2009/sessions-all.php?year=2008

General Category:

GreenCO BMP Category: Irrigation Audits

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☒ Other benchmarking

Study Description: Results of Denver Public Libraries Conservation Audits

Year(s) Data Collected: 2006

Quantitative/Qualitative: Quantitative water use information with projected savings; actual implementation results not yet available.

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:
Irrigation Savings:
• 3,397– kgal annually
• $11,623– annual savings
• $81,635– present worth of savings
• $6,552-– cost of recommended measures
• 12.5– benefit/cost ratio

Summary of Findings Related to Landscape Water Conservation BMPs:

- Study Scope:
  - 22 library branches – 18 irrigation audits
  - Serve 3,800,000 customers annually
  - 5,441 customer days per year
  - 227,787 ft2 irrigated area
  - Total water use– 11,580 kgal in 2006
  - Irrigation– 6,392 kgal in 2006 (58%)
- Shows approach to defining irrigation use
- Practical Problems: limited staff, inadequate irrigation scheduling, vandalism
- Recommendations:
  - Utilize controller percent adjust feature
  - Improve staff training
  - Track billing data
  - Make irrigation upgrades w/landscape upgrade

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- Schedule routine maintenance

Limitations: Don't know outcome of project/whether recommendations were implemented and whether they were successful.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ **Medium** ☐ Low

DRAFT--INTERNAL WORKING NOTES

65. Pennsylvania State University. (1996). *Using Composts to Improve Turf Performance*. University Park: College of Agricultural Sciences Cooperative Extension. http://turfgrassmanagement.psu.edu/composts.cfm

General Category: Soils

GreenCO BMP Category: Soil Amendment

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☒ Other

Study Description: Guidelines on improving turf performance using compost

Year(s) Data Collected: N/A

Quantitative/Qualitative: Guidance oriented; quantitative savings not provided.

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

- In clay soils, good quality compost will improve structure, reduce surface crusting and compaction, promote drainage, and provide nutrients.
- In sandy soils, compost increases water and nutrient retention, supplies nutrients, and increases microbial activity.
- These improvements promote faster turf establishment, improved turf density and color, increased rooting, and less need for fertilizer and irrigation.

Limitations: Quantitative approach to estimating reduced irrigation requirements not provided.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☐ Medium ☒ Low

DRAFT--INTERNAL WORKING NOTES

66. Denver Parks and Recreation. (2009). Martin Luther King Jr. Boulevard Post-Construction Analysis. Fact Sheet provided by Jill Wuertz. June. Denver, CO.

General Category: Irrigation, Landscape, Xeriscape

GreenCO BMP Category: Irrigation Efficiency, Xeriscape

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other

Study Description: Based on the MLK Boulevard Master Plan completed in 2001, the project goals included the beautification of the boulevard's medians, commemoration of Dr. King's legacy, and improvement of maintenance operations and safety conditions. Highlights from the project include: (1) Construction of stone entry monuments at Colorado Boulevard and Quebec Street to identify the Park Hill neighborhood and commemoration of Dr. King's legacy by exhibiting public art along the corridor. (2) Enhancement of the existing flower beds at Monaco Parkway, and new raised planting beds at the ends of every median. (3) Median tree infill with new deciduous and evergreen trees to provide a continuous canopy. (4) Improved water conservation through complete renovation of the existing irrigation system and plant selection. Construction of the project occurred from January 2005 – February 2006 for the approximately 2.1 mile stretch.

Year(s) Data Collected: 2001-2007

Quantitative/Qualitative: Quantitative

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data: Irrigation portion of costs for the project: approx.$300,000.

Summary of Findings Related to Landscape Water Conservation BMPs:
From notes prepared by Jill Wuertz:

DPR Water Conservation reviewed aerial photographs and analyzed 7 of the 15 individual medians within the project boundary. The pre-construction condition of MLK Blvd was a predominantly turf median with tree plantings. The project converted these original turf medians into combinations of turf, planting areas, hardscape and irrigated mulched tree beds. See Fact Sheet for detailed breakdown.

Replacement of the irrigation system in its entirety was recommended for this project based on three reasons: 1) the forty to fifty year life of the existing systems has exceeded the expected life span (typically 15 years) for piping and most irrigation equipment, 2)

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irrigation inefficiencies have grown due to lack of availability of original irrigation equipment, advancements in irrigation technology and years of grit build-up at curbside locations hampering efficient management and operation of the irrigation system, 3) the addition of the proposed splash guard at back-of-curb locations required extensive modifications to the existing irrigation system. Seventeen water meters serving the project site and were determined to be too numerous for a project of this size. Estimates revealed that only eight to ten meters of the existing seventeen meters were required to properly irrigate the project site. Through a process of linking a single water meter to multiple medians via a common irrigation main with street crossings, a means to reduce some costs and upgrade the irrigation control system to current technology was provided. Cost savings were realized through the requirement for fewer radio-controlled irrigation field controllers, fewer backflow prevention devices needing to be replaced or installed, and fewer irrigation management components such as master valves and flow sensors being installed.

Water Consumption Analysis:

Water consumption was analyzed during pre-construction and post-construction periods. Precipitation and evapotranspiration requirements do affect water consumption within a given year, however patterns within consumption can still be assessed. Prior to construction improvements, the irrigation system constructed during the 1950's-60's prevented efficient watering from taking place. In 2001 and 2002, the system consumption shows a 30-35% overwatering based on a 30" per acre water budget for bluegrass turf that is typically used within Denver Parks and Recreation. Overwatering during 2006 possibly takes into consideration a dry year as well as plant establishment watering from the newly constructed medians. Water consumption in 2007, an above normal precipitation year (17" versus 15.81"), and 2008, a below normal precipitation year (10.83" versus 15.81") clearly shows that the irrigation and landscape upgrades allows operation of the system in a way that meets a water budget based on plant requirements for turf, planting areas and mulched tree beds. The current water consumption also shows a savings of 48% from an average of 2001 and 2002 versus an average of 2007 and 2008.

Limitations: Will be valuable to track performance long-term and see similar data from other sites. Results could be adjusted to reflect precipitation and ET variations in the years assessed.

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low

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67. U.S. Environmental Protection Agency. (1998). Water Conservation Plan Guidelines. Washington, DC: Office of Water. http://www.epa.gov/WaterSense/pubs/guide.htm.

General Category: General

GreenCO BMP Category:

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☒ Other benchmarking

Study Description: Appendix B from EPA's Water Conservation Plan Guidelines provide reductions in end use estimates "compiled from various sources."

