Managing Irrigation to Water Budgets in San Diego County

Carlos Michelon*, BSCE
San Diego County Water Authority, 4677 Overland Ave., San Diego, CA 92123, cmichelon@sdcwa.org
(*WSLEP Program Co-Manager)

JoEllen Jacoby, RLA, CLIA, QWEL, WWLP
Registered Landscape Architect, JoEllen.jacoby.baugh@outlook.com

Kyrsten Burr-Rosenthal, BA, MPA
San Diego County Water Authority, 4677 Overland Ave., San Diego, CA 92123, kburr@sdcwa.org

Alyssa Barman, Student Intern
San Diego County Water Authority, 4677 Overland Ave., San Diego, CA 92123, abarman@sdcwa.org

Abstract. *From 2014 to 2016, the San Diego County Water Authority conducted a grant-funded program aimed at improving water use efficiency in large urban landscapes by means of hardware upgrades, water budgeting, water use monitoring, and workforce training. The results were impressive, with an average reduction in water use across 20 participating sites that exceeded 30%. This technical paper and presentation will discuss program protocols; descriptive statistics of hardware enhancements deployed; workforce training; and highlights of program results, including potential program enhancements.*

Program implementation was a collaborative effort with the California Landscape Contractors Association (CLCA), leveraging the expertise and resources of CLCA's Water Management Certification program to empower participating contractors to successfully manage mature landscapes to a water budget.

Keywords. Contractor, Water Manager, Water Provider, Turf/Landscape (Commercial), Audit, Conservation, Distribution Uniformity**,** Scheduling**,** Pressure Regulation, Training, Water Budget.

Executive Summary

With a Proposition 50 Water Use Efficiency grant from the California Department of Water Resources, the San Diego County Water Authority (Water Authority) set out to implement a small-scale demonstration program to showcase the effectiveness of irrigation equipment upgrades when coupled with irrigation management training. Participating landscape maintenance contractors registered in the program with the goal of achieving a twenty percent (20%) reduction in water use relative to a three-year water consumption baseline at twenty commercial landscape sites. The program was a Water-Energy Nexus (WEN) partnership between Water Authority and San Diego Gas and Electric, leading to water and embedded energy savings through effective irrigation management and high-efficiency hardware upgrades. The program was designed to be consistent with CLCA's Water Management principles. Participating sites received financial incentives to evaluate irrigation systems, upgrade equipment and manage water consumption within a water budget. The results demonstrated the water conservation effectiveness of a comprehensive approach that integrated site management, equipment upgrades, and contractor training. The average reduction in water use across twenty participating sites exceeded thirty percent (30%).

Background

In 2008-2009, the Water Authority and San Diego Gas & Electric (SDG&E) successfully carried the first iteration of this type of pilot program. This a performance-based pilot program, entitled the Managed Landscapes Program (MLP), was designed to improve the outdoor water-use efficiency of a variety of large landscapes, which included homeowner associations, apartments, and commercial properties. Through that approach, a single vendor deployed proprietary irrigation control technology and water management services, achieving significant water savings. At the conclusion of the successful MLP, there was interest in implementing a follow-up pilot program to test the viability of a de-centralized approach (involving multiple contractors) and relying on non-proprietary industry best practices. The Water Authority and SDG&E, as part of their ongoing WEN partnership, collaborated from 2013-2015 to implement the Water Savings Landscape Efficiency Program (WSLEP), which included program modifications based on lessons learned from the evaluation of the MLP.

The global objective for WSLEP was to achieve a twenty percent (20%) reduction in water use relative to a three-year water consumption baseline at twenty commercial landscape sites. WSLEP goals included engaging landscape contractors and their existing customer base (pool of candidate sites) to identify high-water use sites, deploying a limited range of proven irrigation technology retrofits, and following specific irrigation management protocols.

Financial incentives were provided to participating landscape contractors for fulfilling specific program requirements and meeting pre-determined performance objectives (See Table 1. Schedule of Incentives). WSLEP was jointly administered by the Water Authority and SDG&E, in collaboration with CLCA. The Water Authority was the program lead for program design, technical oversight, and hardware financial incentives. SDG&E's was the program lead for contracting and administration. Administration of program implementation was outsourced to CLCA. Implementation activities included participant enrollment, workforce development, site assessments, installation verification, incentive disbursement, reporting, and a final determination of each site's irrigation management performance.

Table 1. Schedule of Incentives

Activity	Incentive Amount
Site Participation Enrollment	$100 per site
Landscape Audit, Water Budget Calculation and Water Savings Estimate	$500 per site
Executed Site Agreement	$100 per site
Hardware Upgrade Allowance	$5,000 per site maximum (supplier paid directly)
Installation Labor Allowance	$5,000 per site maximum
Water Management Services	$1,200 ($100 per month per site)
Customer Satisfaction Survey	$100 per site
Performance Fee (for 20% savings or better)	$1,700 per site
Total Fees	**$13,600**

Program Protocols

Selection of sites. The program hinged on the careful selection of sites. The landscape contractor and the site owner were required to jointly enroll to participate. Landscape contractors agreed to follow the principles of the CLCA water management program. The typical site was serviced by dedicated landscape meters with an approximate irrigation area of about four acres (1.62 ha). Some larger sites were treated as separate sites for administrative purposes. For eligibility, prospective sites needed to demonstrate the potential for water savings of at least twenty percent (20%). A site's plant coverage could be a mix of turf and shrubs. However, this program did not allow plant replacement (e.g. turf conversion) to occur during the participation period. Twenty sites managed by nine contractors were ultimately enrolled, totaling 100.6 acres (40.73 ha). See Table 2. Breakdown of Project Types with Total Acreage, for a breakdown of project types and associated acreage.

