Exploring the Role of Landscape Water Conservation and Efficiency in Meeting the Colorado Water Gap: Expected Benefits of Landscape Water Conservation Best Management Practices

Prepared for GreenCO by Wright Water Engineers, Northern Colorado Water Conservancy District and Aquacraft Engineering, September 2015

Executive Summary

Colorado is facing a projected water supply gap that may exceed 500,000 acre-feet (AF) by 2050. A multi-faceted strategy is needed to meet to this gap, and urban landscape water conservation is part of the solution. From 2002-2008, GreenCO worked to develop a scientifically-based set of 39 best management practices (BMPs) for the Green Industry, summarizing practices that conserve (require less) water, increase irrigation efficiency, protect water quality, and support healthy, sustainable landscapes. Represented examples of these BMPs include: Xeriscape, water budgeting, soil amendment/ground preparation, various irrigation efficiency practices (e.g., design, installation, maintenance, technology), and landscape design and maintenance practices. While most agree that landscape water conservation opportunities are plentiful in urban landscapes, the magnitude of water savings achievable through various BMPs is not currently quantified in a manner that is consistently transferable or readily integrated into local watering guidelines, rules and regulations, Water Conservation Plans, Basin Implementation Plans, the State Water Plan, or various legislative House and Senate Bill initiatives.

To help convey the quantitative benefits of landscape BMPs, both within the industry and for water providers, GreenCO has undertaken two efforts to identify and synthesize data useful for quantifying water savings for BMPs. The first effort included a landscape water conservation literature review in 2009, which was funded by the Colorado Water Conservation Board. Because water savings in the literature were reported using a variety of methods and varying levels of site-related characteristics (metadata), additional work was recommended to "normalize" these data sets (i.e., translate to a common metric) for purposes of developing quantitative savings estimates. In 2015, GreenCO undertook a second effort to extract key data from the 2009 literature review studies and review additional literature to better quantify the benefits of landscape water conservation BMPs, as summarized in this report.

The original intent of this effort was to extract new landscape water conservation savings from the literature and normalize the varied findings reported in the literature to support quantitative estimates for various landscape BMPs. One of the challenges associated with interpretation and synthesis of landscape water conservation studies conducted for multiple purposes in various geographic locations and hydrologic conditions (e.g., wet year, dry year) is that the measures of performance are often not directly transferable. For example, a 50%

savings of water during a wet year on the Front Range would overestimate the savings that would be expected during a dry year on the West Slope. In order to increase the transferability and comparability of study findings, additional steps must be taken to normalize study findings. Although such techniques to normalize data are available, adequate metadata (information about the study conditions) are needed to accomplish this task. Because the literature review indicated that limited empirical data were available, an expanded multipronged approach was developed to further the understanding of the potential water savings associated with various BMPs and to develop a better understanding of the role of landscape water conservation BMPs in meeting the state's water gap. These three complementary approaches were used:

1. Compile and normalize the findings of existing empirical data in the literature.

2. Complete engineering calculations to estimate net irrigation requirements for various landscape scenarios using a spreadsheet tool based on the Dual Kc Method described in the Food and Agricultural Organization Handbook 56 (FAO 56). This analysis was used to better quantify how landscape water needs change as BMP-related variables such as plant type, irrigation method and soil characteristics are altered.

3. Conduct macro-scale modeling for the South Platte Basin to estimate potential water demand reductions achievable under several outdoor water use scenarios. This effort was conducted by Aquacraft Engineering, utilizing an approach similar to the one used in the Water Research Foundation-sponsored Water Residential End Uses of Water Study 2 (REUWS2).

Although each of these exercises was primarily oriented to Front Range settings, similar exercises could be conducted for other basins in Colorado. All three of these exercises could continue to be refined based on new data, or other hypothetical scenarios.

Summary of Findings

As a result of the expanded literature review and modeling efforts, key findings supported by the analysis in this report include:

1. Both empirical data and modeling efforts demonstrate that landscape water conservation BMPs can provide significant water demand reductions, without sacrificing attractive, sustainable landscapes. The absolute magnitude of these reductions varies based on site-specific landscape conditions, climate and behavioral change. The primary practices evaluated in this report relate to Xeriscape, including (but not limited to) plant selection, irrigation practice and technology, soil amendment (to a limited extent), and improvements to irrigation systems in response to irrigation audits.