" Actual water savings can vary substantially according to a number of factors. These data are provided for illustrative purposes only and may not be current or applicable. To the extent practical, planners should regionally appropriate or system-specific assumptions and estimates."

Appendix D also lists useful information resources that may have additional information.

Year(s) Data Collected: N/A

Quantitative/Qualitative: Quantitative, but not specific to Colorado

Cost Data: ☐ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

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Excerpts from Table B-4: Benchmarks for Savings from Selected Conservation Measures

Category and Level (1-3)	Measure	Estimated Reduction in End Use
Universal metering (1)	Connection metering	20 percent
	Submetering	20 to 40 percent
Water accounting and loss control (1)	System audits and leak detection	Based on system
Costing and pricing (1)	10% increase in residential prices	2 to 4 percent
	10% increase in nonresidential prices	5 to 8 percent
Information and education (1)	Public education and behavior changes	2 to 5 percent
End-use audits (2)	Outdoor residential use	5 to 10 percent
	Large landscape water audits	10 to 20 percent
Pressure management (2)	Pressure reduction, system	3 to 6 percent of total production
	Pressure-reducing valves, residential	5 to 30 percent
Outdoor water-use efficiency (2)	Low water-use plants	7.5 percent
	Lawn watering guides	15 to 20 percent
	Large landscape management	10 to 25 percent
	Irrigation timer	10 gpcd
Water-use regulation (3)	Landscape requirements for new developments	10 to 20 percent in sector
	Graywater reuse, residential	20 to 30 gpcd

Notes:

- With regard to low-water use plants, EPA discusses cooperating with local nurseries to ensure availability of low water plants.
- EPA encourage selective irrigation submetering to improve irrigation management

Limitations: Data are general ranges, not specific to Colorado or site-specific conditions

Expected Transferability of Findings in Developing Quantitative Estimates:
☒High ☒ Medium ☐ Low (*useful for basic "reality checks"*)

DRAFT - INTERNAL WORKING NOTES

68. Mayer, P., Hayden, M., Davis, R., Caldwell, E., Miller, T., & Bickel, P. (2009). *Evaluation of California Weather-based "Smart" Irrigation Controller Programs*. Presented to the California Department of Water Resources by the Metropolitan Water District of South California and the East Bay Municipal District. California Urban Water Conservation Council. http://www.aquacraft.com/Download_Reports/Evaluation_of_California_Smart_Controller_Programs_-_Final_Report.pdf

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer (*consultant & local governments*)

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other

Study Description: *(selected excerpts quoted from Executive Summary; fairly lengthy notes are provided for this study due to its complexity and magnitude)*

This report presents an evaluation of the California Weather-Based Irrigation Controller (WBIC) programs. This project presents empirical data on the performance of smart controller products distributed and installed through different methodologies in a wide variety of settings. This report is intended to fulfill a key requirement of the DWR grants and provide information and guidance for future smart controller and landscape conservation programs.

This report reflects the results of an effort that began over four years ago in cooperation with the California Department of Water Resources, the California Urban Water Conservation Council, the Metropolitan Water District of Southern California and their 26 member agencies, and a consortium of six water agencies in northern California led by the East Bay Municipal Utility District.

Improving irrigation efficiency is perhaps the single most important goal for water conservation professionals in the coming years. In support of this goal, the California Department of Water Resources (DWR) funded two large-scale regional efforts to affect urban irrigation efficiency and reduce runoff through the installation of smart controllers.

The fundamental unit of analysis for this smart controller evaluation study was on the site level. A site is a property where one or more smart controllers were installed. A single-family residential property with a single smart controller is a site as is a multi-family housing complex with 20 smart controllers installed. Only sites for which sufficient data were provided could be included in the analysis portion of this study. Utility partners

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were able to provide the necessary data for 2,294 sites encompassing 3,112 smart controllers to be included.

The southern California smart controller programs were made up of a large number of distribution programs developed and implemented by more than 20 water agencies. MWD's member agencies invested significant time and resources to implement and market their smart controller programs, tried various approaches, and made mid-stream adjustments because of lack of participation.

Three fundamental smart controller distribution program methodologies were implemented in southern California: rebate and voucher programs, exchange programs, and direct installation. While some agencies tried to target the smart controllers to historically high irrigators, by and large, the southern California program effort was a general distribution program that provided smart control technology to interested and motivated customers.

The northern California Smart Controller programs were made up of rebate, voucher and direct installation programs at five participating agencies under the leadership of the East Bay Municipal Utility District. In an effort to maximize potential water savings, agencies in northern California targeted customers with historically high outdoor water use demands through an analysis of historic billing data.

Fourteen different brands of controller were included in the analysis portion of this study.

Participants were responsible for installing about 60% of the smart controllers in this study. They could have hired someone to perform the installation for them, but that level of detailed information is not known. At about 40% of the sites the controller was installed and/or programmed by an irrigation professional, utility representative, or other party besides the customer.

Other Notes:

"Irrigation demand is the single largest end use of water in the urban sector in California. Irrigation demands typically account for 50% or more of the total water used in many California homes and businesses."

"Research studies over the past 8 years have measured statistically significant water savings and runoff reduction achieved through the implementation of smart irrigation control technology [Citing various references--(Bamezai 2004), (DeOreo, et. al. 2003), (IA, 2006, 2007, 2008), (Jakubowski 2008), (Kennedy/Jenks 2008), (Mayer, et. al. 2008), (MWDOC, IRWD 2004), (SCWA 2005), (US DOI 2007, 2008)]. Over that time nearly

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20 smart control product developers and manufacturers have emerged and weather-based irrigation control has become a strategic focus of the irrigation industry."

Year(s) Data Collected: 2002-2006 (data weather-normalized)

Quantitative/Qualitative: Highly quantitative with statistically based study design and analysis. Quantitative study approach may be useful to implement in Colorado.

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data: Installing smart controllers may or may not be cost-effective for a utility or their customers. The determination of cost-effectiveness depends upon the water savings, the avoided cost for water, local retail water rates, the discount rate factor used, and the expected useful life of the product.

The cost-effectiveness analysis was conducted from two perspectives: (1) the water utility; and (2) the end user or customer. See the report for results.

