Technical Memorandum

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Prepared for: Irvine Ranch Water District

Project Title: WaterDex Savings Analysis

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Technical Memorandum

Subject: WaterDex™ Remote Control Effectiveness Pilot Study

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1. Introduction

Irvine Ranch Water District (IRWD) recently initiated the WaterDex Remote Control Effectiveness Pilot Study (Pilot Study) to test the effectiveness for the WaterDex™ remote irrigation schedule adjustment device (WaterDex). This technical memorandum describes the results observed during the first year of the Pilot Study.

1.1 Background

IRWD provides water, reclaimed water, and sewer services to Southern Central Orange County communities including all of the City of Irvine; parts of the cities of Tustin, Costa Mesa, Newport Beach, Lake Forest, and Orange; and unincorporated portions of Orange County. The IRWD service area encompasses approximately 179 square miles and serves a population of over 300,000 customers. IRWD has historically been a leader in the region in implementing water conservation programs including implementing water budget-based tiered rate structures, pilot testing irrigation controllers, and educating customers about water conservation.

Residential customers comprise the largest sector of potable water use in IRWD's service area, with 81,689 accounts using approximately 26,130 acre-feet in 2010. This represents 34 percent of total system demand. Approximately 58 percent of single family residential annual demand goes to outdoor water use, which makes it a prime target for conservation. Historically, IRWD has achieved water savings by targeting outdoor residential demand with innovative water budget-based rate structures and pilot testing of new water conserving devices.

In the past, IRWD has performed pilot testing using weather-based irrigation controllers. However, customer feedback indicated that some controllers were too complicated to program and maintain. In addition, in some cases, the cost of the device and maintenance fees seemed prohibitive. As a result, although financial incentives are offered in a full-scale program, the rate of adoption is relatively low. It should be noted that these newer products are not always readily available at retail outlets, which presents another barrier to customer participation. In summary, the barriers arising from potential installation and programming challenges, relatively high cost and limited product availability have combined to result in low levels of implementation.

In 2009, IRWD discovered the WaterDex remote irrigation schedule adjustment device (Figure 1). The WaterDex is compatible with any existing controller, easier to install and less expensive, and therefore removes several of the barriers associated with weather-based controllers. IRWD subsequently decided to conduct a pilot study to evaluate the effectiveness of the WaterDex.

1.2 Description of Device

WaterDex devices are manufactured by Rockrose Technology of Irvine, California. A WaterDex device conserves water used for irrigation by adjusting irrigation runtimes up or down based on evapotranspiration (ET) indices. The homeowner can manually adjust the WaterDex remote on a daily, weekly, or monthly basis. The WaterDex device remotely adjusts the irrigation schedule on a controller, and therefore can be located anywhere that is convenient for the customer: in the kitchen, near the computer, or next to the couch. The accessibility makes adjusting the irrigation schedule much easier for the homeowner. The ET indices used to guide the adjustments are available via email, the IRWD web site, the Rockrose

Figure 1. WaterDex Remote Control

Source: [*http://www.waterdex.com*](http://www.waterdex.com)

Technology WaterDex web site, or by using IRWD's monthly Recommended Irrigation Calendar. Making weather-based decisions is more efficient for water run time and can therefore reduce water demand. This Pilot Study will be the first documented field test of the WaterDex device. More information on the WaterDex can be found online at: www.waterdex.com.

1.3 Goals and Objectives

The goal for the Pilot Study is to determine if the WaterDex device provides enough water savings to justify additional staff support and funding needed to implement and expanded program, such as providing customer incentives. To achieve this goal, the Pilot Study must meet the following two objectives:

- Determine whether study participants were able to use the device effectively and that the participants were satisfied with the devices performance, given minimal support from IRWD staff and the manufacturer.
- Water savings attributable to the device were observed based on a review of participant's water usage data using their neighbor's water demand over the same time periods before and during the study, as a benchmark for comparison.