2. Simply reducing over-irrigation remains a significant opportunity for water savings. This practice can be implemented without costly retrofits of landscapes, although

upgrades to irrigation systems and use of advanced irrigation technology will certainly support this objective. Water budgeting is a fundamental tool that can be used to educate property owners and landscape contractors about the irrigation requirements needed to maintain healthy landscapes. When targeting reduction in over-irrigation, recent studies by Denver Water and others show that many service areas include multiple irrigation user types: those who under-irrigate, those who practice sustainable irrigation practices and those who over-irrigate. Efforts to reduce over-irrigation and planning-level reduction targets should be targeted to the subset of customers who are over-irrigating. Modeling conducted by Aquacraft for this report shows that reducing over-irrigation by 20% for single family residential units and 10% for multi-family residential units could save nearly 86,560 AF of water in the South Platte Basin over a 40-year period.

3. Based on the expanded literature review, study characteristics and water savings data were extracted and compiled in a consistent format to facilitate normalization of expected water savings for various landscape BMPs. The lack of consistency in reporting of data in the literature significantly constrained this exercise. Nonetheless, quantitative ranges of savings in gallons per square foot (gpsf) were calculated for the Front Range for the following general practice groups:

    a. Conversion of Cool-Season Turf (e.g. Kentucky bluegrass) to Plants with Lower Irrigation Requirements: Converting cool-season turf areas to shrubs, ground covers and perennials is estimated to save 2.0 to 5.5 gpsf of landscape area. These savings increase to 5.9-11.5 gpsf if the replacement is with low-water xeric plants. Portions of lawns where such conversions may be particularly beneficial include steep slopes, narrow strips that are difficult to irrigate, and other areas where cool-season turf is difficult to efficiently maintain or is not providing aesthetic or functional benefits.

    b. Irrigation Efficiency Audits: Performing irrigation efficiency audits is estimated to save 1.3 to 3.3 gpsf when irrigation efficiency is improved in response to irrigation audits.

    c. Irrigation System Technology and Retrofits: Study designs vary substantially, making generalizations difficult. Examples of reported savings include 4.8 gpsf for replacing old irrigation systems and 3.3 gpsf for weather based irrigation controllers. Some studies have shown increases in irrigation use when manual watering is converted to automated irrigation or when advanced weather-based controllers are implemented. (In such cases, the baseline landscape conditions represent under-watering and the irrigation level is raised to meet the irrigation requirement of the plants.)

   Estimates were also calculated for Grand Junction, with the magnitude of savings (gpsf) generally greater on the West Slope due to higher ET (evapotranspiration) rates and lower precipitation.

4. A spreadsheet model (based on the Dual Kc Method described in FAO 56) was used to calculate the net irrigation requirements of various landscape scenarios, with results compared to two irrigated cool-season turf landscape scenarios. Key findings from this modeling exercise included:

    a. The lowest overall irrigation requirement achieved was for deep-rooted xeric plants, irrigated infrequently using drip irrigation, followed by more shallow rooted xeric ground covers. The ground cover scenario represents approximately 50 to 60 percent savings relative to the baseline turf scenarios. Deep-rooted xeric plants provided an additional 10 percent reduction in water requirement relative to more shallow rooted (6 inches) xeric plants. The root depth could be affected by choice of xeric plants, as well as by soil type.

    b. For annuals, use of drip irrigation rather than spray irrigation resulted in approximately 10 percent less water requirement.

    c. Warm-season turfgrass (e.g., Buffalograss) had lower water requirements than the other cool-season turfgrass scenarios except with regard to the scenario that represented use of soil amendment and irrigation management using a more advanced “manage allowable depletion” (MAD) approach for cool-season turfgrass. This analysis suggests that an aggressively managed cool-season turfgrass with proper soil amendment may achieve water savings comparable to or greater than warm-season turfgrass, depending on the management strategy implemented. This is an important finding because GreenCO and Colorado State University Turf Program both recommend that turf selection should be based on the desired functional, recreational and aesthetic benefits, in addition to considering maintenance and water requirements. For example, cool-season turfgrass is desirable for certain landscape purposes, such as for high use areas, whereas warm-season Buffalograss has lower traffic tolerance and may be more suitable for low-traffic areas.

    d. For cool-season turfgrass (e.g., Kentucky bluegrass) management scenarios, the lowest water use resulted for the scenario represented by soil amendment and aggressively managed irrigation using a MAD approach, which typically requires advanced irrigation technology. (This is the same cool-season turf scenario described in c., above.) This scenario reduced the irrigation requirement by nearly 50% relative to the baseline turf scenarios under an average water year. This scenario approaches the water savings achieved by drip-irrigated annuals and is similar to warm-season turf. In summary, the irrigation management practice at a site is a critical factor in the irrigation requirement. This may represent a significant opportunity for savings on large landscapes or highly managed commercial landscapes, even if this is not directly transferable to the average homeowner.