Table 2. Breakdown of Project Types with Total Acreage

Site Type	Qty.	Total Acres (ha)
Multi-family (SFR HOA and apt/condo)	14	63 (25.50)
City Park	5	32 (12.95)
Commercial Complex	1	6 (2.43)
Average Site Acreage		**5 (2.02)**

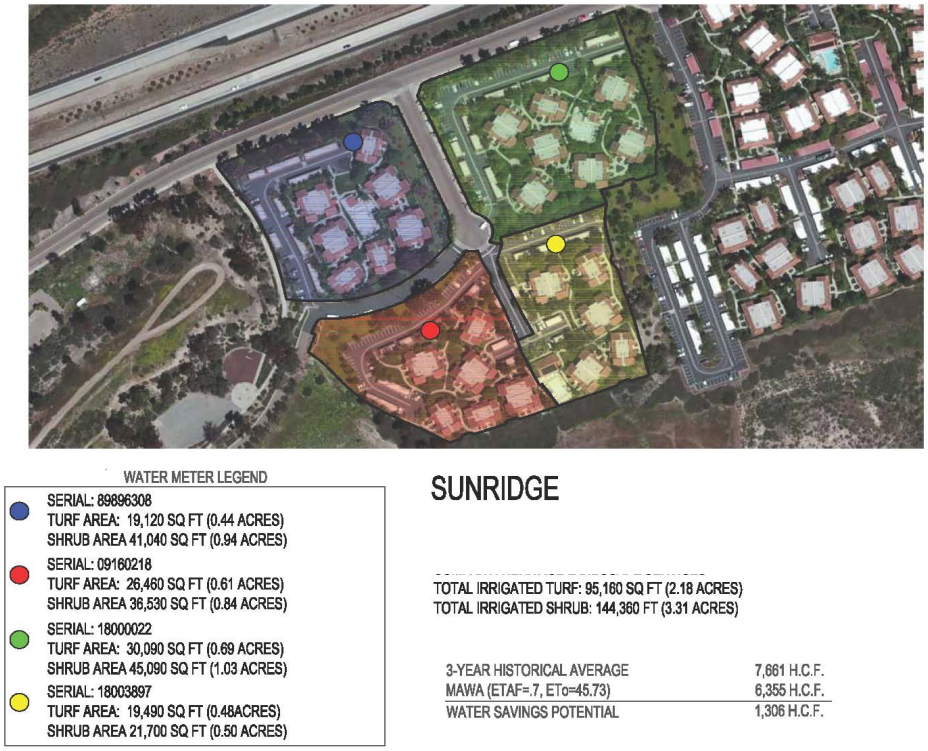
Landscape Irrigation Audit: The potential for water savings was determined through an irrigation audit, comparing historical water use to projected water use as calculated by the Maximum Applied Water Allowance (MAWA), defined by California's Model Water Efficient Landscape Ordinance (2010 version). An audit was performed on each property by a Certified Landscape Irrigation Auditor (CLIA). This free service was provided as part of a separate program entitled WaterSmart Checkup, which is jointly funded by the Water Authority and its member agencies (outside the scope of the WSLEP grant).

The MAWA calculation is based on the factors defined in the Model Water Efficient Landscape Ordinance of 2010 (State of California, Department of Water Resources). MAWA relies on evapotranspiration (ET_o) rates to determine the water needs of various plant types (plant factor) across California's diverse climate zones. It also takes into consideration the state's required level of irrigation efficiency. The ratio of plant factor to irrigation efficiency is known as the ET Adjustment Factor (ETAF). In accordance with the 2010 MWELO, the ETAF factor for existing landscapes was 0.8 (80% of ET_o) and 0.7 for new landscapes. WSLEP targeted participation by established landscapes. WSLEP's requirements were designed to help these sites achieve the same performance levels required of newly designed landscapes. For this reason, a .7 plant factor was used in WSLEP's MAWA calculation to determine the water budget. See Figure 1. Typical Audit Map and MAWA Calculation.

The audit identified the location and serial number of water meters, a measured service area for each meter, plant material and irrigation types, existing irrigation problems and recommendations for improved efficiency. Historical water-use was provided for each meter by the water agency serving each site. Historical water use was compared to each site's calculated MAWA. The irrigation audit helped to identify potential irrigation equipment upgrades. The historical water use baseline and the MAWA budget were used as a screening tools to validate the water savings potential for each site. While the

original expectation was to enroll only sites that demonstrated at least a twenty percent (20%) potential savings based on MAWA, actual values for enrolled sites ranged between two percent (2%) and thirty seven percent (37%) with an average theoretical water savings projection of fourteen percent (14%). See Table 3. Water Savings Potential.