IRWD retained the services of Brown and Caldwell (BC) to develop the initial Pilot Study design and to perform the data analyses. BC was supported by BW Research Partnership, who conducted a customer survey, and Maddaus Water Management, who provided technical guidance, review, and assistance with the documentation.

2. Approach

BC completed the *WaterDex Remote Control Effectiveness Pilot Study Design Report* (Design Report) in March 2010 to provide IRWD staff with guidance on implementing of the Pilot Study (BC 2010). IRWD began by seeking study participants within a pre-defined group of IRWD customers. However, the response was not sufficient to meet the participation requirements of the initial design testing method. Therefore, the study design had to be revised to accommodate a larger group. The following sections briefly describe the initial and revised designs. For more information regarding the original design, refer to the Design Report (BC 2010).

2.1 Initial Pilot Study Design

As presented in the Design Report, the primary goal of the Pilot Study is to quantify outdoor water savings potential for IRWD residential customers at a statistically significant level. The initial concept for the Pilot Study called for the installation of 100 WaterDex devices within a "village," or selected representative group of IRWD customers. IRWD would then monitor the water use of the participants and the "village" over a 12-month period. According to the Design Report, the village used for the Pilot Study should have the following characteristics:

1. A population less than 1,000 accounts where the achievable confidence interval would be independent of sample size; assuming that 100 WaterDex devices are available for installation (thus achieving a 10 percent sample size relative to the control group).
2. Located within the Central climate zone[1], which is the most prevalent climate zone in the IRWD service area.

[1] IRWD maintains a weather station in three different microclimates (Coastal, Central, and Foothill) within their service area to monitor exact wind and weather conditions, including air temperatures, relative humidity, precipitation, solar radiation, and wind direction and speed.

After reviewing data on various villages within the service area, IRWD staff recommended that a village known as The Colony be selected for the Pilot Study. The Colony has 931 single family residential customers and is located in the Central climate zone.

2.2 Revised Design

IRWD sent letters to selected customers in The Colony and received responses from 52 customers who agreed to participate in the study. This was much less than the goal of installing 100 devices. Therefore, IRWD decided to also offer the device to the College Park, which is a similar village of 1018 residential customers located immediately adjacent to The Colony. Aerial photography using Google Earth suggests that landscaping within both The Colony and College park are dominated by turf grass (see Figure 2).

