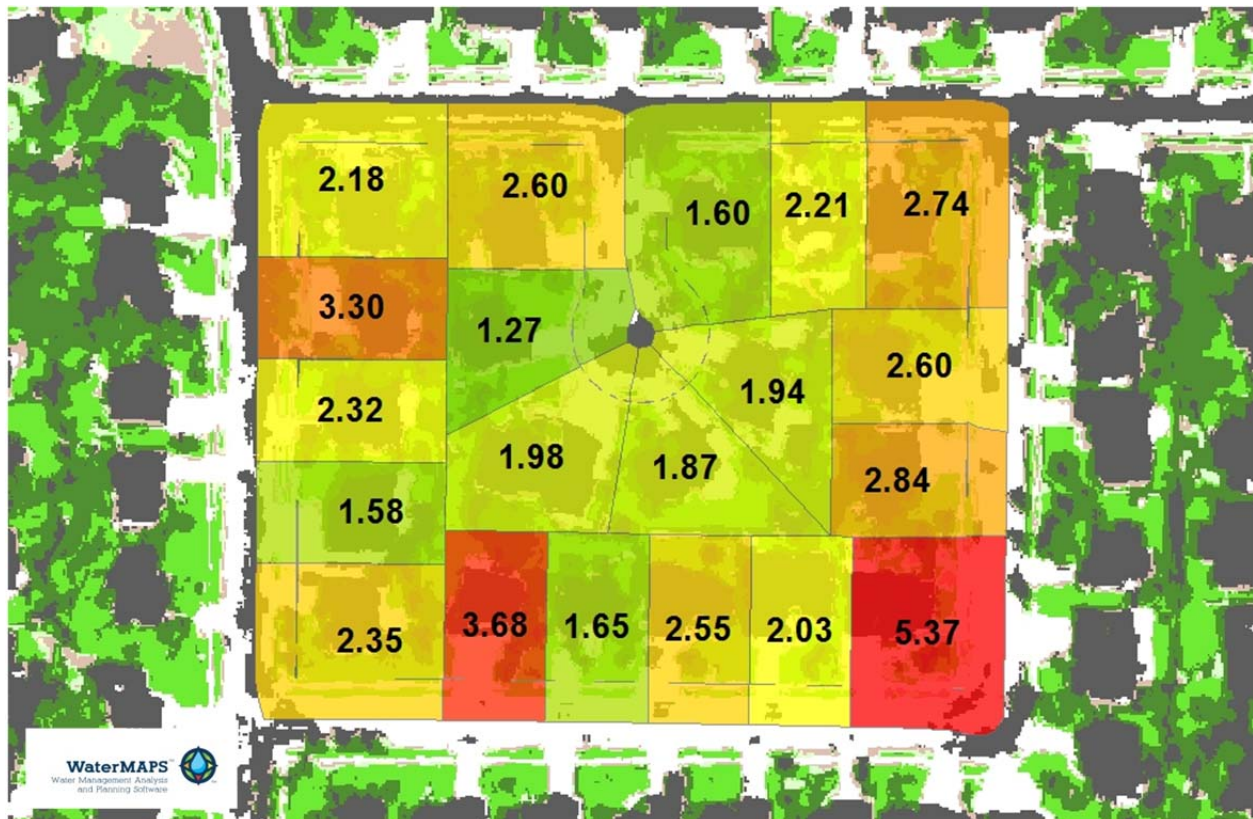


Water User Dimensions of Meter Implementation on Secondary Pressurized Irrigation Systems

RESEARCH RESULTS AND ANALYSIS OF LANDSCAPE WATER USE AND INFORMATION PROVISION FOR PHASES 1 & 2 OF WEBER BASIN WATER CONSERVANCY DISTRICT'S METER IMPLEMENTATION PROJECT



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1 INTRODUCTION

Weber Basin Water Conservancy District (District) secured funding in spring 2011 to install individual secondary water meters at residential connections in order to implement water efficiency and accountability measures included in the District's Water Conservation Plan (Weber Basin Water Conservancy District, 2010). Initially, the District will not use the meters for billing water use but, instead, will use them to help the District determine if end users are exceeding their contracted allotment of water and to promote water use accountability.

The purpose of the study titled "Water User Dimensions of Meter Implementation on Secondary Pressurized Irrigation Systems" conducted by Utah State University (USU) is to help the District implement innovative procedures for sharing meter data in formats designed to enhance users' understandings of landscape water needs and the appropriateness of their own landscape water use. The study assessed how best to interact with water users during system transitions to ensure that metering delivers desired water efficiency and accountability results.

The study was conducted by an interdisciplinary research team from USU's Department of Environment and Society in the Quinney College of Natural Resources, Department of Plants, Soils, and Climate in the College of Agriculture, and Department of Civil and Environmental Engineering in the College of Engineering. The USU researchers are affiliated with the Utah Agricultural Experiment Station (UAES) located at USU and they collaborate with USU Extension through the Center for Water Efficient Landscaping (CWEL).

The study focused on monitoring people's secondary water use and analyzing people's perceptions and behaviors as individual meters were installed on residential secondary systems in two areas where the District delivers secondary landscape water. The study analyzed human aspects related to technological change to see whether and how these aspects contribute or detract from achieving the desired outcome of greater water use efficiency. Particular attention was paid to the role that information based on metered data played in promoting water user accountability. Since initially metered data will not be used for billing purposes, this was a rare opportunity to test various ways to implement accountability and efficiency without using price signals that often incur public resistance.

1.1 WBWCD's Secondary Residential Meter Project

This study is distinct from but associated with the District's residential secondary meter project, which involved the installation of *approximately* 1000 meters in the Uintah Bench area within the District boundaries. During the spring of 2011, Phase I of the secondary meter project installed 500 meters in South Ogden and Washington Terrace neighborhoods. Then in the spring of 2012, Phase II installed 500 meters in South Weber and South Ogden neighborhoods. Phase I and Phase II of the residential secondary meter project comprise the research study area.

1.2 USU Research on Water User Dimensions of Meter Implementation

1.2.1 Background

This project has been unique and interesting with potentially far-reaching implications. The installation of meters on secondary water systems without issuing water bills based on metered consumption has provided an opportunity to assess the influence and effectiveness of interpreted consumption information as a water conservation tool. The information provided to the newly metered locations in this study was produced by USU's WaterMAPS™ software which integrates various data, calculates landscape irrigation ratios (LIRs: ratio of actual water use to estimated need) that indicate how appropriately people are watering to meet landscape need, and identifies their "capacity to conserve." The information was designed to increase people's landscape water use awareness and motivate them to reduce waste. Meter installation was a good time to bring this information to people's attention by having meter data on how much water they were using accompanied by estimates of how much water they should be using given their individual landscapes.

The original plan of this project was altered due to some initial difficulties with meter installation. The original plan was to collect social science data in connection with the 2011 implementation of meters in Phase 1 of WBWCD's project (500 residences). At the end of the 2011 irrigation season, USU would provide people at each of those residences with an end-of-season report on their household's seasonal landscape irrigation ratio and make recommendations on conservation actions they could undertake if they had identified "capacity to conserve." Then in 2012, water use would be monitored and analyzed to evaluate the effectiveness of this information to motivate and aid people to conserve water. Some social science data was collected in 2011 and WBWCD sent people in Phase 1 monthly reports with basic metered use information. However, problems with transmission and collection of the meter data (discovered by WBWCD personnel during the course of the season) made the information on 2011 water use unreliable. Consequently, end-of-season reports with USU WaterMAPS™ calculations were not issued.

A revised plan was implemented in 2012 once problems with meter reliability were resolved and supported with some additional funding provided by WBWCD. The WaterMAPS™ software was redesigned to produce monthly Secondary Water Use Reports which were sent to all residences in Phase 1 and Phase 2 of the meter implementation project (approximately 1000 residences) and to new residences with secondary meters (the district's policy is to install secondary meters on new hook-ups). These reports provided 6 "installments" (or "interventions") of information calculating site-specific landscape irrigation ratios (using local ET data) and tracking the appropriateness of people's use over the course of the season. At the end of the irrigation season, USU conducted a survey inviting people at all residences that received these reports to participate (approximately 1120 locations).

1.2.2 Goals and Objectives

The overarching goal of the study is to develop and implement end user water consumption accountability procedures intended to improve landscape water use efficiency, then assess and understand human responses and behaviors.

The more specific objectives of the study are to:

- (1) utilize data acquired from newly installed meters on secondary landscape irrigation systems to assess, for each residential location, the appropriateness of landscape irrigation water use in relation to area ET and estimated landscape water need, and to share these assessments with residents;
- (2) interact with meter recipients and gather data on their perceptions, attitudes and behaviors associated with landscape water usage, meter installation, and the concepts of water accountability and efficiency;
- (3) investigate how best to help residents interpret the data from their metered water use and how best to promote individual accountability in the use of water;
- (4) determine how metering can be efficiently and effectively completed throughout the District's service area in ways that avoid negative reactions from secondary irrigation customers;
- (5) help the District and its customers achieve accountability for water deliveries by treating the meter transition period as an opportunity to draw people's attention to appropriate landscape water use and to use information as a motivator for eliminating waste even if pricing signals are not in place at this time.

1.3 Integration of Meter Project and Research Study

The District's Residential Secondary Meter Project ran concurrently with many of USU's research activities. The District and USU coordinated their activities to complement the meter installation process and to advance the goals of both projects. The timeline for these activities was as follows:

May 2011	• District (prime) and USU (subcontractor) receive notice of intent to issue award for Bureau of Reclamation funding opportunity announcement No. R11SF40009
May-Oct 2011	• USU conducts WBWCD Service Area Flyover and Landscape Analysis (GIS and aerial) • District provides meter usage data to Phase 1 users and discovers flawed coding in AMR units (Automatic Meter Reading units)
Oct-Dec 2011	• USU revises research strategy and develops protocol for focus group and interviews to be conducted in Spring 2012 • District replaces all faulty AMR units
Jan-Apr 2012	• USU conducts in-home interviews and holds focus group • USU processes Phase 1 and Phase 2 Landscape Analysis (GIS and aerial imagery)

- District installs Phase 2 meters and tests all meters and AMR units prior to start of 2012 irrigation season
- May-Oct 2012
 - District collects meter data monthly and sends to USU
 - USU processes and generates Secondary Water Use Reports using WaterMAPS™
 - District prints and mails Secondary Water User Reports
 - USU develops protocols for post-irrigation season survey and launches on-line survey Oct 23, 2012
- Nov 2012-Jan 2013
 - USU administers post-irrigation season survey (three rounds of invitations). Survey was closed January 31, 2013
- Feb-Mar 2013
 - USU conducts data coding and analysis, prepares project report and presentations

2 USU RESEARCH PROCESSES AND PROCEDURES

2.1 WaterMAPS™

Analyses included in the Secondary Water Use Reports were conducted utilizing an overall approach to identifying capacity to conserve water used on urban landscapes developed by the project PIs (Farag et al. 2001). WaterMAPS™ is a custom software application that enables the user to visualize and interpret the appropriateness of water use on managed urban landscapes. It was developed as an analytic, management, and public information tool for urban water systems. The application can help municipalities identify locations with the greatest capacity to conserve water used outdoors in order to more effectively target and tailor landscape water conservation programs. WaterMAPS™ also helps cities monitor landscape water use over time in order to assess changes in water use and the effectiveness of conservation program delivery. Analysis features of the program enable water purveyors to see how landscape water use fits into management and planning for urban water systems. The option that allows for the creation of reports addressed to end users summarizes and interprets water use to enable end users better track their own use.

The functionality of WaterMAPS™ is based upon the integration of various datasets and the inclusion of options that allows the user to make sets of assumptions or policy decisions relevant to the situation in which it is being applied. Identifying “capacity to conserve” water applied to urban parcels of land is done by producing site-specific Landscape Irrigation Ratios (LIRs). The ratios are produced by dividing the amount of water used on the landscape at a particular location by the estimated amount of water that landscape needs. Landscape water use is determined from mining municipal or water provider meter data. Landscape water need is derived from the classification of remotely-sensed airborne multispectral imagery and localized reference evapotranspiration (ET_o) rates modified to account for the varying water needs of different types of landscape plant material being maintained at that location and for irrigation system inefficiencies. LIRs can be calculated over the entire growing season or a portion of it. In this study, LIRs were produced on a monthly basis.

2.2 Database Acquisition and Integration using WaterMAPS™

2.2.1 Imagery

Aerial photography of Weber Basin Water Conservancy District's (WBWCD) service area was acquired during 2 flights, on July 23 and July 29, 2011. These midsummer and midday flyovers captured canopies at full cover with a 19.75 inch resolution, recording spectra in the red, green, blue, and infrared. Post-processing of the images included orthorectification and a 40-60 percent overlap when mosaicked to create a final merged product.

2.2.2 Land Cover Classification

Using a supervised classification approach in ERDAS Imagine on the 4-banded, processed aerial image, classes were ultimately grouped into one of three categories: trees and shrubs or tall vegetation, turf or low-lying vegetation, and non-irrigated areas.

2.2.3 Parcel Preparation

Parcel polygon shape files for selected areas in Weber and Davis counties were provided by the District. Since the polygon boundaries excluded parking strips and other rights-of-way maintained by property occupants, a non-overlapping buffering routine was developed to expand the parcels by 40 feet. For example, if the width of a road in between parcel edges was less than 80 feet, half of the area was allotted to one parcel and the remaining half to the opposing parcel. Or, if two parcels shared a boundary (neighboring) no extension occurred. These buffers allowed for the addition of tree crowns overlying the street or turf parking strips in the total irrigated area calculation.

2.2.4 Meter Data Preparation

On or after the 16th of each month from April through October, 2012, the District collected metered secondary water use data with the current reading and a history of hourly flows. For the calculation of the landscape irrigation ratio for each property, the more error-prone hourly data was set aside for further analysis at a later time. The difference between the current monthly reading and the previous monthly reading resulted in the numerator (gallons of landscape water use) of the LIR calculation.

2.3 Preliminary Social Science Data Gathering

2.3.1 Pre - "Intervention" or Pre-Report (interviews, focus groups)

We conducted two types of pre-intervention research: face-to-face interviews and a focus group. The research focused on learning about residents' current water use patterns, any efforts they had made to conserve water, how meter installation may have affected their water use, what water use information residents desire to aid their water conservation efforts, and their views about water efficiency, conservation, and accountability. The research protocol was submitted to

USU's Institutional Review Board and approved for use on October 13, 2011 (Appendix B). A sample of 104 residents was selected and a letter of invitation to participate in the research study was mailed with the District's last water usage statement on October 31, 2011. After a minimal response, we began recruiting participants by phone at the end of November 2011 continuing through April 2012 (Table 1). During the recruitment process, we learned that people are very busy and many were unwilling to participate in an hour-long interview. We developed an abbreviated survey consisting of 4 questions that focused directly on residents' information needs regarding water use. Residents were first asked if they would participate in a face-to-face interview or a focus group and, if they declined, were offered the abbreviated 10-minute telephone interview. The hour-long interviews were conducted with 7 residents at their homes and were scheduled at their convenience. The feedback received in the interviews affirmed participants' information needs and that the approach we proposed to use to estimate landscape water use was reasonable and would provide useful information to secondary water users. This information was used to develop a draft version of the Secondary Water Use Report.

The two-hour-long focus group was held on April 18, 2012 at the District's headquarters with 7 residential water users participating. In the focus group, we concentrated on refining the design of the Secondary Water Use Report so that it was easy to interpret and used language that resonated with the readers.

TABLE 1. Data on Participant Recruitment for Pre-Intervention Research	#
Participant Sample Size	104
Participants without land-line telephones	5
Participants with unlisted phone numbers	23
Participants with disconnected or always busy phone numbers	12
Participants who were contacted but declined participation	14
Participants where four phone messages were left without response	23
Participants Recruited	27
Participation in Pre-Intervention Research Activities	
Telephone Interviews conducted	13
In-home Interviews conducted	7
Focus Group participants recruited	7

2.4 Information Intervention through Secondary Water Use Reports

2.4.1 Development of Secondary Water Use Reports

A draft Secondary Water Use Report was designed based upon a literature review of past research studying the effect of information provision on conservation behavior. Kaiser and Fuhrer (2003) found that ecological behavior depends of four types of knowledge:

- Declarative knowledge – understanding how an environmental system works.
- Procedural knowledge – understanding options or courses of action to achieve a conservation goal.

- Effectiveness knowledge – understanding relative conservation effectiveness of different behaviors or courses of action.
- Social knowledge – understanding the shared motives and intentions of other people or social norms.

Kaiser and Fuhrer argue that it is the strength of the convergence of these different forms of knowledge toward an ecological conservation goal that prompts action. The report's estimated landscape water need incorporates weather data and differentiates turf and tree/shrub requirements reinforcing the differing water needs of the two types of landscape material. The weather data over the course of the irrigation season demonstrates that landscape water need changes. Taken together, estimated landscape water need and weather data reinforce knowledge about how the landscape system works. The landscape irrigation ratio (LIR) quantifies the resident's capacity to conserve water and still maintain a healthy landscape, helps sets the conservation goal, and allows the user to assess how effective were their actions to save water.