Figure 1. Typical Audit Map and MAWA Calculation



$$MAWA = (ET_o - Eppt)(0.62)[(0.7)(LA)+(0.3)(SLA)\}$$

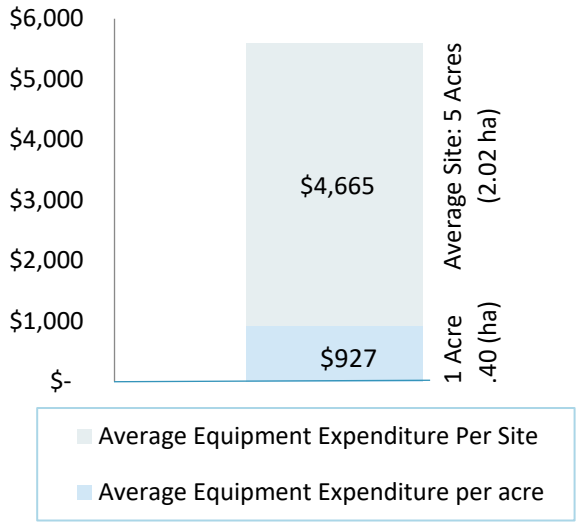
Table 3. Water Savings Potential

	3-Year Historical Avg. HCF (m3)	MAWA Budget HCF (m3)	Water Savings Potential (%)
Average of 20 sites	5,156 (14,600)	4,331 (12,264)	14%

Equipment Upgrades: Each contractor was required to recommend irrigation equipment upgrades from a prioritized list that included pressure regulation, distribution uniformity, water loss (leak repair) and scheduling components. With a maximum budget of $5,000 per site for the equipment upgrades, the materials list recommended by contractors sought to maximize water savings. A designated irrigation supplier provided quotes for the recommended equipment. These were reviewed and approved by the Water Authority and SDG&E prior to purchase. All equipment was sourced from a single supplier. This allowed the supplier to directly invoice SDG&E and contractors did not incur upfront expenses. To

further support the contractor, a $5,000 incentive was provided toward labor for the installation of the equipment. Hardware upgrades averaged $4,665 per site or $927 per acre (.4 ha) with tax. (Figure 2).

Figure 2. Average Equipment Expenditure per Site and per Acre



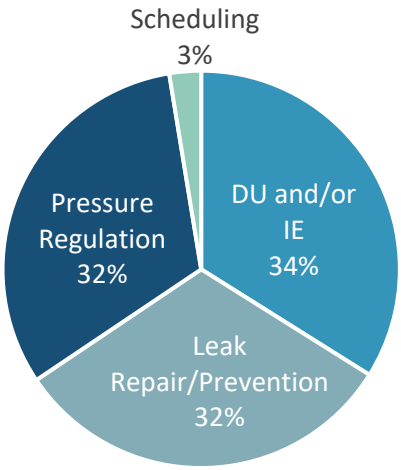
Each site invested in pressure regulation at one of three entry points: the backflow, the valve or the head, as appropriate. The equipment purchases broke down into four broad categories: Distribution Uniformity (DU)/Irrigation Efficiency (IE); Pressure Regulation; Leak Repair/Prevention; and Scheduling. With the first three categories representing ninety-seven percent (97%) of all purchases. The categories and general item descriptions are presented in Table 4. Equipment Categorization by Dollar Amount.

Table 4. Equipment Categorization by Dollar Amount

General Item type	Category	Pre-tax Category Total
Drip Rotator Nozzle Rotor Sprinkler	DU and/or IE	$ 29,145.01
Check Valve Flow Sensor Misc. pipe, fittings, wire, glue, boxes Remote Control Valve Sprinkler w/ check valve Swing Unit Valve	Leak Repair/Prevention	$ 27,215.45
Press Reg Rotor w/ Press Reg Sprinkler w/ Press Reg	Pressure Regulation	$ 27,352.12
Controller Components Rain Sensor	Scheduling	$ 2,219.40
Pre-tax TOTAL		**$ 85,931.98**

Figure 3. Equipment Category by Percent, illustrates the distribution of the broad categories and shows the focus of the WSLEP pilot program on pressure regulation at thirty-two percent (32%), distribution uniformity and/or Irrigation Efficiency at thirty-four percent (34%) and leak prevention/repair at thirty-two percent (32%).

Figure 3. Equipment Category by Percent



Workforce Training: A significant component of the WSLEP was the promotion and expansion of water management skills among landscape contractors. CLCA was tasked with training of the landscape contractors according to the Water Management Certification Program principles. The certification requires managing a landscape site at or below 80% of MAWA for one year. CLCA used its own database and reporting procedures to collect periodic water use reports that would enable them to track water use performance at each site.

Some of the participating contractors already possessed a Water Management certificate, while others took advantage of the program's training and technical support to further develop their irrigation management expertise and credentials. Each contractor had the necessary experience to identify needed irrigation upgrades to improve their site's irrigation performance and the potential for savings through careful water budgeting. All participants not already certified as a Water Manager received the standard one-day certification course. The need for additional support and education became apparent as the program progressed. A supplemental eight-hour specialized training was provided for all participants by Blue Watchdog Conservation, Inc. covering in depth concepts like water budget calculations, water scheduling, soil infiltration rates, runoff, controller programming and pressure issues. In addition, one on one coaching was provided, as needed, in the field and via telephone.