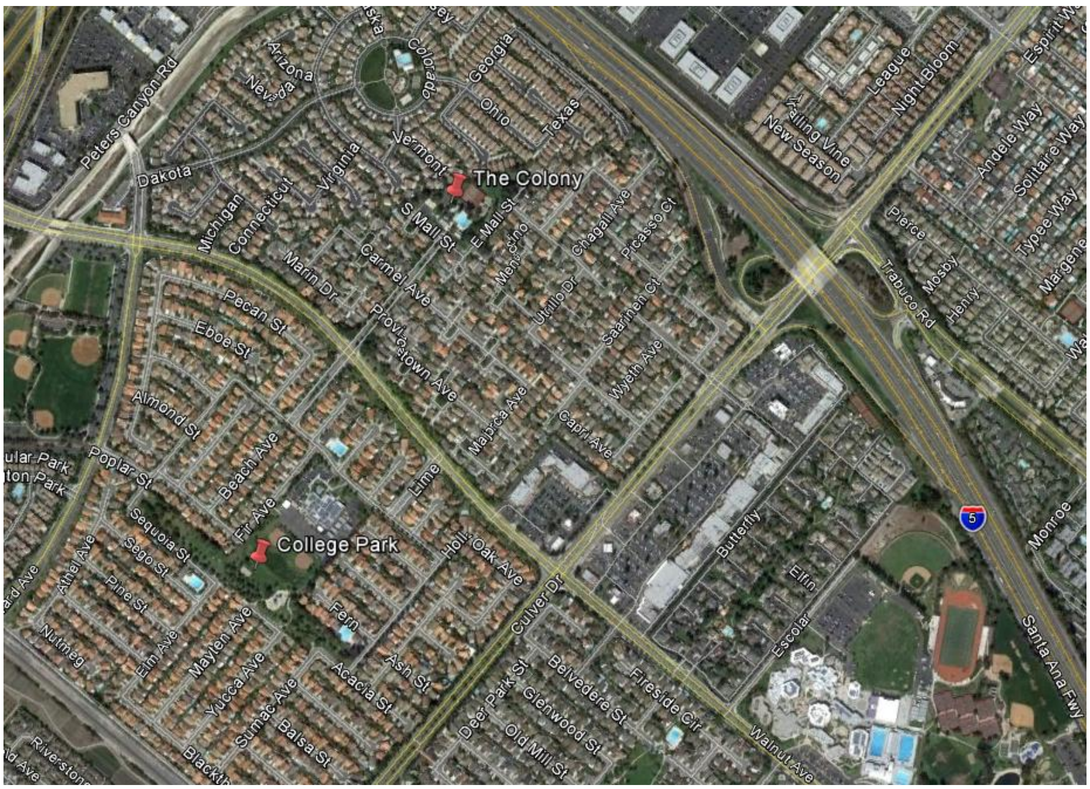

Figure 2. Aerial View of the College Park and The Colony Villages

Furthermore, The Colony and College Park have the following similarities:

- lot sizes;
- age of homes (plumbing fixtures);
- household size;
- type of landscaping (mainly turf with limited number of trees);
- demographics of the residents (e.g., income);
- recent changes in IRWD's water budget based rate structure; and
- water demands (see Section 6.5).

IRWD recognized that, by adding College Park to the study group, the population size of the control group would expand to a combined total of 1949 customers, thereby lowering the potential statistical significance of the study findings. By August 4, 2010 a total of 98 customers had volunteered to participate in the study, a response rate of about 5 percent. During the course of the first year of the study, three participants dropped out and returned their WaterDex devices. This left 95 full participants in the first year; 52 in The Colony and 43 in College Park.

3. Analyses

Analyses were performed to examine the outdoor water savings observed among IRWD residential customers during the WaterDex trial period, and if possible, to quantify those savings with statistical significance. The following sections describe the data collection and analyses.

3.1 Data Collection

Two primary data sources were available for analysis:

1. Information gathered from a customer feedback survey; and
2. Detailed billing records and data for individual customer accounts within the two villages.

3.1.1 Participant Feedback Survey

The overall goal of the post study feedback survey for the WaterDex device was to ascertain both opinions and information from the study participants including:

- Why customers signed up for the study?
- Willingness to pay for the device and how much?
- How often did customers use the device; daily, weekly, monthly or seasonally?
- Were customers overall satisfied with the device?
- Did the participant's unique circumstances lead to unusual data usage patterns (e.g., businesses in the home [daycare], known yet unrepaired leakage, absence from the home for significant periods, etc.)?

Of the 95 participants that completed the WaterDex pilot study, a total of 51 responded to the feedback survey, which included both web-based and telephone survey instruments. A total of 37 questions were asked of the survey participants. Detailed questions and topline analysis of responses are provided in Attachment B. Some general observations from the feedback survey include:

- Approximately 63 percent of responders were “satisfied” or “very satisfied” with the performance of the device.
- Only one responder (approximately 2 percent) used the device to adjust their irrigation schedule on a daily basis.
- Approximately 47 percent of responders used the device to adjust their irrigation schedules on a weekly basis.
- Approximately 16 percent of the responders used the device to adjust their irrigation schedules on a monthly basis.
- Approximately 20 percent of the responders used the device to adjust their irrigation schedules on a seasonal basis.
- Approximately 14 percent of the responders had never adjusted the device.
- The majority of customers, which were self-selected volunteers for the study, stated that they chose to participate due to a desire to be more water efficient. The second most common reason given was due to concerns with high water bills.
- Only two of the customers had home businesses that impacted water demand patterns.