In an energy conservation study, McCalley (2006) studied the effect of information provision, goal setting, feedback, and anchoring bias on conservation performance. In a series of lab experiments, McCalley found that participants who had a goal and received feedback on their performance saved more energy than those who did not. Another important influence in participants' performance was anchoring bias or how a numerical judgment can be influenced by how the goal is framed. An example is an equipment's default setting. Study participants who were given low default settings used 24% less energy than participants with high default settings. This demonstrates that the anchoring criteria for setting the conservation goal is critically important to conservation performance, especially in cases where new goals are being set for longer-term habit changes. For example, if we based our estimated landscape water need on an assumption that a landscape was 100% turf, we would not expect participants to save as much water. An all turf landscape has the highest water need and in water conservation education this is often used as an example of a water-wasteful landscape type. An all turf standard is a water management equivalent of a high default setting. Participants would be primed for a mediocre performance.

The focus group participants provided very insightful feedback on our draft water use report. The participants were first prompted to discuss what type of information they would find most useful to help them efficiently water their landscapes. Information that participants said they would like to see included were:

- A history of their water use so they could see a use trend over the irrigation season.
- A graphic that compared the previous year's water use to the current year's use.
- Weather information – temperature and rainfall.

We then presented participants with sample charts and diagrams that illustrated different ways of depicting water use information, including line graphs comparing water use to estimated need on a monthly or weekly basis, a diagram of the landscape irrigation calculation, and residential lot images comparing infrared photography with the cover classification. Finally, a sample of the proposed water use report was shown to them, in which the sections followed the logic used in

the calculation of the landscape irrigation ratio (LIR = landscape water use divided by estimated landscape water need). Participants provided the following feedback:

- Graphs comparing landscape water use to estimated landscape water need: they thought it was good these were going to be individualized for their particular lot.
- Landscape Irrigation Ratio: this should be depicted as ratio and as a percentage.
- Infrared photo and cover classification: this information should be used to provide some site characteristics used in the calculation, i.e., illustrating different plant types that require different amounts of water.
- Secondary Water Use Report: needs to include weather information used in estimating landscape water need and an explanation of the calculations.
- Announcement box: should include gardening reminders, resources for watering, fertilizing and landscaping techniques.
- Language: this is very important to the message people will receive from the reports. “Report” was preferred over “assessment” or “statement,” which participants said evoke analogies to “fees” and “billing.” They were very adamant that they did not want to feel threatened with a bill for metered water use and every opportunity to use language that promotes a conservation message would be preferred. In labeling the LIR categories, “excessive” was preferred over “wasteful” or “unjustifiable” water use for the highest use category.

The participants were also asked what they would need to know to have high confidence in the information provided in the reports. They stated that people need to understand how the estimated landscape water need is produced and to be convinced that it is a reasonable estimate. This influenced our decision to use a generous assessment of landscape water need. We did not subtract the spring soil moisture balance or rainfall during the irrigation season in calculating the LIR. We also granted some inefficiency in sprinkler system distribution uniformity (DU) and assumed systems were 70% efficient.

Considering the overall approach of defining appropriate water use based upon landscape water need, the focus group participants engaged in a very interesting conversation regarding the credence of different types of comparisons that could be included on the reports. These comments included the following:

- Self comparison: “I want to use the water I need, not what my neighbor needs.” The point this participant was making is that a person’s own history of water use is the most useful information. “I can only be responsible for my own water use,” said one participant.
- Social comparison: Participants observed that a comparison such as average water use localized to a neighborhood (where similar variables would likely be affecting water use) could provide an opening for dialog between people. Such comparisons could be quite convincing if people learned that neighbors who have nice landscapes are able to water more efficiently, because then they would know it is possible to water less in their area and maintain their landscapes to their satisfaction.

All of the participant comments were considered and used to produce a final format design of the Secondary Water Use Report provided to water users during the 2012 irrigation season. Insights

provided through these data have also been integrated into this project. The Secondary Water Use Report's information focuses on self comparison. In the survey, we asked people whether they talked about their reports with their neighbors. Subsequent data analyses of water use patterns would help to reveal the social comparison; whether and how to make those comparisons public has not yet been determined.

2.4.2 Providing Reports to Water Users

Secondary Water Use Reports were produced monthly and mailed to all metered secondary water users. Each report encouraged water users to visit Weber Basin's Learning Garden at the Layton headquarters and to participate in landscape classes, water checks, and other opportunities to learn about water conservation. Report recipients were directed to visit the District's web-site for scheduled events. Water users were also encouraged to call District personnel regarding the meter project or USU personnel with any questions they had regarding their reports. Water users who contacted us were also offered a site visit by District and USU personnel to investigate contextual factors influencing their LIRs and address questions and problems they experienced in watering their landscapes.

2.5 Post-Intervention Social Science Data Gathering

2.5.1 Design of Water User Survey

The end of season survey was designed to gather data on people's perceptions, attitudes and behaviors associated with landscape water use and meter installation. In section 1, we asked questions about the household's secondary water use. We specifically wanted to understand how households distribute responsibility for maintaining their landscapes, applying irrigation water, and reviewing the Secondary Water Use Reports. In section 2, we focused on people's reactions to the Secondary Water Use Report. We explored how people used the report, assessed how they interpreted the report, their understanding of each report element, and their perception of the report's overall message. We then asked people to rate the quality of the information contained in the report in order to assess their level of buy-in to the overall approach of providing site-specific estimated landscape water need and determining their capacity to conserve water. In section 3, we explored the concepts of accountability and efficiency through a series of statements that gauged people's level of agreement with each statement through a Likert scale response set. These statements were designed to first assess water use accountability at the household level and then in subsequent statements broaden the perspective to assess accountability to their neighborhood, the state, the environment, and future generations. The research protocol was submitted to USU's Institutional Review Board and approved for use on October 8, 2012.

2.5.2 Administration of Water User Survey

USU's letter of invitation to participate in the survey was included with the District's mailing of the final Secondary Water Use Report on October 23, 2012 and sent to residents at all metered secondary water use locations in the District's service area. People were invited to participate in a short on-line survey hosted on the USU website. The invitation letter provided each participant

with the web address and a personal login ID. It also provided them with contact information so participants could request a paper copy of the survey and a return envelope be mailed to them if they did not have internet access or preferred to complete the survey that way. USU mailed a reminder letter on November 6 to all locations where a survey had not been completed. Several weeks later, a final reminder was sent on November 28, 2012 that included a paper copy of the survey, a self-addressed return envelope, and an incentive to complete the survey through a flyer announcing that households who completed a survey would be entered into a drawing for five landscaping-related prizes.

TABLE 2. Survey Response Rate by Project Phase.¹

Survey response²	Phase 1	Phase 2	All Cases
No survey completed	78.0%	82.7%	80.0%
Survey completed	<u>22.0%</u>	<u>17.3%</u>	<u>20.0%</u>
	100%	100%	100%
Number of total cases	599	450	1049

NOTE: ¹ Phase 1 meters installed spring 2011 and Phase 2 installed spring 2012. ² Survey A responses counted (2 Survey B responses received).

We achieved an overall survey response rate of 20% (Table 2) and a similar response rate was received from Phase 1 and Phase 2 of the residential secondary meter project. Each meter route, which represents a neighborhood, was represented in the surveys received (Table 3).

TABLE 3. Survey Response Rate by Meter Route.¹

Survey response	Phase 1			Phase 2			All Cases
	Route1	Route 2	Route 7	Route 9	Route 11	Route 12	
No survey completed	80.5%	75.9%	77.1%	81.7%	85.6%	87.5%	80.0%
Survey completed	<u>19.5%</u>	<u>24.1%</u>	<u>22.9%</u>	<u>18.3%</u>	<u>14.4%</u>	<u>12.5%</u>	<u>20.0%</u>
	100%	100%	100%	100%	100%	100%	100%
Number of total cases	261	290	48	345	97	8	1049

NOTE: ¹ Meter route names - 1 Washington Terrace, 2 South Ogden/Ogden, 7 S. Ogden (Badger meters), 9 S. Weber, 11 S. Ogden (Smart meters), 12 S. Ogden (I-Pearl meters)

The response rate was increased significantly by inclusion of the paper copy survey and prize drawing in the last reminder mailing. From November 29 through December 20, respondents returned 88 paper copy surveys by mail compared to only 36 surveys being completed on-line during that period. As shown in Table 4, of people who completed a mailed paper copy survey (90 participants), 71.1% live in the Phase 1 areas, where more older and retired people reside, and only 28.9% live in Phase 2. The on-line survey (120) was completed by 56.7% of Phase 1 residents and 43.3% of Phase 2 residents.

TABLE 4. Type of Survey completed by project phase.

Project Phase	n	On-line	Mail	All Types
Phase 1	132	56.7%	71.1%	62.9%
Phase 2	78	<u>43.3%</u>	<u>28.9%</u>	<u>37.1%</u>
		100%	100%	100%
Number of cases by type		120	90	210

Utilizing multiple methods for enabling people to participate in the survey appears to have been an important adaptation in administration of this survey (the original plan was to have it only be

available online except but request). Even in a world of rapidly changing communication methods, the U.S. mail is still the only method conveniently and reliably available to every resident of this study area.

2.5.3 Cases Used in the Analysis

Three distinct groups receive metered secondary water. Locations within the District's residential secondary meter project (1054) which includes the Phase 1 group where meters were installed in the spring of 2011 and the Phase 2 group where meters were installed in spring of 2012. Areas outside the District's residential secondary meter project (68) comprise the third group. These three groups differ in several ways. The locations within the meter project area were invited to an open house held by the Langdon Group where they were briefed about the purpose of the project and what to expect as meters were installed at their residences. The locations outside the project area have had meters installed as part of the process of constructing a new house. These locations did not receive the meter project open house briefing.

The locations receiving metered secondary water have also received different types of information regarding their secondary water use. In June 2011, Phase 1 locations and homes built outside the project area received a letter from the District informing residents of their water rights allocation in gallons and the percentage they had used to date. In July 2011, the District began sending a "Secondary Water Usage Statement" that included a comparison of their water use and estimated water need based on a standard set of assumptions from area-wide averaged data regarding their lot, landscaped area, type of landscape, and climate. In May 2012, "Secondary Water Use Reports" were prepared by USU. Phase 1 and Phase 2 locations were sent the full report that included a site-specific estimate of landscape water need based upon current weather data, the lot location, lot size, and landscape characteristics (differentiating turf from non-turf areas). New construction locations inside and outside the project area that did not have a landscape installed received an abbreviated report that only included their metered use and the weather data, but did not include an estimate of landscape water need or their Landscape Irrigation Ratio (LIR). Five locations within the project area received abbreviated reports.

Along with obtaining the monthly meter readings, WBWCD also collected hourly flow for each location. This was a larger dataset and more prone to errors. With monthly meter readings, a water meter could still be manually read if the reader was malfunctioning, but this was not the case with the hourly meter readings. When assessing the hourly data at the end of the season, it was found that monthly sums did not always equal the amount obtained from the monthly read since readings may not have occurred on the fifteenth of every month or because of erroneous hourly reads. But, when summing over the entire season, the monthly discrepancies disappeared. In order to accurately assess the hourly data, locations where the summed hourly water use totals did not match the summed monthly meter readings within 1.5 percent were excluded. This 1.5 percent threshold was chosen because there were 3 days out of a total of 195 days where hourly flow data was not available. The initial read was performed on April 5 with hourly data beginning April 6, and the final reads occurred October 15-16 with hourly data up to the morning of October 15.

In order to make relevant comparisons between lots, households, and meter data, we developed criteria for inclusion in the research study analysis (Table 5). Locations were included if:

1. they were in the District’s residential secondary meter project area;
2. they received the full Secondary Water Use Report; and,
3. the summed hourly water use data matched summed monthly meter readings within 1.5%.

After applying these criteria, 869 project locations were used in the water use analysis and 210 survey respondents were used in the survey data analysis.

TABLE 5. Cases included in USU data analysis.

Cases used in water use analysis:	869	
Total meter locations		1122
Meters outside project area		68
Project locations that received abbreviated report		5
Discrepancies between hourly and monthly meter data		180
Cases used in survey analysis:	210	
Surveys from households in project area		210

3 RESULTS AND DISCUSSION

3.1 Description of Watering Patterns (meter data analysis)

3.1.1 Water Use Analysis

For six periods throughout the 2012 season (April 16-May 15, May 16-June 15, June 16-July 15, August 16-September 15, and September 16-October 15), landscape irrigation ratios (LIRs) were calculated by dividing the measured metered flows by estimated landscape needs for each property. These LIRs represented the fraction of water applied to the actual landscape water need. The LIRs were sent to each metered location in the Secondary Water User Report every month. These reports also included the previous month’s meter reading with the current month’s reading and the difference between the two, or the monthly secondary water usage for that location.

Landscape water need was estimated from the ASCE Standardized Penman-Monteith Short Reference ET equation (ASCE-EWRI, 2005) from hourly data at an electronic weather station sited at WBWCD headquarters located at 2837 East Highway 193 in Layton, Utah (Figure 1).



FIGURE 1. Aerial View of WBWCD Electronic Weather Station

These reference ET estimates were multiplied by a factor of 80 percent to represent turfgrass conditions and by a factor of 50 percent to represent trees and shrubs. These depths were then multiplied to tree/shrub and turfgrass areas derived from a July 2011 aerial image classification to obtain a volumetric need. To be conservative on the water user's behalf, carryover winter soil moisture and seasonal rainfall were not included in the calculations, and a high but achievable application efficiency of 70 percent was added to account for irrigation system inefficiencies as shown in the equation below.

$$Need = \frac{(0.8 * Area_{Turfgrass} + 0.5 * Area_{Trees\ and\ Shrubs}) * ET_0}{0.7}$$

LIRs were then calculated by dividing the use by the estimated need. Figure 2 below presents the LIR exceedance probability for each of the 869 sampled locations. The cumulative distribution displays the lower 20 percent below an LIR of 1 while the upper 20 percent exceed an LIR of 2. The middle 60 percent fall between 1 and 2, which reinforces the reasonableness of the assumptions applied to estimated landscape need to account for overwatering.

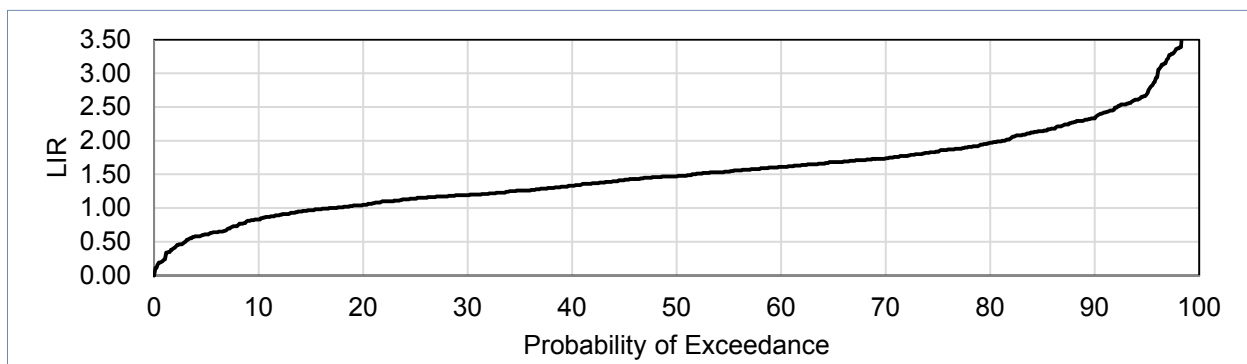


FIGURE 2. Seasonal Landscape Irrigation Ratios (LIR) for 869 WBWCD Residential Properties with Metered Secondary Water in 2012

The subset of 869 locations was then analyzed to provide statistics relating to the LIR, which is why the original group of metered locations was filtered to identify the properties where the summed hourly readings accurately represented the monthly reading calculated in the LIR. These monthly LIRs were then recalculated to represent a seasonal LIR or the seasonal landscape use divided by the seasonal landscape need. The number of days flow was recorded in the meter was tallied (number days usage) along with the total number of hours where a flow was greater than zero (total hours usage), the number of times a flow greater than zero began with a previous hourly reading of zero (number of times usage), and a seasonal (total) sum of usage. These results are shown in Table 6 and are grouped by categorical ranges of the property seasonal LIR. An average seasonal LIR of 1.55 was reported in addition to a total usage in gallons summing to less than the subset's total water rights allocation appurtenant to the parcels (90%). The water rights allocation is determined by parcel size, consequently, smaller lots have smaller allocations. As may be expected, those locations with higher LIRs also averaged the highest number of days with flow and the highest number of times when the system was turned on. In addition, the locations with higher LIRs exceeded, on average, their allocations.