At the start of the project three contactors had their CLCA Water Manager Certification, including two that had attained 'Expert' level. By program end, the ranks of Certified Water Managers grew by an additional four managers, making a total of seven out of nine participants that held a certification. One of the new members has even gone on to attain Expert status.

Training in Action:

Contractor, James Cothrine of Earthwise Industries shared his experience participating in WSLEP. Cothrine had two sites that suffered from significant distribution uniformity and pressure regulation issues. He started WSLEP without a certification in irrigation management. He was aware that to perform effectively, his sites would need to improve distribution uniformity and pressure regulation. WSLEP provided his sites the necessary financial assistance to purchase and install equipment deemed necessary to upgrade the system. He also benefitted from WSLEP's training and guidance to complete the CLCA Water Management Certificate, using the participating sites as his examples of water budgeting. Prior to participating, Cothrine had heard of MAWA and water budgeting, but had never applied it to any of his existing landscapes. He felt that MAWA only worked in a perfect world, not the variable and inconsistent reality of an older irrigation system. Using MAWA as a baseline, the sites started with a 3% (average) potential for water savings. At the end of the program a 40% (average) savings was achieved. Cothrine is now a Water Manager and applies his WSLEP training and experience to other sites under his management.

Maintenance Period: After completion of all irrigation repairs, participating sites entered the maintenance period. Water use performance was recorded for one year. Contractors were required to take monthly meter readings (bi-weekly recommended), maintain the irrigation systems and adjust schedules to maximize performance. No plant material changes (e.g., turf conversion) was allowed during the WSLEP program. To ensure high quality maintenance and a positive outcome for participating sites, a customer satisfaction survey of property owners was conducted at the end of the maintenance period.

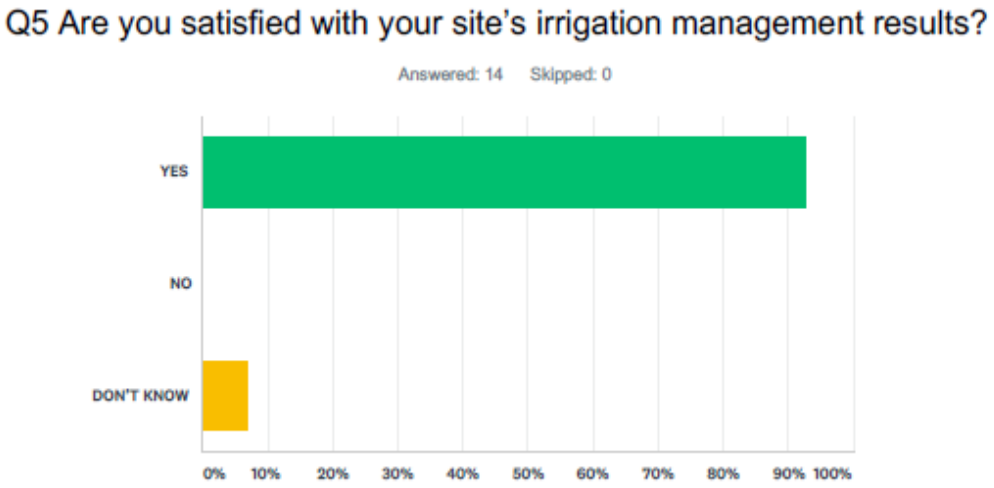
A pre-existing CLCA Water Manager dashboard was adapted for the specific needs of this pilot program, including the ability to record baseline water use information and to compare it to on-going water use. Contractors were responsible for uploading monthly meter readings to the CLCA Water Manager dashboard. CLCA provided oversight and management of the site data. Contractors had the responsibility to program irrigation controllers appropriately for plant type and weather conditions with the aim of achieving water savings while ensuring positive landscape performance.

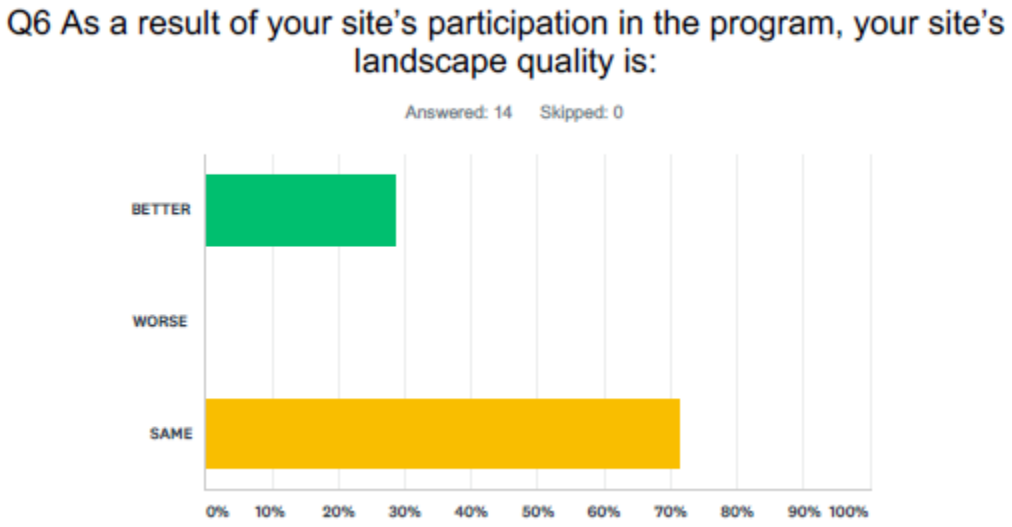
Program Results: The results of the WSLEP can be measured in terms of customer satisfaction and water savings. The definition of program success – and the long-term viability of the WSLEP approach – required both elements to be achieved concurrently. An anticipated program risk was the possibility of a statistical reduction in measured water use at the expense of plant health and aesthetic appearance. The desired target was to realize a significant reduction in water use while ensuring a high level of customer satisfaction.