- A vast majority of customers used spray irrigation on shrubs (leading to an interesting opportunity for a future education and/or incentive program for drip irrigation conversions).
- A few customers had leaks and one had a leak that was unrepaired for more than six months.
- Some customers were dissatisfied with the amount of information and support provided to them, and this is likely due to IRWD requesting that WaterDex provide very limited support to the participants to avoid extending assistance given to the extent that they could influence the outcomes beyond would what would be expected as real world results in the future. In other words, IRWD requested that WaterDex not make any field visits or provide other detailed information beyond “basic assistance.”
- Of those customers who might be willing to pay for the device if given the option to purchase, the majority of customers would pay less than $100. Responses were fairly evenly spread across amounts of $75, $50, $25, and $10.

Overall, the customer feedback indicated that the majority of the study respondents were satisfied and that they regularly used the WaterDex device to adjust their irrigation schedules.

3.1.2 Billing and Account Data

IRWD staff performed a detailed query of their billing system and provided other supplemental information as needed for this analysis. IRWD provided the following information:

- Detailed information from each participant’s pre-survey application and documentation on when the device was installed.
- Historical monthly water billing data for each customer within The Colony and College Park dating from January 1996 through November 2011.
- Changes in homeownership during the study period (to check participants moving and new residents or foreclosures).
- Information on water budget changes over time to better understand water demand trends.
- Variances to the water budget-based rates.
- Details on rebates issued by account, including when and what type of incentive was received.
- Weather ET data for the nearest station applicable to the villages’ location.
- Drought restrictions were not in place during the 2009-2011 drought, but were being discussed locally in media announcements by other local water districts.

Each IRWD customer has a unique account sequence number (ASN), which was the primary identifier for relating data sets.

3.2 Graphical Analysis

As an initial step, a graphical analysis was performed to visually compare water usage trends between the test group (WaterDex users) and the control group (non-WaterDex customers). Observations from the graphical analysis were used to refine the data and choose appropriate methods for the statistical analysis (Section 3.3).

Raw billing data provided by IRWD consisted of water usage (in units of hundreds-cubic feet, or CCF) and the corresponding days of service for nearly 16 years of monthly billing cycles (January 1996 through November 2011). The water usage was converted to gallons and divided by the days of service to obtain the per-account water usage rates in units of gallons per day per account (gpd/account). The following assumptions were made:

- All negative monthly water usage values were removed (zero values were retained).

- All monthly water usage values associated with negative or zero values for the corresponding days of service were removed.
- Monthly water usage values that exceeded 8,000 gpd/account were considered practical outliers and were removed from the analysis.

Scatter Plot. The monthly values were then averaged over the entire record (January 1996 through November 2011) for each account. The results were used to create a scatter plot showing the average water usage for all 1,949 customers in The Colony and College Park including the 95 WaterDex users (Figure 3).