Summary of Findings Related to Landscape Water Conservation BMPs: *(selected excerpts quoted from Executive Summary)*

The evaluation of research described in this report provides strong evidence for the following findings and conclusions:

- On average smart controllers are a moderately effective measure for reducing the amount of water applied by automatic irrigation systems, while maintaining the health, and appearance of landscapes.
- When seeking irrigation water savings, the pre-existing level of excess irrigation at the site is the most important factor to consider.
- The water savings achieved through installation of smart controllers can be maximized by targeting the technology to irrigators with historically high irrigation application rates, not simply customers with high irrigation use.
- The many irrigators who historically apply less than the theoretical irrigation requirement for their landscape are likely to increase their irrigation application rate after installing a smart controller.
- Survey results indicate that smart controllers are likely to achieve a high degree of customer acceptance once they more broadly penetrate the consciousness of irrigation contractors and the general public.
- The utility programs implemented through the DWR grant have succeed in raising public awareness of this technology, but survey results suggest most consumers have no knowledge of smart irrigation control.
- Smart controllers can achieve cost effective water savings for utilities and irrigators under some cost and pricing scenarios, however this technology will not be cost effective for all utilities and customers.

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- Most of the smart control brands and technologies evaluated in this study reduced irrigation demands on average, but not all of these reductions were statistically significant.

The average weather-normalized change in water use per smart controller site is presented in Table ES.3 of the report. Overall, outdoor water use was reduced by an average of 47.3 kgal per site (-6.1% of average outdoor use) across the 2,294 sites examined in this study as part of the California Weather-Based Irrigation Controller Programs. This reduction was found to be statistically significant at the 95% confidence level.

At smart controller sites in northern California the average change in outdoor use was a reduction of 122.2 kgal per site (-6.8% of average outdoor use). This change was not statistically significant at the 95% confidence level, but was significant at the 90% confidence level.

At smart controller sites in southern California the average change in outdoor use was a reduction of 30.9 kgal per site (-5.6% of average outdoor use) and this was statistically significant at the 95% confidence level.

The overall impact of smart controllers installed in this study was to reduce irrigation demands, but the results suggest that those who historically apply less than the theoretical irrigation requirement for their landscape are likely to increase water use after installing a smart controller. The Application Ratio is a measure of how closely irrigation applications at a site matched the theoretical irrigation requirement determined from proximal ET weather stations. The level of excess or under irrigation (pre-AR) prior to the installation of the smart controller was the most important factor in determining if a site increased or reduced water use with the smart controller. In this study, a total of 1,300 (56.7%) of the 2,294 study sites had a statistically significant reduction in weather-normalized irrigation application ratio while 959 (41.8%) sites had a statistically significant increase in application ratio. For 35 (1.5%) of sites, there was not a statistically significant change in application.

Sites that increased application after installation of a smart controller had a mean pre-application ratio of 131% and a median of 95%. The median indicates that more than half of these customers were applying less than the theoretical irrigation requirement prior to the installation of the smart controller. Since smart controllers are designed to adapt irrigation to match the theoretical requirement, it would be expected that installing a smart controller at a site with a history of applying less than the theoretical irrigation requirement will result in increased demand.

Factors that Influenced Water Savings:
Multiple regression analysis was used to determine the factors that did and did not influence changes in application ratio. This analysis methodology allowed the researchers to examine the relationship between key site characteristics (such as controller technology) and application ratio after adjusting for factors known to influence savings such as the application ratio prior to installation of the smart controller. The following

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factors were examined and determined to have a statistically significant impact on the change in application ratio:

- Pre-smart controller Application Ratio – the application rate relative to the calculated theoretical irrigation requirement
- Installation method (self vs. professional)
- Participating agency (sometimes significant)

Factors that Did Not Influence Water Savings:
The following factors were examined and determined not to have a statistically significant impact on the change in application ratio:

- Site classification (residential vs. non-residential)
- Region (northern vs. southern California)
- Climate zone (coastal, intermediate, inland)
- Smart irrigation control methodology (historical ET, on-site readings, remote readings, soil moisture sensor)

See the report for differences in performance among brands of controllers, as well as discussion of long-term performance considerations.

Other Note: "The irrigation controller is important, but only one piece of the puzzle. Even the best, most water efficient controller cannot make up for poor system design, installation, and maintenance. The focus of this report is on irrigation controllers, but a holistic approach to irrigation systems and landscape design and maintenance is required to achieve the full potential of water savings in the urban irrigation sector."

Study provides a detailed breakdown by climate, controller type, installation type, etc. Study design may be a useful model to follow for application in Colorado.

Limitations: Conducted in California

Expected Transferability of Findings in Developing Quantitative Estimates:

☒ High ☐ Medium ☐ Low

DRAFT-INTERNAL WORKING NOTES

69. GDS Associates. (2002). Quantifying the Effectiveness of Various Water Conservation Techniques in Texas. Texas Water Development Board. http://www.twdb.state.tx.us/assistance/conservation/gdsstudy.asp.

General Category: Irrigation

GreenCO BMP Category: Irrigation Audits

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☒ Other benchmarking

Study Description: In May 2001, the Texas Water Development Board (TWDB) contracted GDS Associates, Inc. (GDS) to perform a research study quantifying the effectiveness of various water conservation techniques (Study). The main purpose of the Study is to provide information regarding the effectiveness and costs of water conservation strategies on a regional level. The study also provides the sixteen water-planning regions (Regions) with comprehensive water conservation planning alternatives, as well as providing the TWDB with information to assist in the development of more accurate water demand scenarios. Landscape practices included in the study focused on:

- SF Irrigation Audit for High Users
- SF Rainwater Harvesting
- SF Rain Barrels
- MF Irrigation Audit
- MF Rainwater Harvesting
- Commercial Irrigation Audit
- Commercial Rainwater Harvesting

Where water efficiency measures are not affected by household size the savings per measure (gpd) is used to calculate the savings per person (gpcd). Generally, these measures affect residential outdoor water use.

Maximum Participation Rate Estimates: The maximum participation rates are based upon the maximum percentage of eligible customers who could reasonably be expected to participate in an implemented water efficiency measure. Assumptions were made for each measure regarding the percentage of customers that have already implemented a measure due to regulation, natural replacement, or other factors. The maximum participation rates are also based on the assumption that an effective and aggressive marketing and outreach approach effort is implemented. For the purposes of this Study, maximum participation rates do not vary between Regions.

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Projected Lifetime Considerations: irrigation audits are extremely dependent on customer education. Once an irrigation audit is complete, the savings depend on how well customers implement the recommendations to adhere to a watering schedule, repair broken sprinkler heads, etc. In order to maintain the savings of an irrigation audit over time, frequent follow-ups with the customer is necessary.