Each customer (property owner or representative) completed a satisfaction survey at the end of the program. Program satisfaction was measured across fifteen criteria. Program-wide, survey responses were highly favorable. Customers were pleased with the level of funding support provided, which allowed them the opportunity to upgrade irrigation systems. Respondents generally understood the

goals of the program and the potential implications for their sites' actual performance. Customers were satisfied with their contractors' implementation of WSLEP's irrigation management protocols. WSLEP water saving goals were achieved overall and participants found their landscape quality to be the same or better than prior to program participation. Seventy-nine percent (79%) of customers would participate again, if given the opportunity. On a scale of 1-10 (10 being Extremely Satisfied) the average response was nine (9).

Table 5. Customer Satisfaction Survey Results

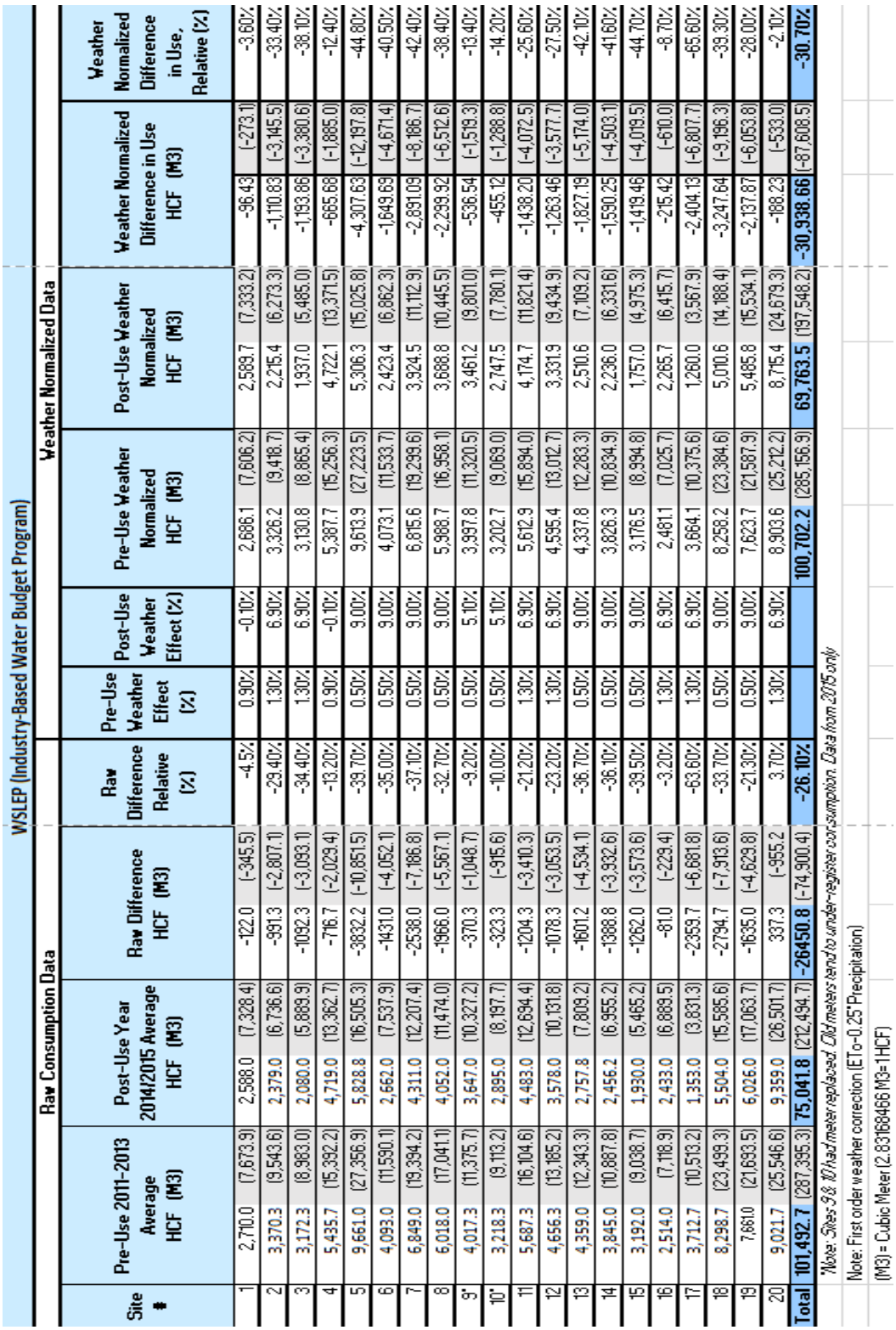




The results of actual water saved are presented below in Table 6. The raw consumption data was adjusted for weather. For the Pre-Use (baseline consumption), the quantities were weather normalized relative to a three-year average of the variance above and/or below the average ET_o. Similarly, the Post-Use consumption was weather normalized to reflect the actual ET_o during the twelve-month period of the WSLEP. Weather-normalized differences ranged from 2.1 percent to 65 percent savings with an average savings of 30.7 percent and a median value of 35.75%. Fourteen of the twenty participants

achieved the goal (minimum 20% savings) and received the final incentive of $1,700. Overall weather-normalized water savings totaled 30,939 Hundred Cubic Feet (HCF) (87,608.5 m3).