TABLE 6. Averaged Irrigation Patterns of Behavior for 869 WBWCD Residential Properties with Metered Secondary Water in 2012

Property Subset	No. of Cases (%cases)	Seasonal LIR	Number Days Usage	Total Hours Usage	Number Times Usage	Total Usage (gal)	Total allocation (gal)	% Allocation Used
ALL	869 (100%)	1.55	143	887	255	264,925	294,061	90%
LIR < 1	146 (16.8%)	0.71	128	728	209	171,236	358,077	49%
1 ≤ LIR < 2	560 (64.5%)	1.46	143	866	262	259,080	288,117	90%
2 ≤ LIR < 3	130 (14.9%)	2.33	154	1088	271	344,862	263,089	130%
LIR ≥ 3	33 (3.8%)	3.73	158	1143	276	463,714	233,730	198%

Note: All figures are averaged values.

Hourly data for these locations were also compared to the seasonal LIR to observe time-of-day behavior. As can be seen in Figure 3 below, secondary water use of the users with the highest LIRs peaks during the morning hours of 2:00 to 4:00 a.m. with a higher hourly flow during the middle of the night. The users who watered more efficiently (as represented by lower seasonal LIRs) irrigated later in the morning hours, generally between 5:00 to 8:00 in the morning. People in all categories of LIRs generally did not water during the middle of the day.

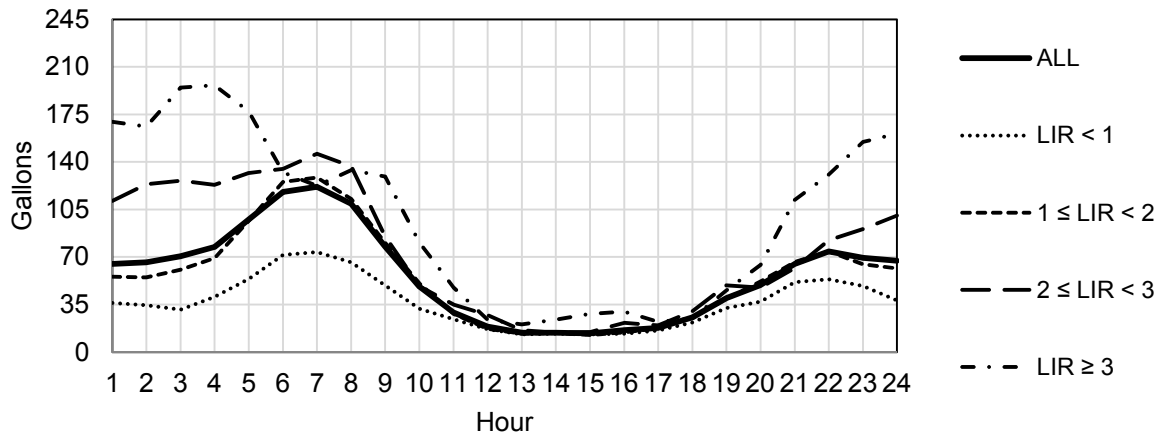


FIGURE 3. Landscape Irrigation Use by Hour for 869 WBWCD Residential Properties with Metered Secondary Water in 2012

Correlations between the hourly flows and the seasonal LIR were determined and are shown below (Figure 4). The highest R coefficients surrounded the middle of night, which correspond to the higher hourly flows for the locations with LIRs above 3. Strong correlation between hourly usage and the seasonal LIR was not observed.

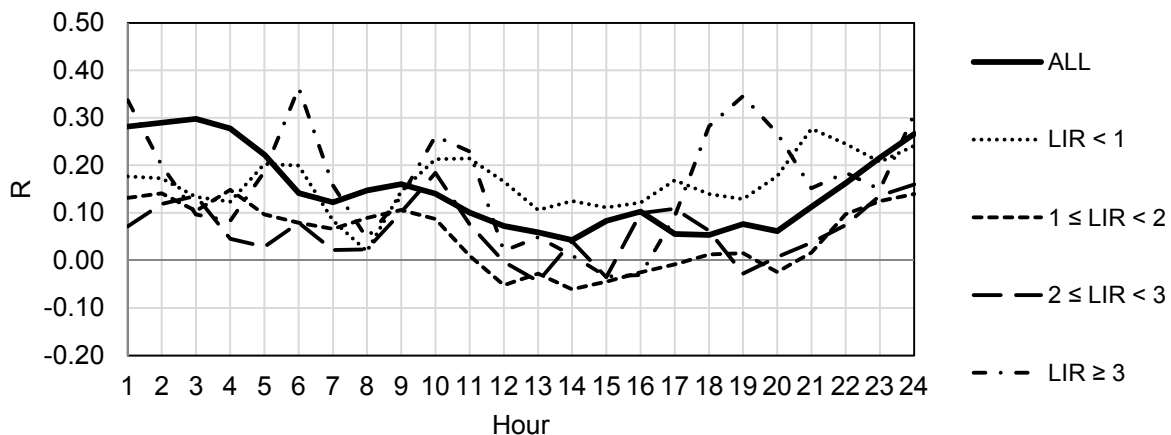


FIGURE 4. Correlation of Landscape Irrigation Use to Landscape Irrigation Ratio by Hour for 869 WBWCD Residential Properties with Metered Secondary Water in 2012

3.1.2 Recalculated Use and Need

In contrast to evaluating the behavior of each property discretely, irrigation usage and landscape needs were totaled for the 869 location subset. A more detailed routine, including a soil moisture balance and precipitation events were added to the need calculation. Crop coefficients were further defined in the spring and autumn portions of the year by relying on observations of Hill and Barker (2010) for turfgrass and then multiplying trees and shrubs by 75 percent of the turfgrass crop coefficient. The season was lengthened to include a green-up date starting April 1

instead of April 16 as delivered to users in the first Secondary Water Use Report. A detailed description of the methods and input parameters is shown below in Table 7.

TABLE 7. Methodology and Input Parameters for Estimation of Landscape Irrigation Requirements at 869 Residential Properties in Weber Basin, Utah

Landscape Evapotranspiration

ASCE standardized Penman –Monteith short reference ET equation, hourly time step (ASCE-EWRI, 2005)

Turfgrass crop coefficient (Hill and Barker, 2010)

Trees and shrubs crop coefficient: 75 percent of turfgrass

Electronic Weather Station

Site: Weber Basin Water Conservancy District Headquarters

Latitude: 41.1095 degrees

Longitude: -111.9128 degrees

Elevation: 4898 feet

Fetch: Irrigated turfgrass surrounded by buildings, garden, open water, and asphalt parking

Meteorological Data: Hourly average temperature, wind speed, humidity, and total solar radiation and precipitation

Soil Water Balance

Assumed Root Depth: 18 inches

Water Holding Capacity: 2 inches / foot

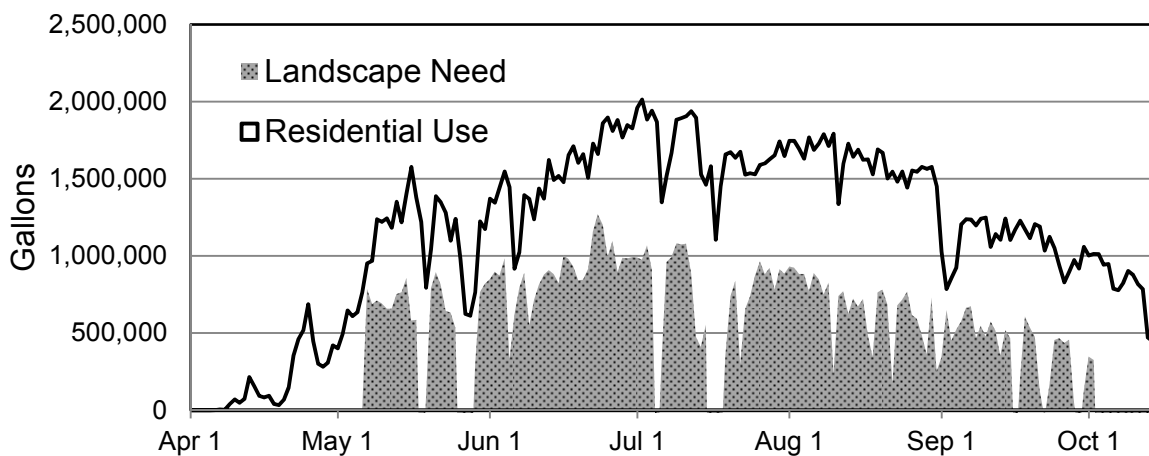
Green Up: April 1

Initial Soil Moisture: At field capacity

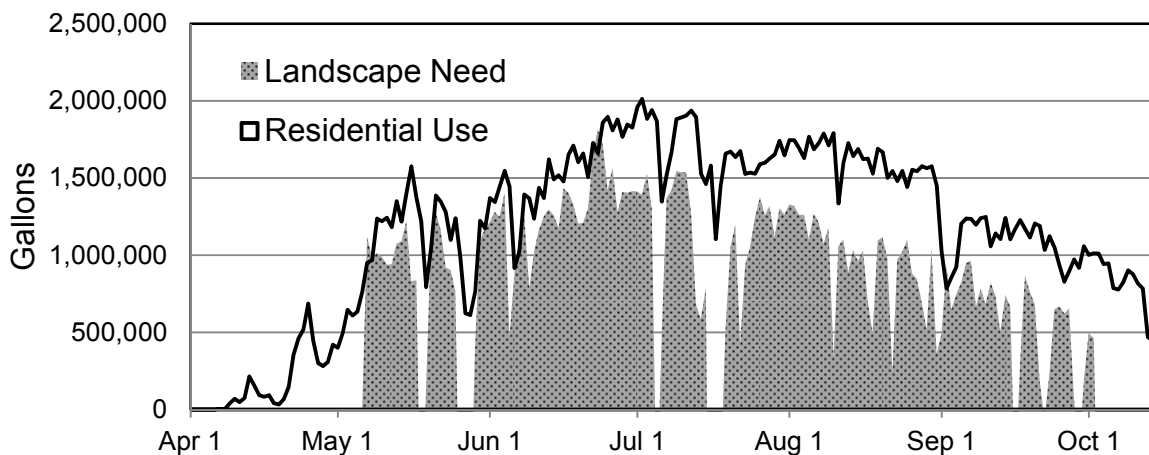
Effective Precipitation: 80 percent

Previous research has shown how use of automatic irrigation systems and the system's design, maintenance, and operation is often correlated with overuse of landscape water (e.g., Endter-Wada et al. 2008; Glenn 2010; Kilgren et al. 2010). Figure 5.a, b, and c presents the sum of the hourly use for the study area on a daily time step compared to the revised daily evapotranspiration assuming three levels of irrigation system application efficiency (measured as distribution uniformity or DU): a) 100% DU; b) 70% DU; and, c) 53% DU. In Figure 5, the pattern of use (gray area) followed the need (solid line) with decreases in irrigation after rain events and at the beginning and end of the irrigation season. A significant increase in irrigation was seen when the soil moisture started to become depleted in the spring with some unnecessary watering in April. However, more water was applied in October than in April, even though there was no need due to sufficient precipitation and low landscape evapotranspiration. If irrigation system efficiencies were perfect (100%) with no losses to evaporation, deep percolation, or runoff (i.e., watering the sidewalk or the gutter), and evenly distributed, Figure 5.a would represent the actual landscape water needs. The comparison between panels a, b, and c in Figure 5 illustrate how much the discrepancy between the amount of landscape water needed and the

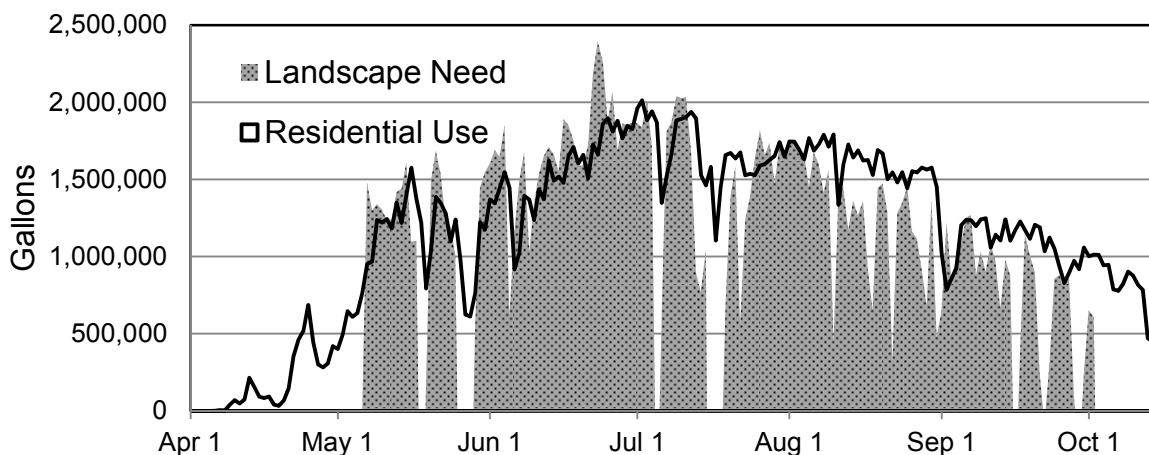
amount applied varies with DU, and reinforces the fact that increasing irrigation system application efficiency is a key factor in realizing landscape water conservation savings.



a) DU = 1.00



b) DU = 0.70



c) DU = 0.53

FIGURE 5. Sum of Daily Landscape Irrigation and Need Assuming Different Distribution Uniformities at 869 WBWCD Residential Properties with Metered Secondary Water in 2012

System evaluations or water checks performed by WBWCD in the region indicated average distribution uniformities (DU) of 53 percent in 2012. The DU neglects any losses and focuses only on output and, by incorporating this relatively poor efficiency to the need estimates, users were seen on a daily basis to match landscape ET (Figure 5.c). As the year 2012 set high temperature records, especially in the spring and early summer, the estimated need at those times was higher than in the fall. The residential use monitored in the spring more closely matches the need in the spring than later in the year as observed in Figure 5.c. The middle case, Figure 5b, embodies the 70 percent irrigation system DU assumption made in the Secondary Water Use Reports that was higher than what WBWCD found in its water checks. This scenario represents realistic water savings if landscape irrigation systems were better designed and managed.

Behavior may be the same in the beginning and the end of the year with only higher spring and summer temperatures resulting in higher transpiration rates. Since 92 percent of households surveyed acknowledged watering with a time clock on their irrigation systems, this could be true, but further years would have to be analyzed to produce a trend. The amount of irrigation assuming a DU of 1.00 (Figure 5.a) was 2.91 times over what was needed, or almost 200% in excess. Assuming a DU of 0.53 (Figure 5.c), use was 1.54 over what was needed, or 54 percent in excess.

WBWCD irrigation contract allocations for these properties were generally determined in the transition of land from agricultural to residential use and based on lot area, which differs from the landscaped area, multiplied by a depth of 3 feet. The sum of the outdoor use of the 869 property sample totaled 90 percent of the allocation (Table 8); therefore, on average, irrigators were within their limits. Yet 36 percent of this subset of households exceeded their allocations, which would result in 10 percent savings if all households remained within their allocations. Net irrigation was also calculated from the methods discussed earlier and totaled a seasonal depth of 16.6 in, which corresponded well with what Hill et al. (2011) reported in a similar study in the area.

TABLE 8. Seasonal Water Use, Landscape ET, and Net Irrigation for 869 WBWCD Residential Properties with Metered Secondary Water in 2012

Landscape	Land Area	ET	Net Irrigation		Use	Allocation
	ac	in	in	ac-ft	ac-ft	ac-ft
Turfgrass	108.6	29.01	19.39	175.5	-	-
Trees and Shrubs	66.6	21.76	12.13	67.3	-	-
Total/Weighted	175.2	26.26	16.63	242.8	706.5	784.2

3.2 Participant Information about Household Landscape Water Use

In section 1 of the survey, we asked some basic questions regarding secondary water use. The purpose of this section of the survey was to determine basic behaviors related to secondary water use in 2012. Questions related to whether their water use that year varied from their normal use,

their type of irrigation system, which landscape maintenance responsibilities various members of their household assume, and whether the people involved in landscape work reviewed the reports because their behaviors were the ones we were trying to influence. The basic characteristics of the survey households' secondary water use is depicted in Table 9. For each of these questions, 98-99% of the 210 participants responded (205-208 of the 210 respondents).