Year(s) Data Collected: N/A

Quantitative/Qualitative: Quantitative estimates based on literature and assumptions

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data: Costs estimated using direct and indirect costs.

Summary of Findings Related to Landscape Water Conservation BMPs:

SF Irrigation Audits – High Users
Maximum Participation Rate: The assumption is that 10 percent of residential customers are high users (consume more than 20,000 gallons per month for outdoor usage during the summer months) who would qualify for this measure and that half of these customers would participate in the program. Therefore, 5 percent of eligible customers could be expected to participate.
· Estimated Costs: $70/audit
· Water Savings: 50 gallons per measure (gpd). The savings calculation assumes an average outdoor water use of 500 gpd and an average audit savings of 10 percent. Therefore, a SF irrigation audit would result in a reduction of 50 gpd.

MF Irrigation Audit

Maximum Participation Rate
With multi-family customers, participation rates are higher than with SF customers due to the cost savings of more efficient large-scale irrigation systems to property managers and owners and the larger number of irrigation audits made by one decision maker. Therefore, it is assumed that 50 percent of eligible customers will participate in a MF irrigation audit.
· Estimated Costs: $150
· Water Savings 125 gallons per day. The savings were calculated based upon the following assumptions:
- 50,000 gallons per month average outdoor water use;
- the audit results in 15 percent reduction of outdoor water use; and
- the estimated savings computes to 250 gallons per day during the summer months and are then annualized.

Commercial Irrigation Audit
Maximum Participation Rate-- With multi-family customers, participation rates are higher than with SF customers due to the cost savings of more efficient large-scale irrigation systems to property managers and owners and the larger number of irrigation audits made by one decision maker. Therefore, it is assumed that overall commercial water use can be reduced by one percent.

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· Estimated Costs Direct Costs: $150
· Water Savings 125 gallons per day. The savings were calculated based upon the following assumptions:

- 50,000 gallons per month average outdoor water use;
- the audit results in 15 percent reduction of outdoor water use; and
- the estimated savings computes to 250 gallons per day during the summer months and are then annualized.

Rainwater Harvesting estimates were also provided, but not included in the review since they are not currently viable under Colorado water law for most urban areas.

Analysis of estimated savings divided among urban, suburban and rural areas, with estimates for base use, seasonal use and dry year provided.

Limitations: Developed for Texas.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

DRAFT--INTERNAL WORKING NOTES

70. Texas Water Conservation Advisory Council. (2008). A Report on Progress of Water Conservation in Texas. http://www.savetexaswater.org/documents/WCAC_report.pdf.

General Category:

GreenCO BMP Category:

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☒ Other benchmarking

Study Description: Annual report on water conservation submitted to legislature with recommendations to maximize water conservation benefits.

Year(s) Data Collected: Annual report for year ending 2008

Quantitative/Qualitative: Qualitative, with a strategy defined for a more quantitative approach to assessing conservation

Cost Data: ☐ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data:

Summary of Findings Related to Landscape Water Conservation BMPs:

According to the 2007 State Water Plan, conservation accounts for nearly 23 percent of the projected additional water supply needed in 2060—a total of about two million acre-feet per year, which is enough to supply half of the current annual municipal use in Texas. To accomplish this, 11 Recommendations are central focus of report:

- Recommendation 1: Develop methodology, metrics, and standards for water conservation implementation measurement and reporting
- Recommendation 2: Develop specific guidelines for how gallons per capita per day should be determined and how it should be applied to population-dependent water use only
- Recommendation 3: Develop reporting guidelines for improved data collection
- Recommendation 4: Expand data collection efforts to include all water providers and water use categories
- Recommendation 5: Develop a pilot project for water use data reporting
- Recommendation 6: Develop a pilot project for determining population figures appropriate for certain water use metrics

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- Recommendation 7: Provide the Council with the necessary resources to sufficiently develop and implement tools to monitor implementation of water conservation strategies recommended in the regional water plans
- Recommendation 8: Expand public awareness of water conservation statewide and coordinate campaigns at the state, regional, and local levels
- Recommendation 9: Establish a statewide water conservation recognition program
- Recommendation 10: Collaborate with national efforts to develop a clearinghouse of resources, tools, and best management practices
- Recommendation 11: Direct the Texas Water Development Board to develop a certification process for conservation training programs and provide preference for technical and financial assistance to these certified programs.

Limitations: Specific to Texas

Expected Transferability of Findings in Developing Quantitative Estimates:
☒ High ☐ Medium ☐ Low
(general recommendations and strategy may be helpful to Colorado)

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71. Zoldoske, D. F. (2003). *Improving Golf Course Irrigation Uniformity: A California Case Study*. Center for Irrigation Technology, California State University, Fresno. California Agricultural Technology Institute. http://cati.csufresno.edu/cit/Golf%20Course%20Irrigation%20Nozzle%20Study.pdf

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other

Study Description:
Five golf courses in California participated in this study, including a total of 606 irrigated acres representing 108 holes of golf (six-18 hole courses). The time span of data collection was one year prior to the nozzle change and one year of operation post nozzle change.

Year(s) Data Collected: N/A

Quantitative/Qualitative:

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data: Since all of the water on the participating golf courses is pumped, there is significant energy savings in addition to water savings. The average estimated gross water savings per golf course in this study (for 18 holes) is 16.6 acre feet per year. For the purpose of illustration, the study assumes a one-time cost of nozzle replacement is $12,000. The cost of water and energy would need to be $361 an acre-foot to achieve an estimated two-year payback period to recover the cost of re-nozzling based on the assumptions listed above. Water and energy costs higher than $361 would provide a shorter payback period, while lower water and energy costs would require a longer payback period to recoup the investment. Also higher or lower initial re-nozzling costs would effect this estimate, either positively or negatively.

Additionally, the golf course superintendent will likely put a dollar value on any perceived improvement in turf quality, reduction in hand-watering, and/or playability of the course. This would favorably impact or shorten the payback period. Finally, each golf course that participated in this study had water savings either higher or lower than the average used in the example used, so individual savings varied. The ultimate determination of whether re-nozzling is a viable option will be based on local economics, and must include all relevant conditions.