Table 6. Results of Water Use Before and During the Water Based Budget Period



WSLEP (Industry-Based Water Budget Program)

Site #	Raw Consumption Data					Weather Normalized Data				
	Pre-Use 2011-2013 Average HCF (M3)	Post-Use Year 2014/2015 Average HCF (M3)	Raw Difference HCF (M3)	Raw Difference Relative (%)	Pre-Use Weather Effect (%)	Post-Use Weather Effect (%)	Pre-Use Weather Normalized HCF (M3)	Post-Use Weather Normalized HCF (M3)	Weather Normalized Difference in Use HCF (M3)	Weather Normalized Difference in Use, Relative (%)
1	2,710.0 (7,673.9)	2,588.0 (7,328.4)	-122.0 (-345.5)	-4.5%	0.90%	-0.10%	2,686.1 (7,606.2)	2,589.7 (7,333.2)	-96.43 (-273.1)	-3.60%
2	3,370.3 (9,543.6)	2,379.0 (6,736.6)	-991.3 (-2,807.1)	-29.40%	1.30%	6.90%	3,326.2 (9,418.7)	2,215.4 (6,273.3)	-1,110.83 (-3,145.5)	-33.40%
3	3,172.3 (8,983.0)	2,080.0 (5,889.9)	-1092.3 (-3,093.1)	-34.40%	1.30%	6.90%	3,130.8 (8,865.4)	1,937.0 (5,485.0)	-1,193.86 (-3,380.6)	-38.10%
4	5,435.7 (15,392.2)	4,719.0 (13,362.7)	-716.7 (-2,029.4)	-13.20%	0.90%	-0.10%	5,387.7 (15,256.3)	4,722.1 (13,371.5)	-665.68 (-1,885.0)	-12.40%
5	9,661.0 (27,356.9)	5,828.8 (16,505.3)	-3832.2 (-10,851.5)	-39.70%	0.50%	9.00%	9,613.9 (27,223.5)	5,306.3 (15,025.8)	-4,307.63 (-12,197.8)	-44.80%
6	4,093.0 (11,590.1)	2,662.0 (7,537.9)	-1431.0 (-4,052.1)	-35.00%	0.50%	9.00%	4,073.1 (11,533.7)	2,423.4 (6,862.3)	-1,649.69 (-4,671.4)	-40.50%
7	6,849.0 (19,394.2)	4,311.0 (12,207.4)	-2538.0 (-7,186.8)	-37.10%	0.50%	9.00%	6,815.6 (19,299.6)	3,924.5 (11,112.9)	-2,891.09 (-8,186.7)	-42.40%
8	6,018.0 (17,041.1)	4,052.0 (11,474.0)	-1966.0 (-5,567.1)	-32.70%	0.50%	9.00%	5,988.7 (16,958.1)	3,688.8 (10,445.5)	-2,299.92 (-6,512.6)	-38.40%
9*	4,017.3 (11,375.7)	3,647.0 (10,327.2)	-370.3 (-1,048.7)	-9.20%	0.50%	5.10%	3,997.8 (11,320.5)	3,461.2 (9,801.0)	-536.54 (-1,519.3)	-13.40%
10*	3,218.3 (9,113.2)	2,895.0 (8,197.7)	-323.3 (-915.6)	-10.00%	0.50%	5.10%	3,202.7 (9,069.0)	2,747.5 (7,780.1)	-455.12 (-1,288.8)	-14.20%
11	5,687.3 (16,104.6)	4,483.0 (12,694.4)	-1204.3 (-3,410.3)	-21.20%	1.30%	6.90%	5,612.9 (15,894.0)	4,174.7 (11,821.4)	-1,438.20 (-4,072.5)	-25.60%
12	4,656.3 (13,185.2)	3,578.0 (10,131.8)	-1078.3 (-3,053.5)	-23.20%	1.30%	6.90%	4,595.4 (13,012.7)	3,331.9 (9,434.9)	-1,263.46 (-3,577.7)	-27.50%
13	4,359.0 (12,343.3)	2,757.8 (7,809.2)	-1601.2 (-4,534.1)	-36.70%	0.50%	9.00%	4,337.8 (12,283.3)	2,510.6 (7,109.2)	-1,827.19 (-5,174.0)	-42.10%
14	3,845.0 (10,887.8)	2,456.2 (6,955.2)	-1388.8 (-3,932.6)	-36.10%	0.50%	9.00%	3,826.3 (10,834.9)	2,236.0 (6,331.6)	-1,590.25 (-4,503.1)	-41.60%
15	3,192.0 (9,038.7)	1,930.0 (5,465.2)	-1262.0 (-3,573.6)	-39.50%	0.50%	9.00%	3,176.5 (8,994.8)	1,757.0 (4,975.3)	-1,419.46 (-4,019.5)	-44.70%
16	2,514.0 (7,118.9)	2,433.0 (6,889.5)	-81.0 (-229.4)	-3.20%	1.30%	6.90%	2,481.1 (7,025.7)	2,265.7 (6,415.7)	-215.42 (-610.0)	-8.70%
17	3,712.7 (10,513.2)	1,353.0 (3,831.3)	-2359.7 (-6,681.8)	-63.60%	1.30%	6.90%	3,664.1 (10,375.6)	1,260.0 (3,567.9)	-2,404.13 (-6,807.7)	-65.60%
18	8,298.7 (23,499.3)	5,504.0 (15,585.6)	-2794.7 (-7,913.6)	-33.70%	0.50%	9.00%	8,258.2 (23,384.6)	5,010.6 (14,188.4)	-3,247.64 (-9,196.3)	-39.30%
19	7,661.0 (21,693.5)	6,026.0 (17,063.7)	-1635.0 (-4,629.8)	-21.30%	0.50%	9.00%	7,623.7 (21,587.9)	5,485.8 (15,534.1)	-2,137.87 (-6,053.8)	-28.00%
20	9,021.7 (25,546.6)	9,359.0 (26,501.7)	337.3 (-955.2	3.70%	1.30%	6.90%	8,903.6 (25,212.2)	8,715.4 (24,679.3)	-188.23 (-533.0)	-2.10%
Total	**101,492.7** (287,395.3)	**75,041.8** (212,494.7)	**-26450.8** (-74,900.4)	**-26.10%**			**100,702.2** (285,156.9)	**69,763.5** (197,548.2)	**-30,938.66** (-87,608.5)	**-30.70%**