TABLE 9. Characteristics of Households' Secondary Water Use

Question Posed to Respondent	Responses
"Were you engaged in any landscaping projects this year that caused your outdoor water use to vary from your normal use?"	
No projects	79.2%
Yes, projects underway	20.8%
Number of respondents	207
"How do you water your landscape?"	
Manually with hose and sprinkler	0.0%
Manual in-ground sprinkler system	3.4%
Automated in-ground sprinkler system	92.8%
Other (combinations of hose and sprinkler system)	3.9%
Number of respondents	207
"Who generally waters your landscape and/or programs the sprinkler timer?"	
A male head of household	80.2%
A female head of household	8.7%
Another member of household	1.0
Joint responsibility of several household members	7.2%
Yard care service provider	1.0%
Other	1.9%
Number of respondents	207
"Did this person(s) review the Secondary Water Use Reports?"	
Yes	98.0%
No	2.0%
Number of respondents	205
"Who generally maintains your landscape (i.e., does the yard work)?"	
A male head of household	46.6%
A female head of household	5.3%
Another member of household	0.0%
Joint responsibility of several household members	32.2%
Yard care service provider	10.6%
Other	5.3%
Number of respondents	208
"Did this person(s) review the Secondary Water Use Reports?"	
Yes	85.0%
No	15.0%
Number of respondents	206
"Is the person(s) who waters your landscape and/or programs the sprinkler timer the same person(s) who maintains your landscape?"	
Yes	87.4%
No	12.6%
Number of respondents	206
All cases	210

One thing we were interested to learn was whether people's water use in 2012 varied from their past use. Since meters were newly installed in these locations and there was no historical water use data, this question was designed to help us determine if people's overall water use patterns were representative of use in these areas. The majority (79.2%) of the respondent households were not engaged in any landscaping projects that would cause their water use to vary from their normal use. However, since 20.8% of them answered yes to this question, it is important to note that this can be a source of year-to-year variability in water use patterns at some locations.

We were also interested in which members of the households water and maintain their landscapes and if those persons reviewed the Secondary Water Use Reports. Of the respondent households, nearly all irrigate their landscapes with an in-ground automated sprinkler system (92.8%). These systems are generally programmed by the male head of household (80.2%) who reviewed the monthly Secondary Water Use Report (98%). Responsibility for maintaining the landscape is divided more broadly among household members with 46.6% of the male heads of households assuming primary responsibility for maintaining the yard and 32.2% of the respondent households sharing the responsibility among several members. Fewer but still a high percentage (85%) of the household members who maintain the landscape also reviewed the Secondary Water Use Reports. When the respondent household member is responsible for both programming the sprinkler timer and maintaining the landscape, 87.4% of them reviewed the Secondary Water Use Report. In order for water use information to be effective, both the people irrigating the landscape and those maintaining the landscape need to review the Secondary Water Use Report so that they can incorporate the information into their landscape management decisions. It appears that the Secondary Water Use Report did reach the appropriate household members.

Additional information on what people did with their Secondary Water Use Reports is contained in Table 10. These data come from Section 2 of the survey, where we asked questions eliciting feedback on the Secondary Water Use Report and accompanying information that was sent to households during the irrigation season (May 2012 through October 2012).

TABLE 10. Secondary Water Use Reports

Question posed to Respondent	Phase 1	Phase 2	All Cases
"What did your household do with the Secondary Water Use Reports and accompanying information that you received this summer?"¹			
Opened and reviewed report	95.4%	97.4%	96.2%
Generally understood information	55.0%	53.2%	54.3%
Kept reports/information	42.0%	42.9%	42.3%
Compared outdoor water use to indoor (city) use	6.1%	3.9%	5.3%
Used reports to monitor water use over summer	61.1%	55.8%	59.1%
Household members discussed reports	41.2%	23.4%	34.6%
Neighborhood discussed reports	34.4%	35.1%	34.6%
Contacted WBWCD	8.4%	6.5%	7.7%
Contacted USU	3.8%	1.3%	2.9%
Referred to report to complete survey	9.2%	7.8%	8.7%
Other	5.3%	6.5%	5.8%
Number of respondents	131	77	208
All Cases	132	78	210

NOTE: ¹ Categories appear in the same order as presented in the survey and respondents were asked to mark all that apply. Multiple responses possible.

Survey respondents in Phase 1 and Phase 2 used the reports in similar ways except in two instances; a) 61.1% of Phase 1 respondents and 55.8% of Phase 2 respondents “used the report to monitor their water use over the summer”, and b) 41.2% of Phase 1 respondent households and 23.4% of Phase 2 respondent households “discussed the report with each other.” However, we did not find a significant relationship between these activities and the seasonal LIR. The respondents saw the report as a useful tool, but may need more time to properly apply the information to their water management.

In terms of the seasonal LIR, we did find a significant relationship with “neighborhood discussed report” ($\chi^2 = 20.8$, $P = 0.00$); there was a significant difference in LIRs between neighbors who did not discuss their reports (mean 1.36) and those who did (mean 1.79) ($t = -4.41$, $P = 0.00$, CI [-0.64, -0.24]). Generally, neighbors who used water in the acceptable range did not discuss their report with their neighbors, but those who were using water inefficiently were more likely to discuss their report with their neighbors. During the irrigation season as we conducted face-to-face interviews and fielded water users’ questions, we also received information indicating that the information we imparted was being shared among some neighbors. This behavior of information sharing highlights the importance of conservation education and the influence that one skilled conservation advocate (or critic) can have in a neighborhood when neighbors engage in group problem solving. It also amplifies the influence of conservation education that is personalized to the needs of individual landscapes since comparisons between lots with different types of landscape material may have very different water needs.

3.3 Effectiveness of the Secondary Water Use Report

We asked a series of open-ended questions that gave respondents the opportunity to provide feedback on the Secondary Water Use Reports in their own words. Participants’ responses to these questions provided some contextual information necessary to more fully understand their survey responses as a whole. These questions asked about each section of the Secondary Water Use Report in the order in which these sections appeared in the reports (see Appendix A).

The first section of the report, Landscape Water Use, lists the meter readings and total gallons of water used. The second section, Landscape Water Need, reports landscaped area and proportions that are turf/non-turf with an estimate of landscape water need in gallons for the period reported. The District’s installation of secondary water meters has provided residents with their first opportunity to learn the amount of water in gallons that they actually use to irrigate their landscapes. While Phase 1 and Phase 2 respondents were equally surprised about the amount of water they use, they had a differing evaluation of how reasonable the estimates of landscape water need was for their lots: 29.7% of Phase 1 respondents (n=128) thought the estimated need was reasonable while 41.1 % of Phase 2 respondents (n=73) thought it was reasonable (Table 11). We found a significant relationship between the seasonal LIR and people’s responses to “surprised by amount of water used” ($\chi^2 = 10.88$, $P = 0.01$), and there was a significant difference in LIRs between people who were not surprised (mean LIR of 1.27) and those who were surprised (mean LIR of 1.60) ($t = -3.42$, $P = 0.001$, CI [-.053, -0.14]). Although the mean LIR for both groups falls within the acceptable use range, respondents who were surprised had higher LIRs than those who were not surprised by the amount of water they used. We also found

a significant relationship between the seasonal LIR and responses to the question about “were estimates reasonable” ($\chi^2 = 27.59$, $P = 0.00$). There was a significant difference in LIRs between people who thought it was reasonable (mean LIR of 1.19) and those who did not (mean LIR of 1.69) ($t = 6.45$, $P = 0.00$, CI [0.35, 0.66]). Again, the mean LIR for both groups falls within the acceptable use range, and respondents who did not think the estimates were reasonable had higher LIRs than those who thought the estimate was reasonable.

TABLE 11. Secondary Water Use Reports: Landscape Water Use and Landscape Water Need

Question posed to Respondent	Phase 1	Phase 2	All Cases
“Landscape Water Use: Were you surprised to learn the amount of water used on your landscape?”			
Yes	74.2%	72.0%	73.4%
No	25.8%	28.0%	26.6%
Number of respondents	128	75	203
“Landscape Water Need: Do you think the estimates of landscape water need for your property were reasonable?”			
Yes	29.7%	41.1%	33.8%
No	70.3%	58.9%	66.2%
Number of respondents	128	73	201
All Cases	132	78	210

In response to the question “Do you think the estimates of landscape water need for your property were reasonable?”, 33.8% of all participants responded “yes” and 66.2% of all participants responded “no” (Table 11). Some of those respondents volunteered written comments explaining their answers. Table 12 provides information on the reasons people thought the estimates were reasonable for the 25% who added comments, including illustrative comments from several respondents highlighting how they interpreted the data and put it to use. Table 13 provides information on the reasons people thought the estimates were not reasonable for the 92.5% who added comments, including a categorized list of the reasons they gave (these responses were coded and categorized since such a high percentage of people who thought the estimates were unreasonable chose to add a comments).

As revealed in Table 12, these respondents recognized that the estimated landscape need was a guideline and used it accordingly (12a), and also were able to identify why they had exceeded the estimate (12b). Response 12c demonstrates the respondent’s understanding that several years of information are needed to refine watering practices and that person has developed a plan of action to accomplish water conservation. Conservation is an on-going endeavor that requires on-going information to achieve those goals. Equally important is the positive reinforcement respondents who are using water efficiently receive (12a, 12d and 12e) and how the LIR is used as a management tool to adjust a watering schedule (12g). Both high and low users appear to be receiving the correct message as to their usage. Response 12f show the person also interpreted the information in the context of their own landscape and recognized that an establishing landscape modifies their need. Overall, these volunteered comments address site-specific conditions that our estimate could not take into account, but respondents understood the goal is to apply water to meet plant need and made adjustments appropriate to their conditions.

TABLE 12. Why Respondents Thought Estimates of Landscape Water Need Were Reasonable

	Phase 1	Phase 2	All Cases
Percentage of respondents who added comments	23.7%	26.6%	25.0%
Number of respondents who added comments	9	8	17
All respondents who thought estimates of landscape water need were reasonable	38	30	68

Illustrative Examples from the 17 Comments:

- "I feel that my system is very efficient. I do not have much overlap onto the sidewalks or driveway."
- "For the most part, we were close to your estimates. Until the end of the season, when we had more rain and didn't turn down the time on our system so we overused water."
- "While I have no history to go on, the estimate seems reasonable. The real test will be with multiple year usage versus estimates. The estimates are certainly a good goal that I will work to meet, though I am not sure it is possible. I plan to change my watering system to provide multiple sequence watering during each application to see if I can stretch the days between watering. I also plan to modify one of my lines that currently has rock garden and lawn. I think separation of the two will help me reduce the lawn water."
- "I could water my lawn and it would stay green with water use close to the estimated need."
- "It was nice to see that we weren't using an overabundance of water."
- "They were accurate of the most part. Like I said, the report doesn't consider the 20 trees I planted 4 years ago. The report helped me cut back on lawn watering but does not consider that I have trees to maintain that are new. You can't paint all lots with the same brush. I would invite the surveyor to visit and help me decide water usage."
- "Usage was consistent. When the water usage report jumped to 1.15, I reset the watering schedule and the next month it was 0.85."

Table 11 also shows that 66.2% of participants responded "no" to the question "Do you think the estimates of landscape water need for your property were reasonable?", and some of them (123) also volunteered written comments explaining why they thought the estimated landscape need was not reasonable (Table 13). It appears that people who had higher LIRs and used more water were hesitant to accept the information, especially if they were conservation minded and thought they were practicing conservation measures already.

TABLE 13 Why Respondents Thought Estimates of Landscape Water Need Were Not Reasonable.¹

	Phase 1	Phase 2	All Cases
Percentage of respondents who added comments	90.0%	97.7%	92.5%
Number of respondents who added comments	81	42	123
All respondents who thought estimates of landscape water need were not reasonable	90	43	133

Categories of Reasons	Percentage who gave this reason		
Soil type was not considered	35.8%	11.9%	27.6%
Disagreed that amount was adequate	24.7%	26.2%	25.2%
Lawn/plant quality deteriorated with reduced irrigation	18.5%	40.5%	26.0%
Landscaped area/plant type not considered or incorrect	13.6%	21.4%	16.3%
Weather was not considered	13.6%	11.9%	13.0%
Sprinkler system is well maintained	2.5%	2.4%	2.4%
Other	7.4%	9.5%	8.1%

NOTE: ¹ Coded with multiple responses possible.

In Table 13, respondent comments were coded into a multiple response set of distinct categories describing why they thought the estimated landscape need was not reasonable. These categories are defined as follows:

- Soil type was not considered: participants thought more water was needed because of their soil type.
- Disagreed that amount was adequate: participants questioned whether the estimate of landscape water need was adequate, but gave no reason why.
- Lawn/plant quality deteriorated with reduced irrigation: participants stated they had tried to meet the estimate, but observed declining plant quality.
- Landscaped area/plant type not considered or incorrect: participants wrote that the size of their lot or type of plants was not considered or thought our characterization was incorrect.
- Weather was not considered: participants mentioned that current weather conditions were not considered.
- Sprinkler system is well maintained: participants mentioned that their system is very well maintained, so they were of the opinion that they could not be using water inefficiently.
- Other: miscellaneous comments.

What is most notable about these comments is that respondents do not dispute the approach that was used to estimate landscape water need, even though they had lingering questions about the details of implementing the method. Each of these categories represents opportunities for refinements to the Secondary Water Use Report format and/or to the landscape classification. The comments also indicate the need for further conservation education.

Respondents who mentioned their soil type talked about sandy soil and how quickly water drains away and thought they needed more water to address this issue. Instead, soil type determines the frequency and method used to apply water. Respondents who mentioned declining plant conditions did not recognize that dry spots and wilting plants can be signs of poor irrigation system design, maintenance, and distribution uniformity. As noted previously, the District's irrigation system evaluation program found an average DU of 53% in 2012. The estimated landscape water need was based on a DU of 70%. Since average DU for the area is much lower, some respondents may have experienced declining plant quality due to inefficient irrigation systems, which require higher water use. On the other hand, respondents who mentioned they have well-maintained and efficient sprinkler systems did not recognize that they are likely to have higher precipitation rates and do not need to run their sprinklers for as much time as they would need to if their sprinkler heads were clogged, tilted, or leaky or there were other design and maintenance flaws.

In terms of the Secondary Water Use Report, respondents who commented that their landscaped area, plant type, or current weather were not considered may not have reviewed the explanatory information sheet sent with the May report, which residents were asked to retain for future reference. The information sheet explained that the estimated landscape water need was determined based upon site-specific information for individual lots. This demonstrates the importance of having that explanatory information accompany every report sent, perhaps as a standardized and printed back side to the individualized reports.

In addition, respondents who disagreed with the size of their landscaped area may have been correct. Aerial imagery does not distinguish between natural vegetation on the whole lot and managed landscapes where the sprinkler system is installed such as along Ben Lomond Avenue. Others disputed the accuracy of the proportion of turf compared to trees and shrubs. Tree canopies hide the amount of turf growing beneath them and it is likely these allocations needed to be adjusted. This adjustment requires comparisons in imagery taken when trees are and are not leaved out, which the researchers have done other places (Farag et al. 2011) but which was not part of this project. The landscaped area also took into account parking strips, which are not owned by the resident, but were added to their landscaped area, thus altering the proportions. Several respondents also mentioned that the “Google Earth image” did not reflect their current landscaping. This image was included with the May report to verify that their location was correctly identified. The image was labeled with their account number and “property aerial photo” and should have included a note that the image was not used for the cover classification. The explanation of the cover classification was addressed in explanatory information sheet and it likely was not clear to residents that we were referring to two different images.

Phase 1 and Phase 2 responses differed on three items; “soil type was not considered,” “lawn/plant conditions deteriorated,” and “landscaped area/plant type not considered or incorrect.” Regarding soil type, Phase 1 residents have received two different versions of water use information. In 2011, the District’s secondary water usage statement included a footnote that noted “soil characteristics” were considered in the estimated water need. In 2012, neither the Secondary Water Use Report nor the explanatory information sheet sent with the May report addressed the influence of soil type on water need. This was a frequently asked question by residents during the irrigation season. Consequently, an information sheet was included with the July report to address this issue. However, more education about the effects of soil type on watering practices appears to be warranted.

Phase 2 respondents observed more deterioration in their landscape quality than Phase 1 residents did. In addition to reasons previously noted, there are many other reasons that may explain why this occurred. It could indicate that there are better designed and maintained systems in Phase 1, which has more retired residents, than in Phase 2, where more working families reside. There may be different “green grass” aesthetic preferences between the two phases or Phase 2 families may spend more time in their yards and make more frequent observations of their landscape plant quality.

The third section of the report, Landscape Water Management, evaluates the efficiency of the landscape water management through the landscape irrigation ratio (LIR), which is presented as a ratio as well as a graphic depicting a percentage of efficiency achieved for the reporting period. The LIR is interpreted through four categories representing ranges of efficiency achieved: “efficient” has LIRs less than 1; “acceptable” has LIRs between 1 and 2; “inefficient” has LIRs between 2 and 3; and “excessive” has LIRs greater than 3. The LIR is designed to be a quick metric that can easily be interpreted and applied to landscape water management. If the LIR is 2, it simply means twice the amount of water is being applied than is needed. We assessed respondents’ level of understanding this concept. The results are depicted in Table 14.