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Summary of Findings Related to Landscape Water Conservation BMPs:

The estimated total gross water savings for all the participants was 99.8 acre feet of water (32,519,304 gallons) or 6.5% of the applied water. Individual golf course gross water savings ranged from positive 21.4% to a negative <11.3%>. Adjusting for useful rainfall, the estimated savings falls to 82.9 acre feet (27,012,799 gallons) or 5.7% of the applied water. Individual golf course-adjusted water savings ranged from a positive 14.7% to negative <3.1%>. Assuming the actual savings is somewhere in between, the total savings experienced may be nearer 91.4 acre feet (29,782,507 gallons) and an average savings of 6.1% per golf course of the applied water.

Limitations: Located in California.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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72. Haley, M., & Dukes, M. (2007). Evaluation of Sensor Based Residential Irrigation Water Application. *2007 ASABE Annual International Meeting* (Paper No. 072251). Minneapolis: American Society of Agricultural and Biological Engineers. http://asae.frymulti.com/abstract.asp?aid=23040&t=2

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☒ Site-specific ☒ Regional ☐ Summary ☐ Other _____

Study Description:

An irrigation study to determine the effects of sensor based irrigation controllers on residential irrigation water use is described in this paper. This project included 59 homes in Pinellas County, Florida, with automatic in-ground residential irrigation systems.

Experimental treatments evaluated include: T1) an automatic time based irrigation controller, set and operated by the cooperator, with the integration of a soil moisture sensor, T2) a rain sensor with a timer-based irrigation schedule, T3) an automatic time based controller only, and T4) similar to T2 with educational material detailing seasonal irrigation recommendations based on historical climate data.

Related Study Cited: Haley et al. (2007) conducted study in St. Johns River Water Management District, where 64% of water went to irrigation, increasing to 88% in the summer. Setting irrigation controllers to historical resulted in a 30% reduction in irrigation use, with a 50% reduction when this was combined with microirrigation of planting beds.

Year(s) Data Collected: 2006-2007

Quantitative/Qualitative: Quantitative

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:
Preliminary results show that sensors are successful for irrigation water use savings at the single family home level. Data reported here is from June 2006, through March 2007. In homes with the installation of the soil moisture sensors (T1), water savings of 51% have

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been recorded compared to homes with an irrigation time clock only (T3). With the installation of a rain sensor (T2) the water used was 19% lower than T3. A further decrease in the amount of water use occurred after the distribution of the educational materials, with a difference of 58% between the two rain sensor treatments (T2 and T4).

Limitations: Conducted in Florida

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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73. Dukes, M. D., Cardenas-Lailhacar, B. and Miller, G. (2008). *Evaluation of Soil Moisture-Based on-demand Irrigation Controllers Final Report,* August 8. Prepared for and funded by Southwest Florida Water Management District. **http://www.acclima.com/08images/research/Dukes,_M._et_al_(2008)_Evaluation_of_Soil_Moisture-based_on-demand_Irrigation_Controllers.pdf**

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: A four-year research project, funded by the Southwest Florida Water Management District (SWFWMD), to evaluate a SMS-based irrigation system was recently completed. Four different SMS models/brands were initially tested and, later on, two more brands were included.

The initial objectives of this experiment were to quantify irrigation water use and to evaluate turf quality differences between: 1) a time-based irrigation schedule system with and without a rain sensor, 2) a time-based schedule compared to a soil moisture sensor-based irrigation system, and 3) different commercially available irrigation soil moisture sensor (SMS) systems. Later on, the consistency of the different SMS units within a brand to control irrigation was evaluated, as well as their potential to completely automate the irrigation systems without the need for seasonal time clock adjustment by personnel ("set and forget").

The research was conducted at the Agricultural and Biological Engineering Department research facilities at the University of Florida, in Gainesville, Florida. The experimental area consisted of common bermudagrass [*Cynodon dactylon* (L.) Pers.] plots (3.7 x 3.7 m).

All agencies involved in addition to SWFWMD staff included: Pinellas County, Pinellas County Florida Yards & Neighborhoods, Institute of Food and Agricultural Sciences, Florida Nursery Growers and Landscape Association, Florida Irrigation Society, Tampa Bay Water, Florida Department of Agriculture and Consumer Services, and the City of St. Petersburg. In addition, the Florida Department of Agriculture and Consumer Services contributed funds toward the project.

Other background notes: "A recent study carried out by Haley et al. (2007) in Central Florida found that homeowners tended to irrigate by as much as 2-3 times the turfgrass requirements. It has been reported that over irrigation promotes the establishment and survival of some turfgrass weeds (Busey and Johnston, 2006), increases the severity of some

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pathogens (Davis and Dernoeden, 1991), and increases evapotranspiration (Biran et al., 1981). Control of irrigation by soil moisture or soil tension has been shown to reduce both over-irrigation (Augustin and Snyder, 1984) and nitrogen leaching below the root zone (Snyder et al., 1984)."

Year(s) Data Collected: 2004-2007

Quantitative/Qualitative: Quantitative

Cost Data: ☒N/A ☐ Savings from BMPs ☐Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

Most SMS systems recorded significant irrigation water savings compared to time-based irrigation schedules typically used by homeowners. During normal/wet weather in Florida, savings ranged from 69% to 92% for three of four SMS brands tested. During dry weather conditions, savings ranged from 28% to 83%. All these water savings were achieved without decreasing turfgrass quality below acceptable levels. Therefore, SMSs represent a promising technology for water conservation. Moreover, one SMS brand enabled a flexible watering schedule for turf, without the need for seasonal adjustments by personnel.

Limitations: Conducted in Florida and on field plots, as opposed installations operated by homeowners.

Expected Transferability of Findings in Developing Quantitative Estimates:
☐ High ☒ Medium ☐ Low

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74. Seattle Public Utilities. (2009). *Seattle Water Supply System Regional 1% Water Conservation Program, Saving Water Partnership 2008 Annual Report*. http://www.savingwater.org/docs/2008%20Annual%20Report.pdf.
General Category:

GreenCO BMP Category:

Study Type ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description: The regional 1% Water Conservation Program (1% Program) is sponsored by the Saving Water Partnership (SWP). This Partnership includes the City of Seattle retail service area (population 628,000) and a group of 17 utilities (population 416,000) purchasing water wholesale from the City of Seattle.