Note: Sites 9 & 10 had meter replaced. Old meters tend to under-register consumption. Data from 2015 only

Note: First order weather correction (ET o-0.25"Precipitation)

(M3) = Cubic Meter (2.83168466 M3= 1 HCF)

Program Challenges and Suggested Enhancements for Future Rounds

Challenges:

- Identifying sites: The ability to find and vet appropriate sites was an initial challenge. In some cases, contractors may hesitate to propose sites that are currently under their management despite having a water savings potential. The general concern is that a significant water savings potential might be perceived by the owner as a sign of current under-performance by the contractor.
- Water management skills and establishing baseline data: Participating contractors had a very diverse range of skills. Determining prior water use baselines, accurately measuring irrigation areas, and calculating accurate water budgets were challenging tasks for most participants. In a few cases, meter issues and confusing water utility consumption records added to these challenges, causing pre-use consumption baselines to be inaccurate. These were later identified and adjusted. In some cases, area measurements were not associated with the correct meter which also impacted performance against the reported MAWA budgets. CLCA retained an independent service provider, Blue Watchdog Conservation, to provide technical assistance and quality control on WSLEP records. This added resource ensured consistent and accurate records across the program.
- Although directed to carefully identify needed equipment in advance to minimize the number of transactions necessary with the irrigation supplier, many contractors had returns, exchanges and multiple purchases as part of their projects. Reconciling these transactions became a heavy burden on the sponsoring agencies, ultimately requiring third party assistance.
- Payment schedules for incentives were impacted by the review process and contractors desired a quicker payout for installation expenses incurred.
- MAWA water budgets did not seem to fit real world conditions in some situations.

Future Program Enhancements:

- Plan timeline to allow for careful screening and selection of sites and completion of audits.
- Increase upfront training to ensure the contractors have the knowledge and tools to effectively participate in the program.
- Prompt contractors to thoroughly plan for equipment requirements and to avoid exchanges. This will avoid delays in the approval process and minimize processing time.
- Modify the incentive schedule to ensure payouts are issued more expediently.
- Modify the CLCA water budget tool to incorporate actual ET_o .
- Improve water use data by installing flow sensors at each meter, or, use automatic meter readings where installed by participating utilities.

Conclusions

The WSLEP pilot program has successfully demonstrated the use of water management protocols based on California's MWELO for managing the water use at large, established landscapes. Thus, MWELO's methodology is as relevant to the design of new landscapes as it is to the ongoing management of existing landscapes. WSLEP areas of emphasis included pressure regulation; distribution uniformity; leak repair; and smart controllers along with workforce training and water management. This comprehensive and integrated approach to irrigation management of mature landscapes has proven to

be an effective and scalable methodology that can be replicated as needed to help meet local and regional water conservation goals.

WSLEP implementation coincided in part with periods of state-mandated water use restrictions in California. Such restrictions can be very challenging to the green industry. WSLEP has demonstrated a business-friendly model that has the potential to help sites comply with such requirements while also generating additional voluntary water savings. WSLEP's training activities demonstrated the importance and effectiveness of workforce development initiatives on topics such as water budgeting, area measurement techniques, reading and recording water use via the water meter, scheduling controllers and regular system adjustments. Such training empowers contractors to achieve water-saving targets while preserving, and even enhancing, landscape quality. Water budgets are an essential tool for effective landscape irrigation management.

On average the program exceeded its stated goal of a 20% reduction in water use. WSLEP validated the premise that a well-trained workforce, coupled with pressure regulation and distribution uniformity improvements can deliver significant water savings. Should the program be implemented again in the future, the use of flow sensing equipment and/or submeters is highly recommended to help automate the WSLEP's extensive data collection needs.