TABLE 14. Secondary Water Use Reports: Landscape Water Management

Question posed to Respondent	Phase 1	Phase 2	All Cases
“Landscape Water Management: What does the Landscape Irrigation Ratio (as presented in the report) mean to you?”			
<i>Respondent expressed an answer that was:</i>			
Correct interpretation	41.9%	37.5%	40.4%
Partly correct interpretation	20.0%	17.9%	19.3%
Incorrect or didn't know its meaning	18.1%	23.2%	19.8%
Miscellaneous comment	20.0%	21.4%	20.5%
Number of respondents	105	56	161
All Cases	132	78	210

Each response was evaluated and coded in a mutually exclusive category depicting the respondent's level of understanding the LIR concept. The categories are defined as follows:

- Correct interpretation: respondent mentioned both landscape water use and landscape water need (the two components for computing an LIR);
- Partly correct interpretation: respondent mentioned either landscape water use or landscape water need, but the comparison through which an LIR is computed was wrong;
- Incorrect or didn't know its meaning: respondent said they “didn't know” or “it meant nothing” or gave a comparison that was completely incorrect;
- Miscellaneous comment: respondent offered a comment, but did not answer the question posed.

There was little difference in the level of understanding between Phase 1 and Phase 2 respondents. The majority of respondents were able to give a correct or partly correct interpretation of the meaning of the Landscape Irrigation Ratio (LIR).

The last section of the Secondary Water Use Report, the Landscape Water Monitor, presented a bar graph comparing landscape water used to estimated need for current and past periods in the irrigation season. Future statement periods showed predictions of landscape water need based on an historical 30-year (1982 – 2011) average ET for the area. The monitor was intended to aid residents in tracking their water use over the season and alerts them to coming changes in water demand so they could act accordingly. Table 15 presents survey results.

TABLE 15. Secondary Water Use Reports: Landscape Water Monitor

Question posed to Respondent	Phase 1	Phase 2	All Cases
“Landscape Water Monitor: How did the information provided in the landscape water monitor section of report aid in your decision making about landscape water use?”			
Took action to decrease water use	33.4%	24.6%	30.2%
Increased awareness of water used	27.2%	35.4%	30.2%
Took no action to change practices	39.4%	40.0%	39.6%
Number of respondents	114	65	179
All Cases	132	78	210

Each response was evaluated and coded in a mutually exclusive category depicting the level of engagement by the respondent. The categories are defined as follows:

- Took action to decrease water use: respondent mention that they used the information to decrease water use;
- Increased awareness of water used: respondent mention they “paid more attention,” “monitored use,” but did not specifically mention if they used less water,
- Took no action to change practices: respondent said they did not change their watering practices or else questioned the reliability of the information and so did not act.

More Phase 1 respondents acted on the information, but more Phase 2 respondents said that the report had increased their awareness of landscape water use. Overall, the majority of respondents incorporated the information into their landscape water management in some manner. Phase 1 respondents have received water use information for 2 years, while Phase 2 respondents saw this information for the first time in 2012. It is likely that people need to consider the information, incorporate it into their decision making about landscape practices, develop a plan of action, and implement actions which may require incurring expenses and including those in their household budget. This process often occurs over a longer period than one irrigation season. In the 2013 irrigation season, it will be important to continue to provide information, monitor changes in LIRs, and possibly conduct brief interactions (e.g., conservation programming, social science surveys) with residents to encourage and support their conservation efforts.

The Secondary Water Use Report was designed to promote individual water users accountability for their own water use and encourage people to engage in active management of applying water to maintain their landscapes. The overall message of the report perceived by residents was essential to encourage residents to “buy-in” to the approach. Table 16 presents these results.

TABLE 16. Message of Secondary Water Use Reports

Question posed to Respondent	Phase 1	Phase 2	All Cases
“Considering the Secondary Water Use Reports overall, what message was conveyed to you?”¹			
Increased awareness of water used	53.4%	42.4%	49.5%
Received a conservation message	15.5%	7.6%	12.6%
Questioned reliability of information	11.2%	9.0%	10.4%
Expressed fear of being billed	9.5%	24.2%	14.8%
Used report as a management tool	7.8%	12.1%	9.3%
Miscellaneous comments	5.2%	4.5%	4.9%
Concerned “Big Brother” is watching	2.6%	7.6%	4.4%
Number of respondents	122	71	193
All Cases	132	78	210

NOTE: ¹ Multiple responses possible.

Each response was evaluated and coded into a multiple response set with categories named by key words or concepts mentioned in the response. In both the “conservation message” and the “awareness of water used” responses, people talked about needing to use less water. However, there was a difference in respondents’ perception of the report’s message expressed in the language of these two response sets. The “conservation message” responses had a more objective goal-oriented view, while the “awareness of water used” responses took the report’s message personally. The most frequently stated response was various forms of “I use too much water.” When considering the “awareness” group’s entire survey and other comments regarding their conservation efforts, this group experienced the most cognitive dissonance. When faced with a

high LIR, and given what their comments suggest is their self-concept of being conservation-minded, these water users were challenged. It is likely this group is or could be motivated to bring their practices in line with the report results in order to reduce cognitive dissonance. Dissonance is a disagreeable psychological state that occurs when a person holds inconsistent cognitions; e.g. believe they are saving water and learn they are actually wasting water. This mental state involves a person's self-concept and results in behavior change that tends to be more persistent and enduring (Aronson 1980; Thibodeau and Aronson 1992). More Phase 2 respondents fear that the District's residential secondary meter project is going to be used to bill their metered water use, which may be explained by Phase 2 being comprised of more young families. While the number of respondents concerned about "Big Brother" watching is small, they have very loud voices even on paper. This group used anti-government language that was confrontational, aggressive and, at times, uncivil.

Next, we asked respondents to rate the quality of the information received in the Secondary Water Use Reports. Again, the elements of the survey appear in the same order as they were presented in the report (Table 17).

TABLE 17. Distribution of Secondary Water Use Report Ratings

Survey Statements¹	n	Mean	SD	Excellent	Very Good	Good	Fair	Poor	Cannot Judge
Landscape Water Use (landscape water use in metered gallons for the past month)	196	3.48	1.6	33.7%	23.0%	24.0%	6.1%	4.1%	9.2%
Landscape Water Need (estimated number of gallons landscape needed over the past month)	196	2.51	1.7	16.3%	15.8%	17.3%	15.8%	22.4%	12.2%
Landscape Water Management (classification of landscape water use as either efficient, acceptable, inefficient or excessive)	194	2.72	1.6	16.0%	18.0%	23.7%	17.0%	14.9%	10.3%
Landscape Irrigation Ratio (landscape water use divided by landscape water need, shown as a number and on a percentage scale)	192	2.76	1.6	16.7%	20.3%	24.0%	13.5%	12.5%	13.0%
Landscape Water Monitor (bar chart tracking landscape water use in relation to landscape water need for the current and previous months and also showing anticipated water needs for future months)	193	3.20	1.5	22.8%	22.3%	28.0%	12.4%	7.8%	6.7%
2012 Weather Data (evapotranspiration, precipitation, and temperature information for the monthly reporting period)	191	2.81	1.6	18.3%	20.4%	22.5%	15.7%	8.9%	14.1%
1982-2011 Weather Data (30-year averages for evapotranspiration, precipitation, and temperature for this same monthly period)	190	2.67	1.7	16.3%	20.0%	23.2%	14.2%	7.9%	18.4%

TABLE 17. Distribution of Secondary Water Use Report Ratings

Survey Statements ¹	n	Mean	SD	Excellent	Very Good	Good	Fair	Poor	Cannot Judge
Note: ¹ Survey respondents were instructed: <i>Please rate the quality of the information presented in each section of the monthly Secondary Water Use Reports.</i> Statements appear in the same order as presented on the Secondary Water Use Report. Responses were coded on a 5-point scale where 5 means “excellent” and 0 means “cannot judge.”									

The majority of people rated each element of the Secondary Water Use Report good or better. The estimated “Water Need” was rated the lowest while the meter reading reported in the Water Use section was rated highest. People appear to accept the approach. They appreciated knowing how much water they were using, but the reasons they thought the estimate was unreasonable (discussed previously) reflect that they think the particularities of their actual landscape was not adequately considered. There is more education to be done regarding the details and method of estimating landscape water need, as well as room for improvement in the specificity of the data used to produce the report. In conducting the focus group and face-to-face interviews, we learned that once people fully understand the report they like it a lot, because they think it represents a holistic assessment of their actual landscape and its water needs.

Lastly, we asked respondents to rate the quality of the information that accompanied the Secondary Water Use Reports (Table 18). The first report sent in May 2012 included a photo of their property and an information sheet explaining the methodology used to estimate landscape water need and how to interpret their report. In July 2012, an information sheet that addressed frequently asked questions and reasons for a high LIR accompanied the report. Every report sent during the irrigation season encouraged water users to visit the District’s web site and to ask questions. Each report included contact information for the District and USU personnel.

TABLE 18. Distribution of Additional Information Ratings

Information Item ¹	n	Mean	SD	Excellent	Very Good	Good	Fair	Poor	Cannot Judge
Property Photo mailed with the May report	158	2.6	1.8	24.1%	0.6%	33.5%	13.9%	5.7%	22.2%
May Information Sheet mailed with the report explaining how to interpret the reports	147	2.9	1.8	28.6%	0.7%	40.8%	9.5%	3.4%	17.0%
July Information Sheet mailed with the report explaining possible reasons for a high landscape irrigation ratio (LIR)	155	2.4	1.8	20.0%	0.0%	34.2%	13.5%	5.8%	26.5%
Water conservation information on the Weber Basin Water Conservancy District website	170	1.7	1.9	15.3%	0.6%	23.5%	8.2%	4.1%	48.2%
Information obtained through programs offered by Weber Basin Water Conservancy District (water check, Learning Garden, classes)	171	1.5	1.9	13.5%	0.0%	22.2%	5.8%	1.8%	56.7%

TABLE 18. Distribution of Additional Information Ratings

Information Item ¹	n	Mean	SD	Excellent	Very Good	Good	Fair	Poor	Cannot Judge
Personal contact with WBWCD or USU personnel to have questions about the reports answered	173	1.1	1.7	9.8%	0.0%	14.5%	6.4%	0.6%	68.8%

Note: ¹Survey respondents were instructed: *Please rate the quality of the additional information that was provided with the Secondary Water Use Reports or that you accessed because of receiving the reports.* Responses were coded on a 5-point scale where 5 means “excellent” and 0 means “cannot judge.”

The majority of respondents rated the additional information they received with the Secondary Water Use Report good or better. The May and July information sheets received the highest ratings. It appears the majority of the respondents did not view the District’s web site, obtain conservation information from the District or contact District/USU personnel and consequently could not judge the quality of the information or the contact. The Secondary Water Use Report could more prominently promote the District’s conservation website and highlight information available from various sources. The District may want to consider including conservation flyers with the Secondary Water Use Reports that are coordinated with pertinent gardening activities occurring over the course of the growing season.

3.4 Information Feedback to Promote Accountability

The research study was a unique and natural opportunity to evaluate the effectiveness of education information based on meter data for promoting efficiency, without the accompanying motivation of a price signal. In Part III of the survey, we explored the concepts of accountability and efficiency through a series of statements that gauged people’s level of agreement with each statement (Table 19). These statements were designed in a series that first assessed water use accountability at the household level and with each statement broadened to assess accountability on a widening scope, from the neighborhood, to the state, the environment, and future generations. The survey respondents were instructed to rate their level of agreement with each statement and were presented with 5 categories beginning with “strongly agree,” “agree,” “neither agree or disagree,” “disagree” and “strongly disagree.” The responses were reverse coded with -2 meaning “strongly disagree,” -1 meaning “disagree,” 0 meaning “neither agree or disagree,” 1 meaning “agree” and 2 meaning “strongly agree.”

TABLE 19. Distribution of Opinions about Secondary Water Use and Report Ratings

Survey Statement ¹	n	Mean	SD	Disagreement ²	Neutral	Agreement
Installation of a secondary water meter has allowed by household to be more accountable for its outdoor water use.	204	.57	1.1	15.7%	27.5%	56.9%
Meter data provided through the Secondary Water Use Reports has enabled my household to monitor its progress toward achieving our water conservation goals.	204	.49	1.0	15.2%	30.9%	53.9%
Secondary Water Use Reports were useful in motivating my household to	205	.51	1.1	20.5%	18.5%	61.0%

TABLE 19. Distribution of Opinions about Secondary Water Use and Report Ratings

Survey Statement ¹	n	Mean	SD	Disagreement ²	Neutral	Agreement
adjust our landscape watering practices over the course of the irrigation season.						
Secondary Water Use Reports provided the information we needed to make decisions about how often and how much to water our landscape.	205	.33	1.1	26.3%	21.5%	52.2%
Secondary Water Use Reports helped my household realize that it is possible for us to conserve secondary water and still maintain a nice landscape.	205	.09	1.1	32.7%	26.3%	41.0%
My household is willing to conserve water used outdoors in order to help Utah deal with long-term water supply issues related to the state's arid climate.	200	1.29	0.7	0.5%	10.5%	89.0%
My household is willing to conserve water used outdoors so that Utah will have adequate water for future population and economic growth.	201	1.19	0.7	1.5%	14.4%	84.1%
My household is willing to conserve water used outdoors to help ensure that enough water is left in rivers, aquifers and wetlands to maintain a healthy environment.	198	1.26	0.6	0.0%	10.6%	89.4%
My household is willing to conserve water used outdoors to help Utah adapt to future water supply uncertainties related to climate change.	199	.95	1.0	6.5%	19.6%	73.9%
We can be good stewards of our water resources by only using as much water as we need.	203	1.31	0.7	1.5%	10.8%	87.7%

Note: ¹ Survey respondents were instructed: *Please rate your level of agreement with each statement.* Statements appear in the same order as presented in the survey.

² Respondents were presented with 5 categories beginning with "strongly agree" through "strongly disagree." Responses were reverse coded on a 5-point scale where -2 means "strongly disagree," -1 means "agree," 0 means "neither agree nor disagree," 1 means "agree" and 2 means "strongly agree."

The majority of respondents agreed with these statements, but there is less agreement that the Secondary Water Use Report helped respondents personally to be more accountable for their water use. However, people expressed high levels of agreement regarding willingness to conserve for the greater good of society. These results seem counter intuitive, but illustrate that the report generated some level of cognitive dissonance for many of the respondents and may likely motivate them to do better in the future. It should also be noted that this form of water use information is one that few people have experience with – secondary water systems have never been metered and people have not had the opportunity to know exactly how much water was applied to their landscape or to have estimates of how much water their landscapes need. People

need the opportunity to master these concepts and incorporate them into their landscape management practices.

4 SUMMARY

Water conservation is a key component of municipal water demand management strategies, particularly in Utah. Conserving water on urban landscapes, which accounts for a high proportion of urban water use, is an important part of demand management. Promoting landscape water conservation requires increasing the public's awareness of the need to conserve water, motivating them to conserve, and helping them understand how to conserve. Information provision to end users is critical to achieving these objectives. The vast literature on promoting behavior change related to conservation behaviors reinforces the need to help people understand not only *why* they should conserve, but *how* they can do it.

This project was designed on the premise that one of the most empowering ways to promote landscape water conservation is to help people understand how much water their landscapes actually need. Oftentimes people's water use exceeds the actual need of plants and, in these instances, people have "capacity to conserve" water while still maintaining a healthy landscape. A process of information provision was designed to produce and deliver monthly Secondary Water Use Reports to people with secondary pressurized irrigation systems where meters had recently been installed. The reports were individualized to each residential location. The purpose of the reports was to inform and provide consistent feedback to recipients on how their "landscape water use" compared to their "landscape water need" (expressed as a Landscape Irrigation Ratio). The overall approach was aimed at helping people monitor the appropriateness of their landscape water use in order to avoid waste. Survey data indicated that people were generally complementary of the reports, the messages that the reports were designed to convey were delivered, and personalized water use reports can be an effective water conservation tool.

Promoting water conservation is a process that requires strategies to promote habit change over the long-term. This project was conducted for only one year, and the benefits of the information provision that it pioneered will likely only be realized if the messages can be reinforced. Continuing the efforts that this project started in future irrigation seasons would enable WBWCD to realize additional benefits. Activities that would be advisable to conduct in the future include: 1) update aerial imagery to provide the most current characterization of residential landscapes (especially important for new lots); 2) refine and then continue producing and distributing Secondary Water Use Reports to people in the meter transition areas (incorporating feedback from the 2012 survey); 3) monitor and analyze metered secondary water use over future irrigation seasons; and, 4) conduct brief surveys to identify which actions people take have the most effect on making them more efficient in landscape water use.