Residential Landscape Program Components

- Reduce peak water use
- Irrigation system performance
- Landscape watering behaviors
- Practices that affect watering (e.g. mulch, soil prep and plant selection)
- Irrigation system efficiency rebates
- Right Plant/Right Place promotion via retailer partnerships (nurseries, home & garden centers)
- Savvy Gardener e-newsletter and classes
- The Garden Hotline
- Natural Lawn & Garden Guides (how-to materials)
- Trainings for irrigation professionals
- Development of standards for irrigation component performance through Irrigation Association Smart Water Application Technologies Initiative
- On-line weather data, watering index and irrigation scheduling tools

Commercial Landscape Program Components

- Improve watering efficiency
- Upgrade irrigation equipment (controllers, rain sensors, drip)
- Improve scheduling & maintenance
- Targeted outreach to large commercial customers
- Provide site-specific recommendations and technical assistance
- Financial incentives (custom projects and set rebates)
- Targeted recruiting and promotion to large commercial customers

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- Market transformation by establishing and building vendor and contractor relationships
- On-line weather data, watering index and irrigation scheduling tools
- Trainings for irrigation professionals

A variety of supportive measures for the program include youth education, overall messaging and program evaluation.

The Saving Water Partnership (SWP), with the support of residential, commercial and institutional customers, completed the eighth year of the 1% Program (2000- 2010). Regional per capita use is continuing to decline when normalized for variation in weather conditions. In 2008 the 1% Program achieved 0.75 million gallons per day (mgd) of savings, for a cumulative total of 8.4 mgd.

In the landscape sector, the Savvy Gardener lecture series added a new winter class to keep the message going year-round, and built on the "Right Plant, Right Place" campaign to promote a 'climate-smart' message in partnership with participating garden centers. The irrigation rebate program conducted mailings in July and September, and co-sponsored the largest Washington Irrigation Contractors Association biannual professional training yet. In the commercial sector, two successful customer events were held. An Integrated Conservation Workshop included topics ranging from new technologies to customer motivation, and attracted more than 100 attendees. A Green Properties Forum attracted more than 40 property managers to learn about regional incentive programs. In addition a research study of a large customer, the University of Washington (U of W), showed that their cumulative efforts since 2000 have reduced their water use by 30 to 40%, saving nearly $20 million.

Since 1990, water consumption has steadily declined due to the combined effects of conservation programs, increases in water and sewer rates, the state plumbing code, and improved system operations, despite continued population growth. Annual consumption is now about 123 mgd. The last time the Seattle regional system used that little water was about 50 years ago.

Year(s) Data Collected: 2008 (with reference to past 8 years)

Quantitative/Qualitative:

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: Cost was not the primary purpose of this report. Cost data are assumed to be available. **"**One of the motivating factors behind the aggressive conservation program is that **c**ost-effective extension of existing supplies. The measures identified in the 1% Program are less costly on a per unit basis than developing most traditional new sources of water supply. This benefits customers by keeping rates lower than they would be if a new source of supply

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were added to the system to meet demand in lieu of reducing it through conservation."

Summary of Findings Related to Landscape Water Conservation BMPs:

During 2008, the new annual savings associated with landscape water usage were: 0.08 annual average mgd at a cost of $ 269,000.

Price and Behavioral Savings include permanent conservation achieved from changes in customer water-using behaviors. Estimated to be 0.26 mgd annual average in 2008, behavior savings are difficult to separate from price savings since price has a strong influence in stimulating customers to change water using behaviors. The price savings estimate of 0.08 mgd is derived from the price elasticity and overlap parameters from SPU's water demand forecast model and actual changes in water and sewer prices. ET controllers are a key component of the program and have been shown to reduce water use by up to 30%. From review of a bar chart, it appears that the conservation component of the savings has grown ten-fold from 2000 to about 10 mgd (average annual) savings. Educational component involvement is detailed according to participation in the report. Landscape-related savings include:

2008 Landscape Rebates

	Number of Customers	**Savings (gallons/day)**
Single Family Homes	108	9,600
Single Family Non-Rebate	NA	21,055
Commercial (Including Multifamily)	44	16,506
Commercial Non-Rebate	NA	28,243
Total Savings		75,404

The rebates focused on ET and soil moisture sensor controllers.

"Soils amended with compost hold more moisture, decreasing the amount of water needed in gardens and the demands on water supply."

Savvy Gardener E-newsletter: By mid-2008, the newsletter had nearly 2000 subscribers and it was time to assess the newsletter's effectiveness and identify areas for improvement. SWP sent an electronic survey to subscribers and received 188 responses. We found that as a result of reading the newsletter, 40-48% of the respondents had applied mulch (40%), added compost to their soil (41%) and selected plants based on the sun, shade and soil in their garden (48%).

Commercial Outreach: staff conducted intensive outreach to commercial customers and to irrigation and landscape contractors who specialize in commercial properties. Forty-four commercial projects took place, saving nearly 17,000 gallons per day.

Contractor Training: In December, the SWP co-sponsored a weeklong irrigation training series with the Washington Irrigation Contractors Association (WICA) and, for the first time, with Cascade Water Alliance. Approximately 160 individuals attended one or more

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classes. The training included the only Spanish-language irrigation classes offered in western Washington. These Spanish language classes have been some of the most popular classes since the SWP began offering them in 2007. In 2009, staff will work to expand training opportunities for landscape professionals in the region by collaborating with other organizations and local irrigation distributors.

Evaluation Planning for Landscape Programs: Over the life of the 1% Water Conservation programs, staff have used many forms of evaluation to assess customer awareness, knowledge and behavior change in residential landscapes. An effort to summarize this work in a report has begun. The report is expected to be especially helpful to wholesale partners in understanding the complex nature of affecting change in customers' water use habits. Development of the report has been helpful to staff in identifying evaluation gaps as well as important continuing methods of evaluation. As a follow up to these recommendations, staff began development of a short set of key indicators to monitor behavior change on an annual basis. Prior to this, SWP has executed large and costly surveys that are several years apart. While these surveys are more comprehensive, they have not allowed staff to assess the impacts of the landscape programs on a more immediate basis.

Limitations: Data/savings are specific to Seattle, but overall approach has application in Colorado

Expected Transferability of Findings in Developing Quantitative Estimates:

☒High ☐ Medium ☐ Low

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75. Seattle Public Utilities. (2009). Water Smart Technology, Irrigation Case Study, Shoreline School District. Retrieved June 2009 from the Saving Water Partnership: www.savingwater.org

General Category: Irrigation

GreenCO BMP Category: Irrigation Technology

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description:
The Shoreline School District irrigates 16 sites scattered over approximately 15 square miles just north of Seattle. The suburban setting of the district's schools features extensive irrigated landscapes in addition to irrigated turf athletic and playfields.