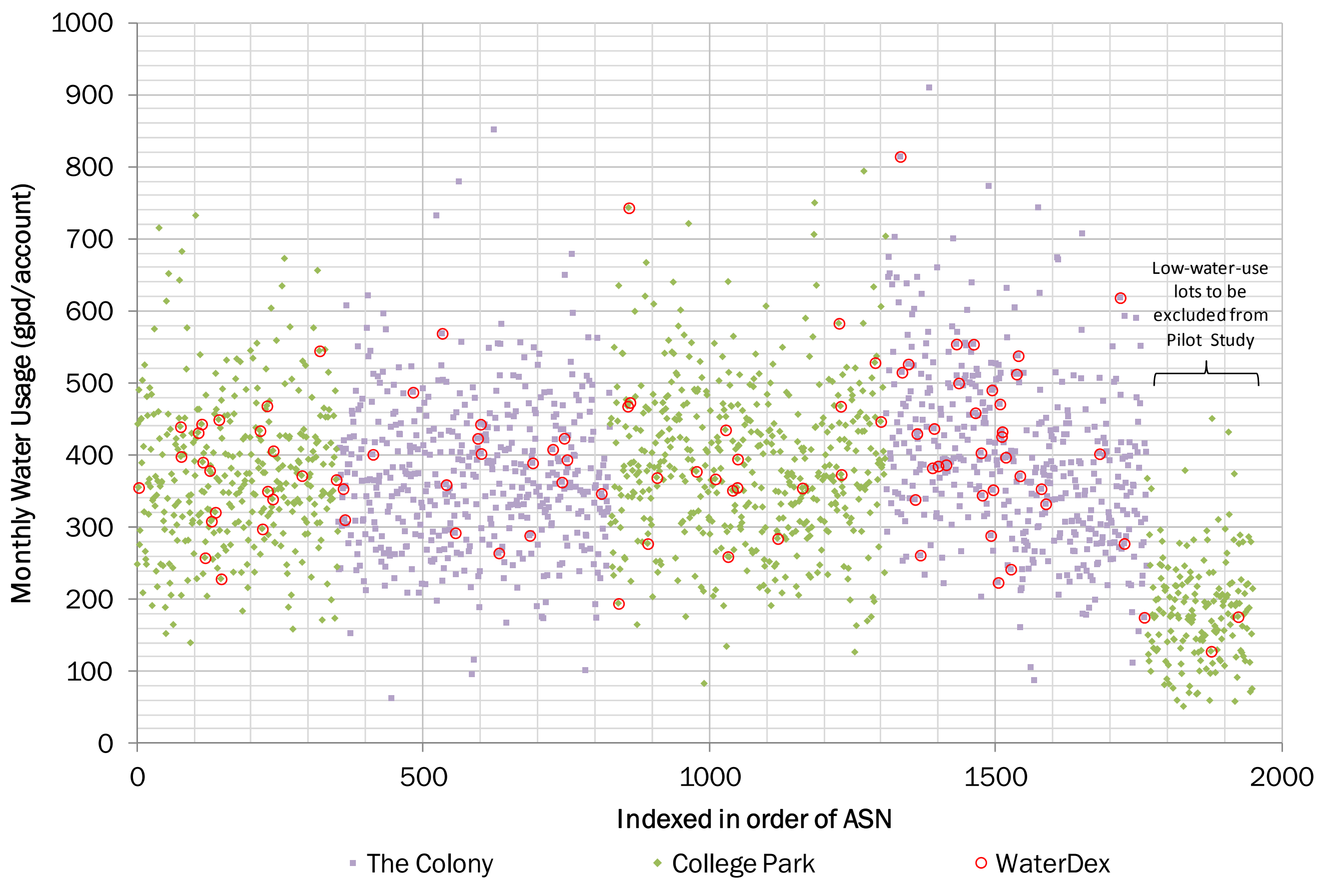

Figure 3. Average Water Usage for The Colony and College Park Customers (January 1996 through November 2011)

Figure 3 illustrates that a segment of the College Park community had significantly lower water usage. IRWD found that these homes are much newer (approximately 1992 housing stock), are zero-lot lined homes with minimal landscaping, and have common areas associated with them surrounding the homes which are irrigated with reclaimed water. These homes corresponded with ASN numbers greater than 100000; data from these account were omitted from all further analyses. This reduced the total number of customers to 1,764, and the number of WaterDex users was reduced to 93.

Monthly Usage Trends. Monthly water usage was averaged for all WaterDex accounts and all non-WaterDex accounts. Similarly, average monthly water usage time series were calculated for:

- All accounts (The Colony and College Park, WaterDex and non-WaterDex)
- The Colony WaterDex accounts
- The Colony non-WaterDex accounts

- College Park WaterDex accounts
- College Park non-WaterDex accounts.

Comparisons of the average monthly usage for each of the above groups are shown in Figures 4 though 7, along with a 12-month moving average for each time series.