5 REFERENCES

- Aronson, E. (1980). Persuasion via self-justification: Large commitments of small rewards. In *Retrospections on social psychology*, edited by Leon Festinger. New York: Oxford University Press.
- ASCE-EWRI. (2005). *The ASCE Standardized Reference Evapotranspiration Equation*. R. G. Allen et al., eds., Environmental and Water Resources Institute of the American Society of Civil Engineering, Standardization of Reference Evapotranspiration Task Committee Final Rep., ASCE, Reston, VA.
- Endter-Wada, J., J. Kurtzman, S.P. Keenan, R.K. Kjelgren, and C.M.U. Neale. (2008). Situational Waste in Landscape Watering: Residential and Business Water Use in an Urban Utah Community. *Journal of the American Water Resources Association (JAWRA)* 44(4):902-920.
- Farag, F.A., C.M.U. Neale, R. Kjelgren, and J. Endter-Wada. (2011). Quantifying Urban Landscape Water Conservation Potential Using High Resolution Remote Sensing and GIS. *Photogrammetric Engineering and Remote Sensing* 77(11):1113-1122. [This paper received the 2012 award for ESRI Best Scientific Paper in Geographic Information Systems]
- Glenn, D.T. (2010). *Residential Landscape Water Check Programs: Exploring a Conservation Tool*. Master's Thesis, Utah State University, 2010.
- Hill, R. W. & J. B. Barker. (2010). *Verification of Turfgrass Evapotranspiration in Utah*, Research Report No. 211. Utah Agricultural Experiment Station, Utah State University, Logan, UT.
- Hill, R. W., J. B. Barker, and C. S. Lewis. (2011). *Crop and Wetland Consumptive Use and Open Water Surface Evaporation for Utah*, Research Report No. 213. Utah Agricultural Experiment Station, Utah State University, Logan, UT.
- Kaiser, F. G. & U. Fuhrer. (2003). Ecological Behavior's Dependency on Different Forms of Knowledge. *Applied Psychology: An International Review* 52(4), 598-613.
- Kilgren, D., J. Endter-Wada, R. Kjelgren, and P.G. Johnson. (2010). Implementing Landscape Water Conservation in Public School Institutional Settings: A Case for Situational Problem Solving. *Journal of American Water Resources Association (JAWRA)* 46(6):1205-1220.
- McCalley, L.T. (2006). From motivation and cognition theories to everyday applications and back again. The case of product-integrated information and feedback. *Energy Policy* 34,129-137.
- Thibodeau, R. & E. Aronson. (1992). Taking a closer look: Reasserting the role of self-concept in dissonance theory. *Personality and Social Psychology Bulletin* 18(5), 591-602.

Weber Basin Water Conservancy District. 2010. *Water Conservation Plan*. Available at:
<http://www.weberbasin.com/conservation/index.php/publications/conservation-plan>

APPENDIX A:
**SECONDARY WATER USE REPORTS
AND ACCOMPANYING INFORMATION**

USU Letter to Water Users (May 15, 2012)

2012 Secondary Water Use Report Information Sheet (sent with May 2012 reports)

Example Maps Sent with Secondary Water Use Reports in May 2012
(Illustrating different lots and landscape types implying different water needs)

Example July 2012 Secondary Water Use Report

July Flyer: Possible Reasons for a High LIR

Example October 2012 Secondary Water Use Report



Department of Environment and Society
College of Natural Resources

Dear Weber Basin Water Conservancy District Water User,

We are excited to collaborate with Weber Basin Water Conservancy District and conduct research in connection with their secondary water meter installation project. The transition to metered secondary water is a unique opportunity to utilize an approach we have developed for analyzing urban landscape water use, to share information produced by that analysis with users of secondary metered water, and to study how the information can aid water users in efficiently irrigating their landscapes. The Weber Basin Water Conservancy District is supporting our research on this project through a grant from the U. S. Bureau of Reclamation and Utah State University is providing matching funds.

Throughout the irrigation season, we will work closely with the Weber Basin Water Conservancy District to provide you with monthly Secondary Water Use Reports. We are available to answer any questions you may have about those reports and are interested in your feedback.

We will also conduct research to better understand how to assess the appropriateness of landscape water use, what water use information you desire to aid your water conservation efforts, and your views about water efficiency, conservation, and accountability. We invite you to participate in one of the following research activities during the irrigation season: 1) a *focus group* that will consist of 6 to 8 people from other households where meters have recently been installed; or 2) an *interview* (either in person or over the phone). At the end of the irrigation season, we will conduct a *household survey* and we encourage you to complete that survey when it arrives. Your experiences and insights will provide valuable contributions to our research and to water management.

*If you have questions or comments about your Secondary Water Use Report, or
If you would like to participate in a focus group or be interviewed about landscape water use,*
Please call or email Diana Glenn at the USU Urban Water Conservation Research Lab at:
(435) 797-9084 or diana.glenn@aggiemail.usu.edu

We appreciate your time and want to thank you in advance for your participation. The results of this research will help the District consider the needs and preferences of their water customers and the effectiveness of water use information as a conservation tool. Our goal is to provide information that can help the District manage water resources efficiently and equitably.

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2012 SECONDARY WATER USE REPORTS INFORMATION SHEET



Prepared by:
Utah State University and
Weber Basin Water Conservancy District



This information sheet will help you interpret the Secondary Water Use Reports that will be sent to you each month during the irrigation season. *Please retain this information sheet for future reference.*

WBWCD will read secondary meters on approximately the 15th of each month starting in May and ending in October. About one week after each meter reading, you will receive an individualized Secondary Water Use Report. This report is designed to provide information on your water use for the past month along with a summary of your landscape water use to date over this year's irrigation season. The Report also provides a site-specific estimate of your landscape's water need. Landscape water need is the amount of water needed to keep your landscape plant material in healthy condition given weather conditions in your local area. This Secondary Water Use Report provides information to aid you in efficient landscape watering and to help you contribute to personal, community and state water management and conservation goals.

Landscape Water Use. Landscape water use is the amount in gallons of secondary metered water used. Meter readings for the current and past read dates and the days in the current reporting period are shown.

Landscape Water Need. Landscape water need is the amount in gallons of irrigation water needed to replace water in the soil used by the plants in your landscape. Landscape water need is determined primarily by a combination of *weather, plant type, size of landscape, and irrigation system efficiency*. The assumptions we made for each of these categories provide a generous estimate of landscape water need.

Weather: Sunny, hot, dry and windy weather results in landscape plants using more water than cloudy, cool, humid and still weather. Day length is also important, as plants will use more water during long July days than under the same weather conditions in September. Rain affects landscape water use two ways. Cool, cloudy, humid conditions reduce plant water use, and rain greater than one quarter inch provides sufficient water to sustain plants, eliminating or reducing the need to add irrigation water. These factors are continuously monitored at weather stations and incorporated into a measurement known as evapotranspiration (ET), which represents the amount of water that "evaporates" from the soil and is "transpired" by plants. USU accessed weather and ET data from Ogden-area stations. Our estimates of landscape water need do not subtract rainfall, thus assuming for the benefit of the user that rain is "extra irrigation water."

Plant type: Your landscape plant types will determine water use and the amount you need to irrigate. Trees and shrubs are one main type of landscape plant material that needs water at a lower rate than turfgrass, the other main type of landscape plant material. Trees and shrubs can have particularly low water needs when they are integrated into non-continuous landscapes with open areas of mulch and hardscape like rocks and paths or when they are in the shade of buildings (such as planters under eaves of houses). USU determined the landscape types on your property from 2011 aerial remotely sensed images that were classified for buildings, hardscape, and plant types in urban areas in and around Ogden.

Size of Landscape: USU combined remotely sensed images with publicly-available county GIS data that identified property boundaries and then calculated the area of your different landscape types. Enclosed with your initial Water Use Report is an image of your property. Our estimates of your landscape water need include parking strips and tree canopies that overhang streets. Even though these areas are not part of your property, people are required to maintain and water them, so we have included them in our water need estimates.

Irrigation System Efficiency: Irrigation systems often do not apply water efficiently or uniformly as measured by distribution uniformity (DU), mainly due to design and maintenance issues. In calculating landscape water need, we assumed irrigation system distribution uniformity (DU) of 70%, thus increasing estimates of landscape water need to account for system inefficiencies.

Landscape Water Management. To assess the effectiveness of your landscape water management and your potential capacity to conserve, we used the Landscape Irrigation Ratio (LIR) developed by the USU research team. LIR is calculated by dividing your metered landscape water use (in gallons) by the estimated landscape water need (in gallons):

$$LIR = \frac{\text{Metered landscape water use (in gallons)}}{\text{Estimated landscape water need (in gallons)}}$$

Thus, an LIR of 1 means you are using approximately the same amount of water (or 100%) that your landscape needs. A LIR of 2 means you are using approximately twice as much water (or 200%) as we estimate your landscape needs. Use the LIR to decide how much to adjust your water schedule or to identify problems with your sprinkler system.

Find your LIR in the following table of landscape water use categories that provide benchmarks of the appropriateness of your landscape water use given landscape water need.

<u>Landscape water use is:</u>	<u>when your LIR is:</u>	<u>and use as a percentage of need is:</u>
Efficient	less than or close to 1	less than 100%
Acceptable	between 1 and 2	between 100% and 200%
Inefficient	between 2 and 3	between 200% and 300%
Excessive	greater than 3	over 300%

Landscape Water Monitor. Use this information to monitor your landscape water use over the irrigation season. The chart in this section graphs your *landscape water use (blue bars)* for each metered monthly period and compares it to the *estimated landscape water need (green bars)* for that same time period. For the current and previous statement periods, the blue and green bars provide a graphical representation of your landscape irrigation ratio (LIR). For future statement periods, projections of your landscape water need are shown in green bars, which are based on an historical 30-year (1982-2011) average ET. These projections give you a rough estimate of how much water may be needed for the period(s) ahead. As the irrigation season progresses, landscape water need (green bars) calculated with 2012 data for the current and previous statement periods will replace what previously were projections which were based on 1982-2011 historical averages.

Weather Data. Weather data for the calendar days included in the statement period are shown for both the current year (2012) and for the historical 30-year-average from 1982 to 2011.

Note on Interpretation. The information in your Secondary Water Use Report represents our most valid assessment of your secondary water use and its appropriateness for your property's landscape characteristics. However, we recognize that context-specific site conditions vary and that our assumptions as well as limitations of data sources can affect the accuracy of the LIR (and capacity to conserve) estimates. We assume that metered secondary water is only used to maintain outdoor landscapes and that meter data accurately records amount of landscape water used. Data limitations can occur in property boundary information (obtained from county records), resolution of the aerial imagery, or classification of landscaped or watered areas (e.g., if you have made significant changes to your landscape since the date of the aerial image).

Contact Information. If you have questions or comments about your Secondary Water Use Report, please contact Diana Glenn at the USU Urban Water Conservation Research Lab: (435) 797-9084 or diana.glenn@aggiemail.usu.edu. USU researchers are happy to answer questions and/or further investigate your secondary water use situation. Your feedback is welcomed and will help us refine our landscape water use assessment procedures.



WEBER BASIN WATER CONSERVANCY DISTRICT

2837 East Highway 193 • Layton, Utah 84040 • Phone (801) 771-1677 • (SLC) 359-4494 • Fax (801) 544-0103

Account Number:

PROPERTY AERIAL PHOTO



WEBER BASIN WATER CONSERVANCY DISTRICT

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2837 East Highway 193 • Layton, Utah 84040 • Phone (801) 771-1677 • (SLC) 359-4494 • Fax (801) 544-0103

7/18/2012

June 16 through July 15, 2012

Account Number:

Name
Address

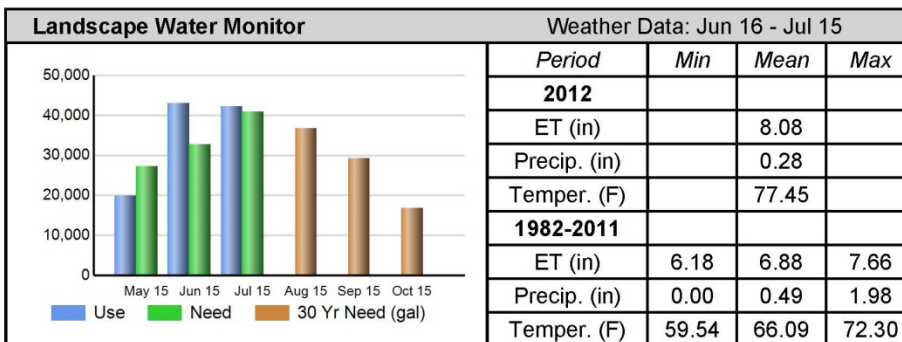
SECONDARY WATER USE REPORT

For more information on interpreting your Secondary Water Use Report, refer to the double-sided information sheet sent with the May report or also available online at: www.weberbasin.com/conservation/

Landscape Water Use				
Last Meter Reading	Current Meter Reading	Number of Days	Your Landscape Water Use	
272,118	314,314	30		42,196 gal

Landscape Water Need				
Landscaped Area (sq. ft.)	Turf LA (%)	Non-Turf LA (%)	Your Landscape Water Need	
8,374	60	40		40,900 gal

Landscape Water Management				
<u>Water use is:</u> Efficient Acceptable Inefficient Excessive	<u>when LIR is:</u> less than 1 between 1 and 2 between 2 and 3 greater than 3	Your Landscape Irrigation Ratio (LIR)	$\frac{\text{Landscape Water Use}}{\text{Landscape Water Need}} =$	1.03



The chart in this section graphs your landscape water use (blue bars) for each metered monthly period and compares it to the estimated landscape water need (green bars) for that same time period. For current and previous periods, blue and green bars provide a graphical representation of your landscape irrigation ratio (LIR). Future periods (reddish-brown bars) show projections of your landscape water need based on an historical 30-year (1982-2011) average ET.

We encourage you to visit Weber Basin's Learning Garden at our Layton headquarters (address above) or participate in landscape classes, water checks, and other events. All classes and programs are free. For a full water conservation schedule, visit Weber Basin's website: www.weberbasin.com/conservation/.

If you would like to receive this report by email or have questions about the meter project, please contact David Rice, Weber Basin's Water Conservation Coordinator: drice@weberbasin.com or (801) 771-1677.

If you have questions or comments about your Secondary Water Use Report or if you are willing to participate in a USU research focus group or interview, please contact Diana Glenn at the USU Urban Water Conservation Research Lab: diana.glenn@aggiemail.usu.edu or (435) 797-9084.

Developed from research at UtahStateUniversity



WEBER BASIN WATER CONSERVANCY DISTRICT

2837 East Highway 193 • Layton, Utah 84040 • Phone (801) 771-1677 • (SLC) 359-4494 • Fax (801) 544-0103

10/17/2012

September 16 through October 15, 2012

Account Number:

Name
Address

WBWCD hopes these reports have helped you track and assess your secondary water use. We encourage you to complete the USU survey.

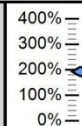
SECONDARY WATER USE REPORT

For more information on interpreting your Secondary Water Use Report, refer to the double-sided information sheet sent with the May report or also available online at: www.weberbasin.com/conservation/

Landscape Water Use				
Last Meter Reading	Current Meter Reading	Number of Days	Your Landscape Water Use	
510,664	542,522	30		31,858 gal

Landscape Water Need				
Landscaped Area (sq. ft.)	Turf LA (%)	Non-Turf LA (%)	Your Landscape Water Need	
7,871	50	50		16,500 gal

Landscape Water Management				
<u>Water use is:</u> Efficient Acceptable Inefficient Excessive	<u>when LIR is:</u> less than 1 between 1 and 2 between 2 and 3 greater than 3	Your Landscape Irrigation Ratio (LIR)	$\text{Landscape Water Use} = \frac{\text{Landscape Water Use}}{\text{Landscape Water Need}}$	1.93



Landscape Water Monitor		Weather Data: Sep 16 - Oct 15		
Period	Min	Mean	Max	
2012				
ET (in)		3.62		
Precip. (in)		0.53		
Temper. (F)		59.53		
1982-2011				
ET (in)	2.67	3.33	3.79	
Precip. (in)	0.11	1.68	5.48	
Temper. (F)	44.18	52.54	62.97	

The chart in this section graphs your landscape water use (blue bars) for each metered monthly period and compares it to the estimated landscape water need (green bars) for that same time period. For current and previous periods, blue and green bars provide a graphical representation of your landscape irrigation ratio (LIR). Future periods (reddish-brown bars) show projections of your landscape water need based on an historical 30-year (1982-2011) average ET.

We encourage you to visit Weber Basin's Learning Garden at our Layton headquarters (address above) or participate in landscape classes, water checks, and other events. All classes and programs are free. For a full water conservation schedule, visit Weber Basin's website: www.weberbasin.com/conservation/.

If you would like to receive this report by email or have questions about the meter project, please contact David Rice, Weber Basin's Water Conservation Coordinator: drice@weberbasin.com or (801) 771-1677.

If you have questions or comments about your Secondary Water Use Report or if you are willing to participate in a USU research focus group or interview, please contact Diana Glenn at the USU Urban Water Conservation Research Lab: diana.glenn@aggiemail.usu.edu or (435) 797-9084.

Developed from research at UtahStateUniversity

2012 Secondary Water Use Reports



Possible Reasons for a High LIR (LIR = Landscape Irrigation Ratio)



Prepared by:

Utah State University and
Weber Basin Water Conservancy District

We appreciate the questions and comments we have received regarding the Secondary Water Use Reports. Please remember our goal is to provide you with a *site-specific* estimate of the amount of water needed to keep your landscape plant material *healthy* given weather conditions in your local area. The *LIR approach* differs from the one used last year and should be a more accurate reflection of *your personal landscape water use and landscape water need*. This information sheet describes reasons why you might have a high landscape irrigation ratio (LIR) and suggests ways to conserve water to lower your LIR.