Acknowledgements

The authors gratefully acknowledge the following individuals and organizations for their contributions to this program:

The California Public Utilities Commission; the California Department of Water Resources (funding made possible in part by a Proposition 50 grant administered by DWR); Jeff Alexander (Program Co-Manager) of San Diego Gas & Electric; David Silva (Implementation Administrator) of the California Landscape Contractors Association (CLCA); the San Diego Chapter of CLCA; and Patrick Crais of Blue Watchdog Conservation, Inc. (training, technical assistance and quality control); all participating property owners and landscape contractors, especially James Cothrine (WSLEP participant) of Earthwise Industries for sharing his WSLEP insights and experience.

The WSLEP program was implemented in close collaboration with the following member agencies of the Water Authority: City of Carlsbad, City of San Diego, Helix Water District; and Olivenhain MWD.

References:

Chesnutt, Tom, June 2017, A & N Technical Services, Inc., DROP Grant Program Process Evaluations, San Diego County Water Authority.
San Diego County Water Authority, June, 2017, Proposition 50 Urban Drought Assistance Grant 2008 Drought Response and Outreach Program (DROP), Final Report.
Model Water Efficient Landscape Ordinance, 2009, State of California, Department of Water Resources, https://water.ca.gov/LegacyFiles/wateruseefficiency/docs/MWELO09-10-09.pdf

Appendix A Results of Water Use Before and During the Water Based Budget

WSLEP (Industry-Based Water Budget Program)										
Raw Consumption Data					Weather Normalized Data**					
Site #	Pre-Use 2011-2013 Average (HCF)	Post-Use Year 2014/2015 Average (HCF)	Raw Difference (HCF)	Raw Difference Relative (%)	Pre-Use Weather Effect (%)	Post-Use Weather Effect (%)	Pre-Use Weather Normalized (HCF)	Post-Use Weather Normalized (HCF)	Weather Normalized Difference in Use (HCF)	Weather Normalized Difference in Use, Relative (%)
1	2,710.0	2,588.0	-122.00	-4.5%	0.9%	-0.1%	2,686.1	2,589.7	-96.43	-3.6%
2	3,370.3	2,379.0	-991.33	-29.4%	1.3%	6.9%	3,326.2	2,215.4	-1110.83	-33.4%
3	3,172.3	2,080.0	-1092.33	-34.4%	1.3%	6.9%	3,130.8	1,937.0	-1193.86	-38.1%
4	5,435.7	4,719.0	-716.67	-13.2%	0.9%	-0.1%	5,387.7	4,722.1	-665.68	-12.4%
5	9,661.0	5,828.8	-3832.17	-39.7%	0.5%	9.0%	9,613.9	5,306.3	-4307.63	-44.8%
6	4,093.0	2,662.0	-1431.00	-35.0%	0.5%	9.0%	4,073.1	2,423.4	-1649.69	-40.5%
7	6,849.0	4,311.0	-2538.00	-37.1%	0.5%	9.0%	6,815.6	3,924.5	-2891.09	-42.4%
8	6,018.0	4,052.0	-1966.00	-32.7%	0.5%	9.0%	5,988.7	3,688.8	-2299.92	-38.4%
9*	4,017.3	3,647.0	-370.33	-9.2%	0.5%	5.1%	3,997.8	3,461.2	-536.54	-13.4%
10*	3,218.3	2,895.0	-323.33	-10.0%	0.5%	5.1%	3,202.7	2,747.5	-455.12	-14.2%
11	5,687.3	4,483.0	-1204.33	-21.2%	1.3%	6.9%	5,612.9	4,174.7	-1438.20	-25.6%
12	4,656.3	3,578.0	-1078.33	-23.2%	1.3%	6.9%	4,595.4	3,331.9	-1263.46	-27.5%
13	4,359.0	2,757.8	-1601.20	-36.7%	0.5%	9.0%	4,337.8	2,510.6	-1827.19	-42.1%
14	3,845.0	2,456.2	-1388.80	-36.1%	0.5%	9.0%	3,826.3	2,236.0	-1590.25	-41.6%
15	3,192.0	1,930.0	-1262.00	-39.5%	0.5%	9.0%	3,176.5	1,757.0	-1419.46	-44.7%
16	2,514.0	2,433.0	-81.00	-3.2%	1.3%	6.9%	2,481.1	2,265.7	-215.42	-8.7%
17	3,712.7	1,353.0	-2359.67	-63.6%	1.3%	6.9%	3,664.1	1,260.0	-2404.13	-65.6%
18	8,298.7	5,504.0	-2794.67	-33.7%	0.5%	9.0%	8,258.2	5,010.6	-3247.64	-39.3%
19	7,661.0	6,026.0	-1635.00	-21.3%	0.5%	9.0%	7,623.7	5,485.8	-2137.87	-28.0%
20	9,021.7	9,359.0	337.33	3.7%	1.3%	6.9%	8,903.6	8,715.4	-188.23	-2.1%
Total	**101,492.7**	**75,041.8**	**-26450.83**	**-26.1%**			**100,702.2**	**69,763.5**	**-30938.66**	**-30.7%**

** Sites 9 & 10 had meter replaced. Old meters tend to under-register consumption. Data from 2015 only*

*** First order weather correction ($(ET_o$ -0.25*Precipitation)*