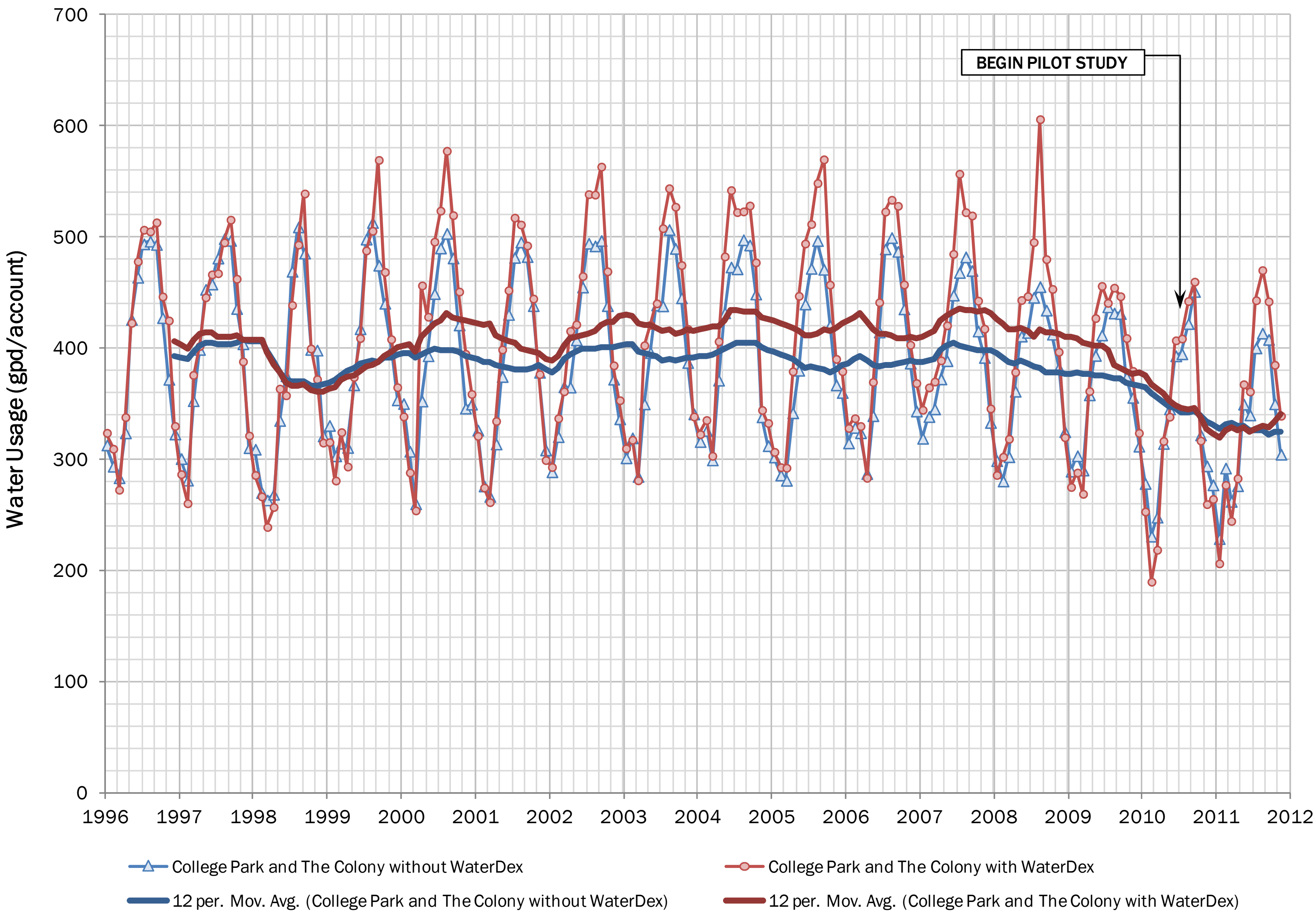

Figure 4. Monthly Water Usage and 12-month Moving Average for WaterDex and Non-WaterDex Customers