Watering Schedule: Knowing how much water your landscape needs can be difficult since water that plants do not utilize generally seeps below the root zone undetected. General rules:

- Adjust your time clock run times to account for varying landscape water needs:
 - Areas with trees and shrubs should be watered less than turfgrass areas;
 - You should water shaded areas less than areas fully exposed to the sun;
 - Landscapes need less water on cool and rainy days than on hot and sunny days;
 - Irrigate less frequently during the spring and fall when evaporative demand is less.
- Normally, you should water every other day during very hot weather, even if you have sandy soils. The appropriate irrigation run time will depend on the type of sprinkler head you use and the pressure of your system.
- Morning is the best time to inspect plants for wilting due to water stress, because many plants wilt in the afternoon to cope with heat even when they have sufficient water.
- We encourage you to *experiment* with applying less water to see how you can maintain a healthy landscape while conserving water at the same time.

Soil Type: The type of soil you have affects how *frequently* you need to water, not the *amount* of water you need to apply. General rules:

- Water quickly moves down through sandy soils beyond the shallow root zone of turfgrass so water less each time to make sure the water you apply does not exceed the soil's ability to absorb it. In order to help keep water within the turfgrass root zone in sandy soils, apply the water in two cycles. Divide your total watering time in half, run through your turfgrass sprinkler zones, then when the last zone finishes run through all the turfgrass zones again.
- Depending on the weather, you should water turfgrass no more frequently than every 1-2 days for sandy soils, and every 3–4 days for loam or clay soils.
- Use a soil probe or moisture meter to check whether soil is dry and needs to be irrigated.

Irrigation System Inefficiencies: Several issues related to sprinkler system design and maintenance as well as to site characteristics can affect water use, such as the following.

- *Sprinkler system does not apply water evenly across the landscape.* This can be caused by:
 - tilted or clogged sprinkler heads that need to be straightened or cleaned;
 - sprinkler heads that are spaced too far apart (the spray from one head should reach the adjacent head);
 - sprinkler zones with more than one type of sprinkler head (spray heads apply water at a higher rate than rotor or impact sprinkler heads);
 - nozzle precipitation rates do not match (a half circle nozzle should apply twice as much water as a quarter circle nozzle);
 - irrigation system leaks (find leaky heads or damaged pipes and replace or repair them).
- *Sprinkler zones apply the same amount of water to plants that have different water needs.* Strategies to exercise greater control and flexibility over water application:
 - Shrub beds do not need to be watered as frequently as lawn so separate sprinkler zones.
 - Plants are not grouped by water need so rearrange the plants into matched groupings.

Data Issues: The information in your Secondary Water Use Report represents our most valid assessment of your secondary water use and its appropriateness for your property's overall landscape characteristics. However, we recognize that data limitations can occur that may affect your report. We have learned a lot from people who have contacted us with additional information about their particular lot. That information has enabled us to provide them with more accurate Secondary Water Use Reports. *We welcome your feedback because it will help us provide you with better site-specific information and refine our landscape water use assessment procedures.*

Additional Water Conservation Information: For more water conservation information and for a schedule of classes, events and garden fairs, please visit the WBWCD conservation website at <http://www.weberbasin.com/conservation/>

At this website, you will find fact sheets and brochures on topics such as the following:

- General Conservation Brochure
- General Garden Brochure
- Healthy Lawn Basics
- Soils Basics
- Drip Irrigation System Basics
- Flagstone and Pavers Basics
- Landscape Design Basics
- Learning Garden Plant Lists

Contact Information for Questions and Suggestions:

Weber Basin Water Conservancy District: If you have questions about the meter project or conservation programs, or if you would like to schedule a water check, please contact David Rice at drice@weberbasin.com or (801) 771-1677.

Utah State University: If you have questions or comments about your Secondary Water Use Report, please contact Diana Glenn at the USU Urban Water Conservation Research Lab: (435) 797-9084 or diana.glenn@aggiemail.usu.edu. USU researchers are happy to answer questions and/or further investigate your secondary water use situation. We would also like to know what additional information you would find useful.

APPENDIX B:
**USU INSTITUTIONAL REVIEW BOARD APPROVED
PROTOCOLS FOR INFORMATION GATHERING**

Fall 2011 Home Interviews and Focus Group

Fall 2012 Household Survey

FALL 2011 HOME INTERVIEWS AND FOCUS GROUP



Page 1 of 2
USU IRB Certified Exempt: 10/13/2011
Exempt Certification Expires: 10/12/2014
IRB Password Protected per IRB Coordinator

Department of Environment and Society
College of Natural Resources

Water User Dimensions of Meter Implementation Study Letter of Invitation 2011-2012

Dear Weber Basin Water Conservancy District Water User,

We would like to invite you to participate in a research study investigating the influence of water use information on landscape water conservation efforts in the Weber Basin Water Conservancy District. Utah State University has partnered with the District to conduct this study. Early in spring 2011, the District installed new meters in your area. We are seeking residents interested in participating in a focus group discussion or an interview regarding the implementation of meters on the District's pressurized secondary water system. The transition to metered secondary water is a unique opportunity to study how water use information can aid water users in efficiently irrigating their landscapes. If you are interested in this important issue, we hope you will consider joining us.

The research will focus on learning about your current water use patterns, any efforts you have made to conserve water, how meter installation may affect your water use, what water use information you desire to aid your water conservation efforts, and your views about water efficiency, conservation, and accountability. Your experiences and insights will provide valuable contributions to our research and we look forward to your participation. You can choose to participate in either a focus group that will consist of 6 to 8 people from other households that have recently had meters installed or a personal in-home interview. Either opportunity will take approximately 1.5 hours.

We are an interdisciplinary team of faculty members from Utah State University that focuses on urban landscape water use. The Weber Basin Water Conservancy District is supporting this research through a grant from the U. S. Bureau of Reclamation. Your participation is completely voluntary and we will keep all information regarding your property as well as your responses and comments confidential. In conducting this research, we will audio record the session, code numbers will be used in place of your name, the code list will be kept separate from our notes, surveys, and electronic files, and the code list will be destroyed once data analysis is complete. There are minimal risks involved in this study. The Institutional Review Board (IRB) for protection of human subjects at Utah State University has reviewed and approved the procedures employed in this research. If you have questions or concerns about your rights as a research participant, you may contact the IRB Administrator at (435) 797-0567 or e-mail irb@usu.edu. If you wish to participate, please call and leave a message at our Urban Water Conservation Research Lab at (435) 797-9084 or contact our research associate, Diana Glenn by email at diana.glenn@aggiemail.usu.edu and include "meter study" in the e-mail subject line. Focus groups will be held at the Weber Basin Water Conservancy District offices. We will be scheduling focus groups in the next couple of weeks. If you would like to do an interview, these

will be scheduled at your convenience and conducted at your home. Please choose a participation method that best suits your schedule.

We appreciate your time and want to thank you in advance for your participation. The results of this research will help the District consider the needs and preferences of their water customers and the effectiveness of water use information as a conservation tool. Our goal is to provide information that can help the District manage water resources efficiently and equitably.

If you have any questions about this study, we are happy to answer them. Please either contact Diana Glenn at the phone or e-mail address provided above, or contact any one of us at the e-mails or telephone numbers listed below.


Respectfully,


Joanna Endter-Wada, PhD.

Associate Professor
Dept. of Environment & Society
College of Natural Resources
Utah State University
Ph: 435-797-2487
Email: joanna.endter-wada@usu.edu


Roger Kjellgren, PhD.

Professor
Dept. of Plants, Soils, & Climate
College of Agriculture
Utah State University
Ph: 435-797-2972
Email: roger.kjellgren@usu.edu


Christopher Neale, PhD.

Professor
Dept. of Civil & Environmental
Engineering
College of Engineering
Utah State University
Ph: 435-797-3689
Email: christopher.neale@usu.edu

Introductions and Explanations

- *Focus Group Facilitator: Have everyone introduce themselves. Talk about objectives of the focus group, the role of Utah State University, and expectations for the focus group discussion (e.g., set some basic ground rules). Answer any questions.*
- *Interviewer: Introduce the study and the role USU is playing. Review interview objectives and informed consent letter. Answer questions.*

PART 1: Questions about Secondary Water Use

The Weber Basin Water Conservancy District plans to share the meter data with its customers by providing households with secondary water usage statements. These statements can help residents to better understand and track their secondary water use. The District wants to provide people with enough water to maintain their landscapes in healthy condition, but anticipates that metering data can help the district and its customers work together to assess the appropriateness of landscape water use and identify opportunities for water conservation. So, to start off, we would like to discuss secondary water use and how meter information can be most useful to you.

1. For what purposes do you use your secondary water?

Probes:

- a. Is secondary water the only type of water that you use outside?
- b. Do you use your secondary water for purposes other than watering your landscape?
- c. Do you grow fruits or vegetables?

If yes, . . .

... Are you a new gardener?

... Do you irrigate your garden differently than the rest of your landscape?

2. What type of system do you use to irrigate your landscape(s)?

3. How do you determine when and how much to water your landscape(s)?

4. Do you anticipate that having a water meter will change how you use secondary water?

Probes:

- a. *Why* would having a meter change your secondary water use?
- b. *How* would having a meter change your secondary water use?

5. In what ways is secondary water different from culinary water?

6. What type of information would you find most useful to help you efficiently water your landscapes?

Probes: [Present alternative formats for displaying secondary water meter information in relation to estimated landscape water need information and ask for their feedback and suggestions.]

7. How and when should this information be delivered to you to aid in your decision making about landscape water use?

8. For research purposes, would you be willing to keep and share a diary of your watering practices and landscape maintenance next summer?

PART 2: General Questions about Water Efficiency, Conservation, and Accountability

Weber Basin Water Conservancy District participates in the State of Utah's long-term planning efforts to reduce per capita water use by 25% by 2050. Government funding for water infrastructure is dependent on a water purveyor having a water conservation plan. Metering and tracking water use is an important part of the District's water conservation plan and its accountability to Utah taxpayers. The District's Water Conservation Plan helps ensure that the District's water resources are used efficiently and conserved when possible. In this last section, we would like to hear your views about water efficiency, conservation, and accountability.

9. What does water efficiency mean to you?
10. Why is water conservation important?
11. What do you think are the most important principles, practices or procedures that can help people conserve water and use it most efficiently?
12. Under what conditions do you think the District should implement water conservation programs?

Probe:

- a. What actions do you think the District should take during a drought?

13. Do you think water conservation programs should be implemented on a *voluntary* or *mandatory* basis, and under *what circumstances* do you think each would be most appropriate?

Probe:

If the District is able to determine through meter data analysis that some locations use more landscape water than their lot size and current landscape type would warrant, what do you think the District should do to encourage people to conserve water outdoors?

14. What does accountability for water use mean to you?

Probes:

- a. In what ways can the District exhibit accountability?
- b. In what ways can individual users exhibit accountability?

Institutional Review Board

USU Assurance: FWA#00003308

USU RGS Logo

Exemption #2

AAHRP seal

Certificate of Exemption

FROM: Richard D. Gordin, Acting IRB Chair
True M. Rubal, IRB Administrator
Richard and True
Signatures

To: Joanna Endter, Christopher Neale, Roger Kjellgren

Date: October 13, 2011

Protocol #: 4047

Title: Water User Dimensions Of Meter Implementation On Secondary Pressurized Irrigation Systems

The Institutional Review Board has determined that the above-referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #2:

Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through the identifiers linked to the subjects; and (b) any disclosure of human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

This exemption is valid for three years from the date of this correspondence, after which the study will be closed. If the research will extend beyond three years, it is your responsibility as the Principal Investigator to notify the IRB before the study's expiration date and submit a new application to continue the research. Research activities that continue beyond the expiration date without new certification of exempt status will be in violation of those federal guidelines which permit the exempt status.

As part of the IRB's quality assurance procedures, this research may be randomly selected for continuing review during the three year period of exemption. If so, you will receive a request for completion of a Protocol Status Report during the month of the anniversary date of this certification.

In all cases, it is your responsibility to notify the IRB prior to making any changes to the study by submitting an Amendment/Modification request. This will document whether or not the study still meets the requirements for exempt status under federal regulations.

Upon receipt of this memo, you may begin your research. If you have questions, please call the IRB office at (435) 797-1821 or email to irb@usu.edu.

The IRB wishes you success with your research.

4460 Old Main Hill Logan, UT 84322-4460 PH: (435) 797-1821 FAX: (435) 797-3769 WEB: irb.usu.edu EMAIL: irb@usu.edu

FALL 2012 HOUSEHOLD SURVEY



USU IRB Approval 10/8/2012
Approval terminates 10/7/2015
Protocol #4679

Department of Environment and Society

Fall 2012

Account Number:

[NAME]
[STREET ADDRESS]
[CITY, STATE ZIP]

Subject: Invitation to Provide Feedback on Secondary Water Use Reports

Dear [NAME]:

Weber Basin Water Conservancy District aims to provide you with prompt and reliable information regarding your secondary water use. Metering and tracking secondary water use is an important part of the District's water conservation plan and helps the District and individual water users ensure that water resources are used efficiently and conserved when possible.

As this irrigation season ends, **we invite you to participate in a research survey evaluating the Secondary Water Use Reports you have received this year.** As a recipient of these reports, we want you to participate in the survey, whether or not you also use the secondary water at this location. The transition to metered secondary water is a unique opportunity to study how water use information can aid water users in appropriately irrigating their landscapes and can help the District manage its share of Utah's scarce and variable water supply.

We hope you are interested in the important issue of outdoor water use and will **complete a short online survey on our website, <http://qcnr.usu.edu/envs/htm/uwcr1-survey/>.** The survey should take about 10-20 minutes depending on the extent of your comments, and you should plan on completing it in one session (the survey interface does not allow you to save and return to the survey). When asked for your Login ID, please use the following information:

Login ID: [Case #]

Alternatively, **if you prefer to participate by receiving a mailed copy of the survey (with a postage-paid return envelope included) or having someone call you to conduct the survey over the telephone,** please call USU's Urban Water Conservation Research Lab *message phone* at (435) 797-9084 or send an *email* to diana.glenn@aggiemail.usu.edu. Please provide your mailing address and telephone number(s) so we can contact you and make arrangements to provide one of these alternative survey formats.

We are an interdisciplinary team of researchers from Utah State University that focuses on urban landscape water use and conservation. The Weber Basin Water Conservancy District is supporting this research through a grant from the U. S. Bureau of Reclamation. The information

from this survey will be used to refine the Secondary Water Use Reports for next year's irrigation season. We value your insights and feedback.

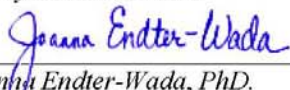
Your participation is completely voluntary and you are free to decline to answer individual survey questions. There are minimal risks involved in this study related to loss of confidentiality but we will take steps to reduce this risk. **We will keep all research information regarding your property as well as your responses and comments confidential.** In conducting this survey, we will use code numbers in place of your name, the code list will be kept separate from the survey data and electronic files, and the code list will be destroyed once data analysis is complete. The Institutional Review Board (IRB) for protection of human subjects at Utah State University has reviewed and approved the procedures employed in this research. If you have any questions or concerns about your rights as a research participant, you may contact the IRB Administrator at (435) 797-0567 or e-mail irb@usu.edu.

We appreciate your time and want to thank you in advance for your participation. The results of this research will help the District consider the needs and preferences of their water users and the effectiveness of water use information as a conservation tool.

If you have any questions about this study, we are happy to answer them. Feel free to contact one of us at the telephone numbers or e-mails listed below and please leave a message indicating that you are calling about the Weber Basin meter project research survey.

Respectfully,

Survey Administrators:


 Joanna Endter-Wada, Ph.D.
 Associate Professor
 Dept. of Environment and Society
 College of Natural Resources
 Utah State University
 Phone with voice mail: (435) 797-2487
 E-mail: joanna.endter-wada@usu.edu


 Diana T. Glenn, M.S.
 Research Associate
 Dept. of Environment and Society
 College of Natural Resources
 Utah State University
 Message Phone: (435) 797-9084
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*On behalf of the Utah State University
 Urban Water Conservation Research Team:*

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 College of Natural Resources

Roger Kjelgren, Ph.D.
 Department of Plants, Soils, & Climate,
 College of Agriculture

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EXPLANATION TO IRB ABOUT SURVEY INSTRUMENTS AND ADMINISTRATION

This survey is being targeted primarily at people who meet two criteria:

- 1) They use secondary water at the meter location;
- 2) They have seen the Secondary Water Use Reports that provide and interpret the meter data and that are designed to promote secondary water use conservation.

The letter of information and invitation to participate in the survey will be included with the final Secondary Water Use Report sent by BWCD on approximately Oct. 18. Thus, we are reasonably certain that condition 2 is at least partially satisfied for people invited to participate in the survey. Secondary Water Use Reports have been sent May-Oct to BWCD's contract list of urban secondary water users. The people on that list generally own the property but they may not live there. However, when the reports have been returned to BWCD (in instances such as when the USPS forward request has expired or the resident has returned it because someone else's name is on it), BWCD has changed the name on the reports to "Current Resident." Thus, the people who use the water and who have seen the reports are not always the same.