Working with Seattle Public Utilities, the school district developed a comprehensive program to reduce the amount of water used in irrigation. Conservation strategies centered around installation of a weather-based control system. As a result, the school district's cost for irrigation water has dropped by up to 50 percent.

Year(s) Data Collected: Not specified in fact sheet; problem identified in 1992

Quantitative/Qualitative:

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

Project Cost: $175,358
Rebate: $59,031
Water/Wastewater Savings: 20 million gallons/year = $50,600 per year
Payback time under 2 years.

Summary of Findings Related to Landscape Water Conservation BMPs:

- Moved toward 'scientific scheduling' of irrigation, based on actual irrigation system performance, soil characteristics, plant water needs and climatic data. Site audits showed that this alone decreased water use by 30 percent with no adverse effects.

- Installed rain sensors and widespread use of sprinklers with in-head check valves.

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- The school district's landscape architects also joined in the effort, modifying accepted design standards and incorporating new products and technologies into specifications. The synergy that developed as a result of collaboration with SPU, designers, vendors and Shoreline's management allows for vastly improved, value-added projects to be developed.

Limitations: Located in Seattle

Expected Transferability of Findings in Developing Quantitative Estimates:

☐ High ☒ Medium ☐ Low

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76. Johnson, G. A., Davis J.G., Qian Y.L., Doesken K.C. (2006). Topdressing turf with composted manure improves soil quality and protects water quality. *Soil Science Society of America Journal*, 70, 2114-21.
General Category: Soil Amendment

GreenCO BMP Category: Soil Amendment, Turf Management

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☐ Summary ☒ Other field tests

Study Description: (from study abstract)

Compost can improve soil properties when incorporated into soil; however, little information is available regarding impacts of compost topdressing. Objectives of this study were to evaluate the effects that topdressing composted dairy manure onto Kentucky bluegrass (Poa pratensis L.) has on: (i) soil physical properties, (ii) soil chemical properties, (iii) soil nitrate (NO3–N) and P concentrations below the rootzone, (iv) total runoff and sediment losses, and (v) N and P concentrations in runoff.

Plots were topdressed with compost at 0, 33, 66, and 99 m3 ha–1. Saturated hydraulic conductivity, bulk density, water retention, and soil nutrient levels were measured. A rainfall simulation was conducted, and runoff was collected and analyzed for total nitrogen (TN), nitrate nitrogen (NO3–N), ammonium nitrogen (NH4–N), total phosphorus (TP), total dissolved P (TDP), and ortho-phosphate (OP).

Year(s) Data Collected:

Quantitative/Qualitative:

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

Summary of Findings Related to Landscape Water Conservation BMPs:

Compost application of 99 m3 ha–1 reduced bulk density, and increased water retention and P, K, Fe, and Mn concentrations in the surface soil.

Compost applications of 66 m3 ha–1 or greater raised soil electrical conductivity (EC); however, this increase in soil EC did not negatively impact turf quality.

Other benefits also reported.

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Topdressing composted manure onto established turf improved soil physical properties and nutrient concentrations without increasing nutrient runoff, with the exception of increased NH4–N levels in runoff.

See a related unpublished(?) 2006 manuscript by Johnson, Quian, and Davis (2006) titled "Topdressing Kentucky Bluegrass with Compost Increases Soil Water Content and Improves Turf Quality during Drought.".

Limitations:

Expected Transferability of Findings in Developing Quantitative Estimates:

☐ High ☒ Medium ☐ Low

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77. Johnson, G. A., Qian Y.L., Davis J.G. (2006). Topdressing Kentucky Bluegrass with Compost Increases Soil Water Content and Improves Turf Quality during Drought. Obtained from original manuscript. Fort Collins: Colorado State University. (*final publication location unknown*).
General Category: Soil Amendment, Turf Management

GreenCO BMP Category: Soil Amendment, Turf Management

Study Type: ☐ Journal ☐ Private Study ☐ Book ☐ Government/Agency ☒ University ☐ Manufacturer

Data Type: ☒ Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description:

Study conducted because little information has been available concerning the effects of compost topdressing after core cultivation on turfgrass drought response. The objectives of this study were to evaluate the effects that core cultivation and topdressing compost onto established Kentucky bluegrass has on: i) soil water content; ii) turf canopy temperatures; and iii) turfgrass quality during periods of drought. Following core cultivations in May and September 2003 and May 2004, compost treatments [0 (control), 33, 66, and 99 m3 ha-1] were topdressed onto established 'Nuglade' and 'Livingston' Kentucky bluegrass in the field (Experiment I). In Experiment II, 'Kenblue' Kentucky bluegrass was topdressed with 0 (control), 66, and 99 m3 ha-1 compost after core-cultivation. In addition, a non-core-cultivated and no-compost-topdressed treatment was included. Three 10-d dry down periods were imposed during the summers.

Year(s) Data Collected: 2006(?)

Quantitative/Qualitative: Quantitative

Cost Data: ☒ N/A ☐ Savings from BMPs ☐ Cost to Implement

Summary of Cost Data: N/A

Summary of Findings Related to Landscape Water Conservation BMPs:

During the dry down periods, compost treatment increased SWC in the 15-30 cm soil depth during the first four days of dry down and in the 0-15 cm depth 7-10 into the dry down period. Compared to the control, compost treatments at 66 and 99 m^3 ha^{-1} reduced turf canopy temperature by 1.2-3.3°C during 4-10 days of dry down, indicating less drought stress. While turf quality in the control of 'Nuglade' and 'Livingston' varieties declined to an unacceptable level on day 8 of dry down, plots with 66 and 99 m^3 ha^{-1} compost treatments maintained acceptable turf quality during the entire dry down

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periods. In Experiment II, turf quality of Kenblue dropped to below 6 on day 4 for the non-cultivated and no-compost-topdressed treatment, on day 7 for the core-cultivated but no-compost-topdressed control and on day 9 for 66 and 99 m^3 ha^{-1} compost treatments. Results suggested that compost topdressing after core cultivation is a management practice that could reduce turfgrass irrigation requirements.

Other notes extracted from the report:

In typical agricultural settings, researchers have found that organic material amendments have beneficial effects on soil physical properties, such as increased water-holding capacity, soil aggregation, soil aeration and permeability, and decreased soil crusting and bulk density (USDA, 1957; USDA 1978; Hornick and Parr, 1987). [*obtain these references in the future*] These improvements to soil physical properties could improve root growth and increase the proportion of water that is available to plants, which could reduce irrigation requirements.