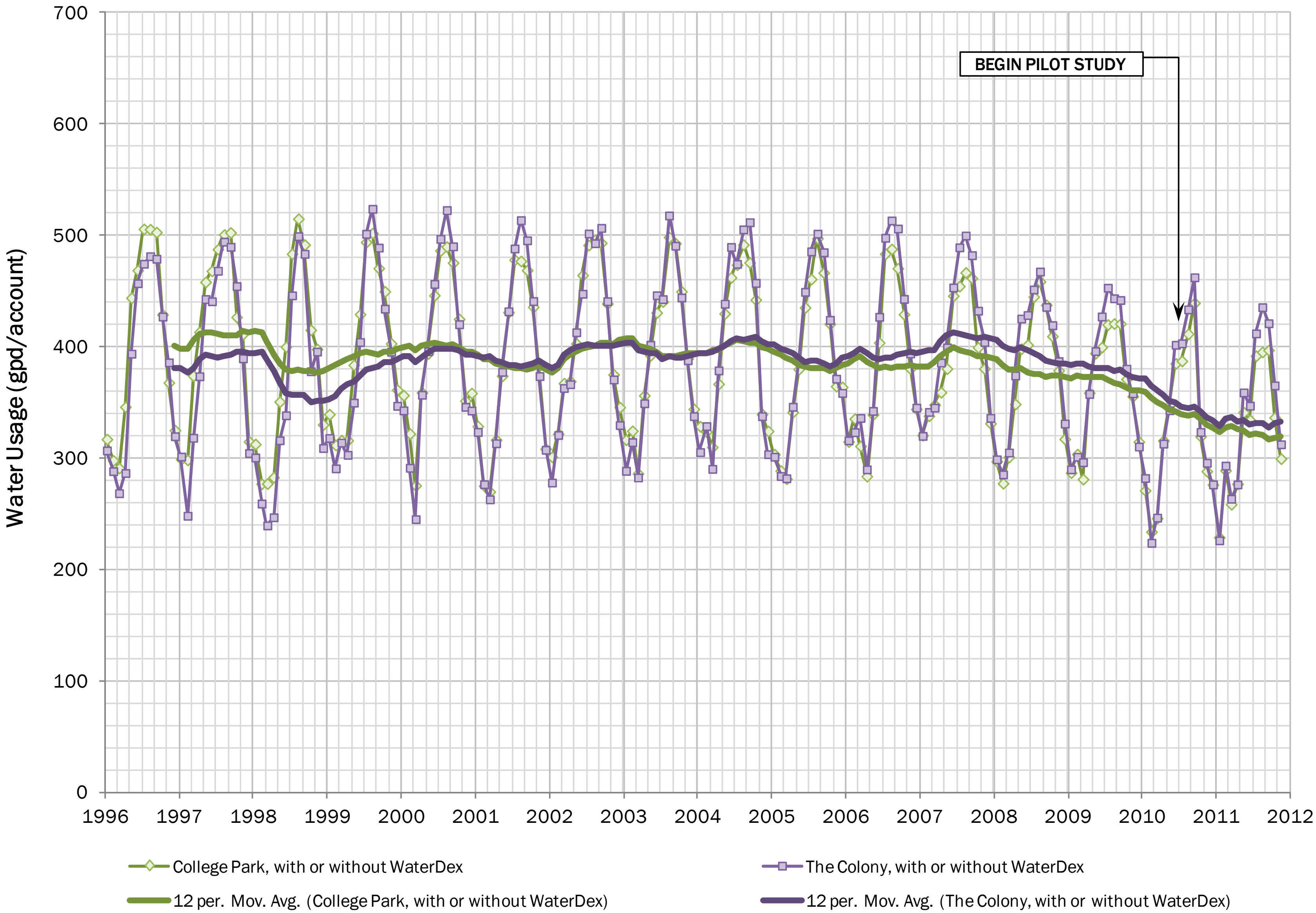

Figure 5. Monthly Water Usage and 12-month Moving Average for The Colony and College Park Customers