Consequently, before we administer the survey, we are asking people for some record keeping personally identifiable information that will be shared with Weber Basin Water Conservancy District for the purpose of helping them verify and/or correct their records so that appropriate people receive future reports. This information will also be used to determine whether the respondent continues with the survey and which survey version they are given (explained more below).

Respondents are asked five preliminary questions in the record-keeping section (P-1 through P-5). Based on answers to preliminary questions 1 and 2 and the assumptions we make as a result of those answers, the following courses of action are taken in the survey administration.

<i>If P-1 is:</i> <i>[they use the</i> <i>water]</i>	<i>and P-2 is:</i> <i>[they received the</i> <i>report(s)]</i>	<i>Assume:</i>	<i>Research Action Taken:</i>
yes	yes (either yes response)	<ul style="list-style-type: none"> - Owner occupied property - Renter; owner sent them reports - Reports were sent to "current resident" - Vacant house that owner is maintaining 	Respondent continues with Survey A (we know # reports received)
(yes)	(no)	(people in this category would not have been invited to take the survey but we might be directed to them by the owners)	Send them 2012 reports and information; possibly change recipient name for future reports No Survey Given
no	yes	- Non-resident property owner who received reports from BWCD and/or they were forwarded by renter or USPS	Respondent continues with Survey B
no	no	(not really a possible option because they would not have gotten invitation to participate in the survey)	<i>But in case:</i> Respondent is thanked and asked no further questions No Survey Given

NOTE: The shaded boxes seen in the rest of this document will not be seen by the participants. The boxes are here so researchers and IRB reviewers can easily identify the different parts.

INTRODUCTION and LOG-IN PAGE

Note: This grey box will not appear on survey

Weber Basin Meter Implementation Project Survey

This is your chance to have input! The purpose of this survey is to learn more about secondary water use in areas where meters have been installed and to evaluate the monthly Secondary Water Use Reports sent this year from May through October. We value your insights and feedback.

By logging in, you acknowledge your informed consent as a research participant. If you have any questions about the research and/or would like contact information for people at Utah State University, please click here to refer to the letter of informed consent: [Link to Letter of Informed Consent].

Please log in to this survey with information provided in the letter sent to you from Utah State University:

Login ID: [Case#]

RECORD KEEPING QUESTIONS

Note 1: This grey box will not appear on survey

Note 2: The numbering scheme {P-# } will not show on the “survey”

PRELIMINARY NON-RESEARCH RECORD-KEEPING QUESTIONS

Prior to starting the research survey, you will be asked a few non-research record-keeping questions. This information will be shared with Weber Basin Water Conservancy District to help them verify who has been receiving the Secondary Water Use Reports and to determine who should receive them in the future. Then you will be directed to the USU Research Survey.

{P-1} Are you or members of your household the users of secondary (outdoor) water at this location?

[indicate address]

- ☐ Yes
- ☐ No

{P-2} Secondary Water Use Reports corresponding to the meter at this address were mailed by Weber Basin Water Conservancy District each month from May through October 2012. Did you receive these reports?

- ☐ Yes, we received *all* of these reports
- ☐ Yes, we received *some* of these reports
- ☐ No, we did not receive any of these reports

If you only received some of these reports, please check which ones you received:

- ☐ May
- ☐ June
- ☐ July
- ☐ August
- ☐ September
- ☐ October

Was the most recent report you received addressed to you or a member of your household?

- ☐ Yes
- ☐ No

If not, to whom should future reports be addressed?

{P-3} Do you live at the location indicated on the Secondary Water Use Reports?

- ☐ Yes
- ☐ No

Comment: [comment box]

How long have you lived at this location?

_____ years

{P-4} Do you own or rent the property located at the address indicated on the Secondary Water Use Reports?

- ☐ I and/or members of my household *own* this property
- ☐ I and/or members of my household *rent* this property
- ☐ Other: [comment box]

{P-5} How many people reside at this address?

(This question is asked for information purposes only to help with future water supply planning.)

The number of people residing at this location is _____

Comments: [comment box]

SURVEY A – People who use water at the meter location and received reports

Note: This grey box will not appear on the survey

USU RESEARCH SURVEY

This survey is being conducted with people who use secondary water at the meter location and who have received the Secondary Water Use Reports. These reports are designed to share meter data with people living at the locations where meters have been installed and to promote water conservation. You have indicated that you use secondary water at this location and that you have received all or some of the Secondary Water Use Reports. Your responses are very important to us and we appreciate the time you take to fill out this survey.

We would like to remind you that your participation in the research survey is voluntary, you are free to decline to answer individual survey questions, and your responses will be kept confidential. Utah State University is conducting this survey for Weber Basin Water Conservancy District. USU researchers will keep participants' responses to questions in the research survey anonymous and only information that cannot be identified with you will be shared with Weber Basin Water Conservancy District and presented in research reports.

PART I: YOUR HOUSEHOLD'S SECONDARY WATER USE

In this section, we ask a few questions to help us understand your household's secondary (outdoor) water use and landscape maintenance. Please feel free to provide further explanations or clarifications in the comment boxes.

1. How do you water your landscape?

- ☐ Manually with a hose and sprinkler attachments
- ☐ With an in-ground sprinkler system that is manually started (it has no controller)
- ☐ With an automated in-ground sprinkler system that has a controller
- ☐ Other: [comment box]

- ☐ Decline to answer

2. Were you engaged in any landscaping projects this year that caused your outdoor water use to vary from your normal use?

- ☐ No
- ☐ Yes
If yes, please specify: [comment box]
- ☐ Decline to answer

3. Who generally waters your landscape and/or programs the sprinkler timer?

- ☐ A male head of the household
- ☐ A female head of the household
- ☐ Another member of the household
- ☐ It is the joint responsibility of several household members
- ☐ Yard care service provider
- ☐ Other: [comment box]
- ☐ Decline to answer

Did this person (or persons) review the Secondary Water Use Reports?

- ☐ Yes
- ☐ No
Comment: [comment box]
- ☐ Decline to answer

4. Who generally maintains your landscape (i.e., does the yard work)?

- ☐ A male head of household
- ☐ A female head of household
- ☐ Another member of the household
- ☐ It is the joint responsibility of several household members
- ☐ Yard care service provider
- ☐ Other [comment box]
- ☐ Decline to answer

Did this person (or persons) review the Secondary Water Use Reports?

- ☐ Yes
- ☐ No
Comment: [comment box]
- ☐ Decline to answer

5. Is the person (or persons) who waters your landscape and/or programs the sprinkler timer (as identified in Question 3) the same person (or persons) who maintains your landscape (as identified in Question 4)?

- ☐ Yes
- ☐ No
Comment: [comment box]
- ☐ Decline to answer

PART II: SECONDARY WATER USE REPORTS

Questions in this section ask you to provide feedback on the Secondary Water Use Reports and accompanying information that you received this year (May through October). Please feel free to provide further explanations or clarifications in the comment boxes.

6. What did your household do with the Secondary Water Use Reports and accompanying information that you received this summer? (please mark all that apply)

- ☐ Opened and reviewed the information
- ☐ Generally understood the information that was provided
- ☐ Kept the reports and accompanying information for future reference
- ☐ Compared our secondary water use to our indoor (city) water use
- ☐ Used the reports to monitor our secondary water use over the summer
- ☐ Several members of our household discussed the reports with each other
- ☐ Discussed the reports with other members of our neighborhood
- ☐ Contacted Weber Basin Water Conservancy District to ask questions about the reports
- ☐ Contacted Utah State University to ask questions about the reports
- ☐ Got the reports out so I could refer to them while responding to this survey
- ☐ Other: [comment box]

- ☐ Decline to answer

7. Landscape Water Use. Were you surprised to learn the amount of water used on your landscape?

- ☐ Yes
- ☐ No

Comments: [comment box]

- ☐ Decline to answer

8. Landscape Water Need. The estimate of landscape water need for your property was based upon the size and type of your landscape and current local weather conditions while also accounting for possible irrigation system inefficiencies which generally require additional water application (we assumed irrigation system distribution uniformity, which is a measure of irrigation system effectiveness, was 70%).

Do you think the estimates of landscape water need for your property were reasonable?

- ☐ Yes
- ☐ No

Why or why not? [comment box]

- ☐ Decline to answer

9. Landscape Water Management. What does the Landscape Irrigation Ratio (as presented in the Secondary Water Use Reports) mean to you?

[Comment box]

☐ Decline to answer

10. Landscape Water Monitor. How did the information provided in the landscape water monitor section of the reports aid in your decision making about landscape water use?

[Comment box]

☐ Decline to answer

11. Considering the Secondary Water Use Reports overall, what message was conveyed to you?

[Comment box:]

☐ Decline to answer

12. Please rate the quality of the information presented in each section of the monthly Secondary Water Use Reports.

	Excellent	Very good	Good	Fair	Poor	Cannot Judge
<i>Landscape Water Use</i> (your landscape water use in metered gallons for the past month)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Landscape Water Need</i> (estimated number of gallons your landscape needed over the past month)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Landscape Water Management</i> (classification of your landscape water use as either efficient, acceptable, inefficient or excessive)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Landscape Irrigation Ratio</i> (landscape water use divided by landscape water need, shown as a number and on a percentage scale)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Landscape Water Monitor</i> (bar chart tracking landscape water use in relation to landscape water need for the current and previous months and also showing anticipated water needs for future months)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>2012 Weather Data</i> (evapotranspiration, precipitation, and temperature information for the monthly reporting period)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>1982-2011 Weather Data</i> (30-year averages for evapotranspiration, precipitation, and temperature for this same monthly period)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comments: [comment box]

☐ Decline to answer

13. Please rate the quality of the additional information that was provided with the Secondary Water Use Reports or that you accessed because of receiving the reports.

	Excellent	Very good	Good	Fair	Poor	Cannot Judge
Property Photo mailed with the May report	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information Sheet mailed with the May report explaining how to interpret the reports	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information Sheet mailed with the July report explaining possible reasons for a high landscape irrigation ratio (LIR)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water conservation information on the Weber Basin Water Conservancy District website	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information obtained through programs offered by Weber Basin Water Conservancy District (water check, Learning Garden, classes)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Personal contact with WBWCD or USU personnel to have questions about the reports answered	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comments: [comment box]

☐ Decline to answer

14. What additional information would you need to know to have high confidence in the Secondary Water Use Reports provided to you?

[Comment box:]

- ☐ Decline to answer

PART III: OPINIONS ABOUT SECONDARY WATER USE AND THE WATER USE REPORTS

In this section, we present a few statements regarding secondary water use and the Secondary Water Use Reports. Please rate your level of agreement with each statement.

15. Installation of a secondary water meter has allowed my household to be more accountable for its outdoor water use.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

16. Meter data provided through the Secondary Water Use Reports has enabled my household to monitor its progress toward achieving our water conservation goals.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

17. Secondary Water Use Reports were useful in motivating my household to adjust our landscape watering practices over the course of the irrigation season.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

18. The Secondary Water Use Reports provided the information we needed to make decisions about how often and how much to water our landscape.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

19. The Secondary Water Use Reports helped my household realize that it is possible for us to conserve secondary water and still maintain a nice landscape.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

20. My household is willing to conserve water used outdoors in order to help Utah deal with long-term water supply issues related to the state's arid climate.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

21. My household is willing to conserve water used outdoors so that Utah will have adequate water for future population and economic growth.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

22. My household is willing to conserve water used outdoors to help ensure that enough water is left in rivers, aquifers and wetlands to maintain a healthy natural environment.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

23. My household is willing to conserve water used outdoors to help Utah adapt to future water supply uncertainties related to climate change.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

24. We can be good stewards of our water resources by only using as much water as we need.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree or disagree
- ☐ Disagree
- ☐ Strongly disagree

Comments: [comment box]

- ☐ Decline to answer

25. Please use this space to provide any other information or express additional opinions about secondary water use or the Secondary Water Use Reports that you wish to share.

[comment box]

May we contact you if necessary to clarify information you have provided?

- ☐ Yes
- ☐ No

If yes, please provide your preferred contact information:

Phone Number: [comment box]

Email Address: [comment box]

- ☐ Decline to answer

**You may review your answers to the survey prior to submitting it.
Once you are satisfied and are ready to submit, please click on the button below.**

Submit Survey

[Note: A thank you notice will appear indicating that their responses have been submitted.]

Thank you very much for your time, interest, and participation in this survey!

[Note: In the event that not all the required questions are answered, the following instructions will pop-up:]

The following questions were not answered. We want to be sure you did not miss seeing them. As you review these questions, note that “decline to answer” is one of the response options. Please complete answering these questions before submitting the survey.

SURVEY B – People who do not use water but received the reports

Note: This grey box will not appear on survey

USU RESEARCH SURVEY

This survey is being conducted with people who use secondary water at the meter location and who have received the Secondary Water Use Reports. These reports are designed to share meter data with people living at the locations where meters have been installed and to promote water conservation. Since you do not use the water at that location but have indicated you received the reports, we would appreciate your answering *five* brief questions that will aid us in conducting this survey. Please feel free to provide further explanations or clarifications in the comment boxes.

We would like to remind you that your participation in the research survey is voluntary, you are free to decline to answer individual survey questions, and your responses will be kept confidential. Utah State University is conducting this survey for Weber Basin Water Conservancy District. USU researchers will keep participants' responses to questions in the research survey anonymous and only information that cannot be identified with you will be shared with Weber Basin Water Conservancy District and presented in research reports.

1. Who uses the water at this location?

[comment box]

- ☐ Decline to answer

2. Who maintains the landscape at this location?

[comment box]

- ☐ Decline to answer

3. What did you do with the Secondary Water Use Reports and accompanying information that you received this summer? (please mark all that apply)

- ☐ Opened and reviewed the information
- ☐ Generally understood the information that was provided
- ☐ Kept the reports and accompanying information for future reference
- ☐ Forwarded the reports to the people living at the address listed on the report
- ☐ Discussed the reports with other members of my household
- ☐ Contacted Weber Basin Water Conservancy District to ask questions about or comment on the reports
- ☐ Contacted Utah State University to ask questions about or comment on the reports
- ☐ Got the reports out so I could refer to them while responding to this survey
- ☐ Other: [comment box]

- ☐ Decline to answer

4. What do you think about the quality of the information in the Secondary Water Use Reports?
[comment box]

☐ Decline to answer

5. Do you think that the Secondary Water Use Reports will be an effective water conservation tool?

- ☐ Yes
- ☐ No

Why or why not? [comment box]

☐ Decline to answer

May we contact you if necessary to clarify the information you have provided?

- ☐ Yes
- ☐ No

If yes, please provide your preferred contact information:

Phone Number: [comment box]

Email Address: [comment box]

☐ Decline to answer

**You may review your answers to the survey prior to submitting it.
Once you are satisfied and are ready to submit, please click on the button below.**

Submit Survey

[Note: A thank you notice will appear indicating that their responses have been submitted.]

Thank you very much for your time, interest, and participation in this survey!

[Note: In the event that all the required questions are not answered, the following instructions will pop-up:]

The following questions were not answered. We want to be sure you did not miss seeing them. As you review these questions, note that “decline to answer” is one of the response options. Please complete answering these questions before submitting the survey.

NO SURVEY GIVEN

Note: This grey box will not appear on survey

This survey was designed for people who: 1) use secondary water at the meter location; and, 2) have seen the Secondary Water Use Reports that provide and interpret the meter data. Since your responses indicate that you are not among this group of people, we have no further questions.

Thank you for your time!

Institutional Review Board

USU Assurance: FWA#00003308



Exemption #2



Certificate of Exemption

FROM:

Melanie Domenech Rodriguez, IRB Chair

True M. Rubal, IRB Administrator

To:

Joanna Endter, Diana Glenn

Date:

October 08, 2012

Protocol #:

4679

Title:

Water User Dimensions Of Meter Implementation - Survey

The Institutional Review Board has determined that the above-referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #2:

Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through the identifiers linked to the subjects: and (b) any disclosure of human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

This exemption is valid for three years from the date of this correspondence, after which the study will be closed. If the research will extend beyond three years, it is your responsibility as the Principal Investigator to notify the IRB before the study's expiration date and submit a new application to continue the research. Research activities that continue beyond the expiration date without new certification of exempt status will be in violation of those federal guidelines which permit the exempt status.

As part of the IRB's quality assurance procedures, this research may be randomly selected for

continuing review during the three year period of exemption. If so, you will receive a request for completion of a Protocol Status Report during the month of the anniversary date of this certification.

In all cases, it is your responsibility to notify the IRB prior to making any changes to the study by submitting an Amendment/Modification request. This will document whether or not the study still meets the requirements for exempt status under federal regulations.

Upon receipt of this memo, you may begin your research. If you have questions, please call the IRB office at (435) 797-1821 or email to irb@usu.edu.

The IRB wishes you success with your research.