5. The Dual Kc modeled results compare relatively well to the normalized empirical data from the literature with regard to plant selection, as shown in these examples for the Front Range:

    a. Xeriscape/Plant Selection--replacement of cool-season turf areas with shrubs, ground covers and perennials: Literature = 2.0 to 5.5 gpsf and Dual Kc Model =3.7 to 5.4 gpsf (average year).

    b. Xeriscape/Plant Selection--replacement of cool-season turf areas with xeric groundcovers and deep-rooted xeric plants: Literature = 5.9 to 11.5 gpsf and Dual Kc Model =8.5 to 12 gpsf (average year).

    These results assume that portions of lawns replaced with plants with lower water requirements would be irrigated appropriately (according to hydrozones).

    Study designs and site conditions were too variable to make this comparison for irrigation technology.

6. At a basin-scale, Aquacraft's modeling exercise demonstrated that landscape water conservation and efficiency measures can help to significantly reduce the water gap in Colorado. Three landscape-related conditions were evaluated that considered reductions in over-irrigation and effective irrigated area (scenarios including 10% and 25% reductions in irrigated area). Model results for the South Platte Basin indicate that reductions in over-irrigation and reducing effective irrigated landscape areas can play a significant role in filling the projected 2050 water gap, without eliminating or reducing the aesthetic quality of Colorado landscapes. Of the three landscape-related conservation scenarios evaluated, reduction in over-irrigation provided the most significant water savings, with essentially no impact to landscape quality (since this scenario simply reduces water waste). With regard to reduced effective irrigated area, there are multiple combinations of plant types that can be selected to achieve a 10 to 25 percent effective irrigated area reduction on individual landscape parcels, without drastically changing the character of Colorado's landscaped areas. However, implementing this type of change at a basin or state-wide scale would be challenging. The feasibility of implementation of the modeled scenarios would require additional input from water providers.

Recommendations

Many of the recommendations from GreenCO's 2009 Literature Review remain valid, with some additional recommendations emerging as a result of this 2015 study. These recommendations apply to state-led efforts, water providers and the Green Industry, with recommended actions including:

1. Support well-designed monitoring efforts that can be used to better quantify the expected benefits of landscape BMPs and that can be used to support modeling efforts

based on empirically-derived relationships (real-world data). Overall, this analysis indicates that there are significant data gaps for empirical studies related to landscape water conservation, particularly studies that provide adequate metadata to normalize data sets to support broader planning objectives. Empirical studies are important because they can incorporate behavioral aspects of water conservation in a manner that agronomic models and theoretical calculations do not. Empirical studies can be used to develop better estimates of uncertainty in demand models and should continue to be conducted and funded.

2. Develop a set of standardized monitoring and reporting protocols for large-scale and site-specific landscape water conservation studies to increase transferability of study findings through better metadata reporting.

3. Assess interest in a statewide database to store conservation studies that follows a standard format noted in #2 above. Such a database would need to be kept as simple as possible to encourage participation and use. It may also be worthwhile to discuss pursuing funding at a national scale from EPA and professional organizations, following a model similar to that used for stormwater BMPs (www.bmpdatabase.org).

4. Support efforts to implement separate metering of indoor and outdoor water use to refine estimates of outdoor water demand. Denver Water and others are implementing this practice in certain areas.

5. Analyze and evaluate House Bill 10-1051 data sets to develop a realistic baseline of outdoor water demand. Although residential single-family water demands have been characterized in several large-scale studies nationally and in Colorado, data for the multi-family properties and irrigation-only accounts is far less reliable and could be improved by obtaining better information on the multi-family sector and irrigated urban landscape areas.

6. Organize a large, systematic study of residential water use and landscape irrigation based on sampling from all of the large water providers in targeted basins such as the South Platte, similar to the end use studies in the Aquacraft models. This would be a major undertaking, but the work would provide a wealth of details on the parameters needed to make accurate predictions of water use, and would greatly improve the accuracy of the predictive tools. This would allow water demand projections and potential savings to be made in a more explicit and mathematically satisfying manner.

Conclusion

As Colorado works to meet the projected water gaps identified in the State Water Plan, the findings above should be considered in the development of sound water policy. This study further confirms that there are significant opportunities for landscape water conservation through the use and adoption of Best Management Practices, and it is possible to reduce outdoor water use and still enjoy the environmental and aesthetic benefits that the urban landscape provides.