The experiment indicated that core cultivation could help Kenblue Kentucky bluegrass maintain its turf quality 3 days longer during the 10-day-period without irrigation or precipitation. Compost topdressing (at 66 and 99 m^3 ha^{-1}) after core cultivation could help Kentucky bluegrass maintain acceptable turf quality 2-3 days longer compared to the core cultivated but no-compost-topdressed control. This will translate into reduced irrigation frequency, thereby reducing turfgrass irrigation demands. Core cultivation is considered one of the routine management practices to control thatch and enhance water infiltration. We have documented with this work that compost topdressing after core cultivation will provide additional benefits of increased water infiltration rate, enhanced water movement into deeper soil depths, and therefore, improve water conservation.

In summary, this experiment suggested that compost topdressing following core cultivation could provide a means of water conservation in managing aesthetically appealing turfgrass systems. Compost topdressing following core cultivation can increase water infiltration and penetration into deep soil depths, which increases root zone water availability. The mulching effect of compost also reduces evaporation loss of water in the soil. To reduce urban water use, it is necessary to combine various means in such a way as to attain the maximum conservation at the lowest cost with the least inconvenience. Compost topdressing can be considered as an important water conservation method in turfgrass management.

Limitations: none

Expected Transferability of Findings in Developing Quantitative Estimates:

☒ High ☐ Medium ☐ Low

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78. Medina, J., & Lee, A. (2006). *FX Project, Fargo Xeriscape Project, Final Report*. Bureau of Reclamation and City of Fargo. http://www.cityoffargo.com/attachments/085a3837-2779-406d-8f30-4298f66e43ea/Fargo%20Xeriscape%20Project%20Final%20Report.pdf

General Category: Xeriscape

GreenCO BMP Category: Xeriscape

Study Type: ☐ Journal ☐ Private Study ☐ Book ☒ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☒Site-specific ☐ Regional ☐ Summary ☐ Other _____

Study Description:
As part of the NXDP, Fargo was selected as one of the five cities involved with the Bureau of Reclamation's landscape water use study. Fargo has relatively low rainfall and its rising population. The Fargo Xeriscape Project's intent was to provide information to the about installation costs, maintenance costs, and water savings when installing Xeriscape style landscaping versus a traditional style landscape.

Year(s) Data Collected:

Quantitative/Qualitative: Quantitative

Cost Data: ☐ N/A ☒ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:
For a house to retrofit itself into a Xeriscape, it would average $0.71 per square foot and for a new start construction it would average $1.11 per square foot.

Summary of Findings Related to Landscape Water Conservation BMPs: (notes extracted from Executive Summary)

Signing up initial participants was the most challenging aspect of the project; new start participant numbers were the most difficult demonstration to fill. The initial cost of a house with the burden of having enough discretionary money left over to install plant material and an automatic irrigation system was daunting for many homeowners.

June of 2000 brought about a large rainfall event of nearly 8 inches over 2 hours. This left many home basements flooded and planting beds left in disarray. Maintenance of planting beds was not a priority for most participants, due to the heavy amount of clean up left to do inside the house. The results of the FX project demonstrated that maintenance costs were higher for both Xeriscape retrofits and new starts, when compared to their respective controls. Retrofits required 32% more maintenance and new starts required close to 10% increased maintenance than the control landscapes.

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Water savings on Xeriscape new starts averaged 29% water savings, while retrofit Xeriscapes used more water on average. This was partly due to the slightly higher rainfall amounts over the study period leaving retrofit control properties with little or no need to water. Consequently, retrofit Xeriscape properties were in the initial plant establishment period where water usage is quite high. Additionally, many of the retrofit control properties watered very little outdoors, which is a good thing, but when taken in the context of this study it has shown that retrofit properties can use more water in the establishment period. Homeowner demographics likely play a large part in the retrofit demonstration with older residents rarely using water for outside plants.

Fargo demonstrated that water savings can easily range from 10% up to 50% when properly designed, installed and maintained. Reducing the amount of turf area has the highest impact on water usage per property, and when turf is limited to one-third to one-half of the landscape area, maximum results can be achieved.

Limitations:

Expected Transferability of Findings in Developing Quantitative Estimates:

☒ High ☐ Medium ☐ Low

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79. Gregg, T., Strub, D., & Gross, D. (2007). Water Efficiency in Austin, Texas, 1983-2005, An Historical Perspective. *Journal AWWA*, 99 (2), pp. 76-86. ***not the actual reference; this is a summary from another NXDP project; need to go to original***

General Category: Xeriscape

GreenCO BMP Category: Xeriscape

Study Type: ☐ Journal ☐ Private Study ☒ Book ☐ Government/Agency ☐ University ☐ Manufacturer

Data Type: ☐ Site-specific ☐ Regional ☒ Summary ☐ Other _____

Study Description:

Year(s) Data Collected:

Quantitative/Qualitative:

Cost Data: ☐ N/A ☐ Savings from BMPs ☒ Cost to Implement

Summary of Cost Data:

Summary of Findings Related to Landscape Water Conservation BMPs:

- Buffalo grass (considered water conserving) saved about 30 percent water over St. Augustine (high use turf).
- Irrigation systems were associated with about 38 percent more water use (than without).
- Highest income areas were associated with 57 percent more water use than middle incomes.
- Lowest incomes were associated with a 28 percent decrease in water use from middle income water use.
-

Additional study by Gregg (1999) yielded these additional findings:

- Xeriscapes used approximately 211 gallons per day (gpd) less water in summer than non-Xeriscapes
- In-ground irrigation systems raised water consumption by 83 percent regardless of grass type.
- A Xeriscape rebate program reduced summer water use by about 133 gpd. It was estimated that the benefit/cost becomes positive at 13 years.
- An irrigation audit program was successful in altering watering by 69 percent of participants

Limitations:

DRAFT - INTERNAL WORKING NOTES

Above average rainfall in 3 of the 5 study years accounted for some unexpected abnormalities.

Expected Transferability of Findings in Developing Quantitative Estimates:

☒ High ☐ Medium ☐ Low

DRAFT--INTERNAL WORKING NOTES

Note: See bibliography and Attachment 2, Tabulation of Water Conservation Measures for additional information. Several references identified near closure of the scope of work were not included in these notes sheets.

DRAFT--INTERNAL WORKING NOTES