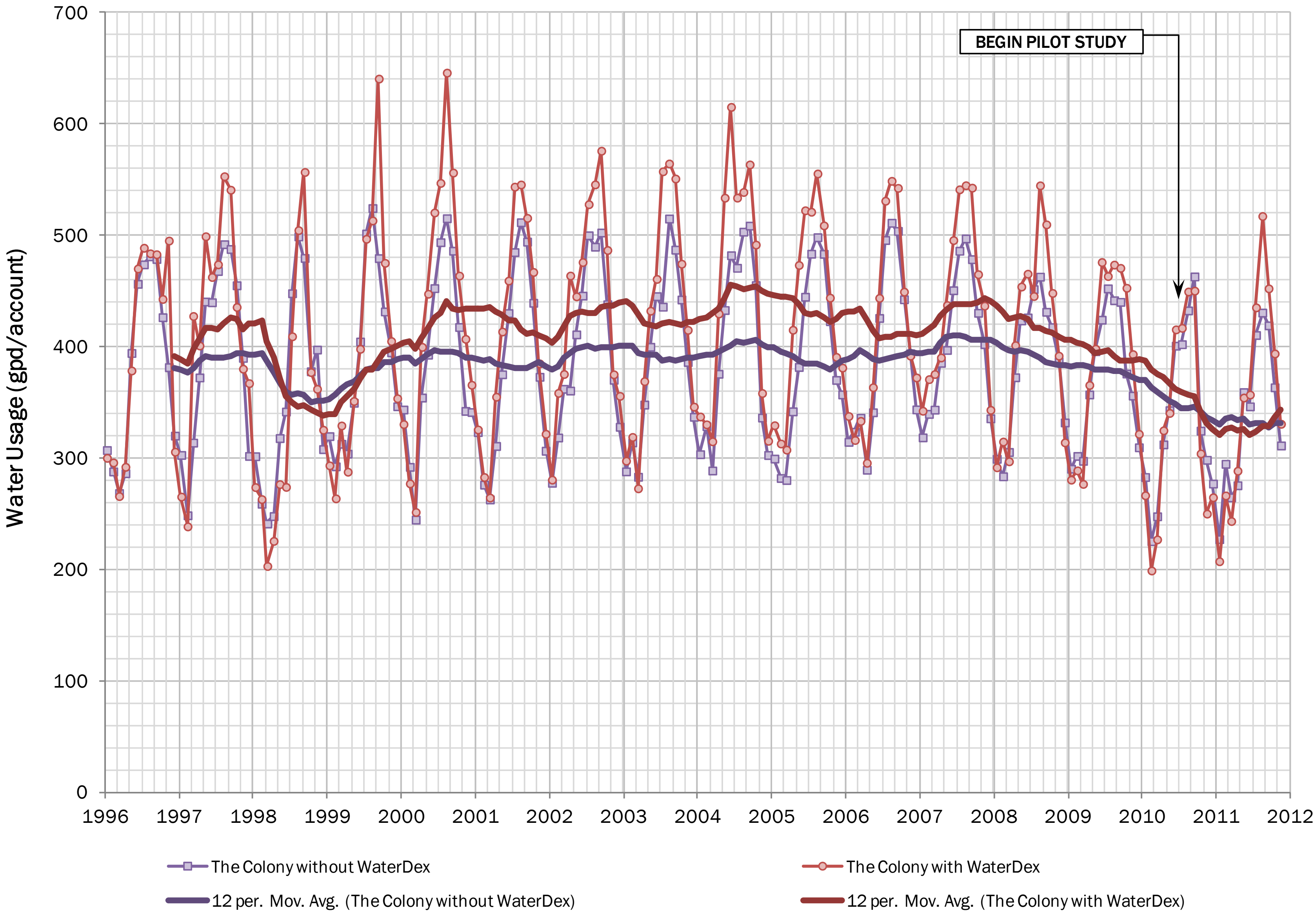

Figure 6. Monthly Water Usage and 12-month Moving Average for WaterDex and Non-WaterDex Customers in The Colony

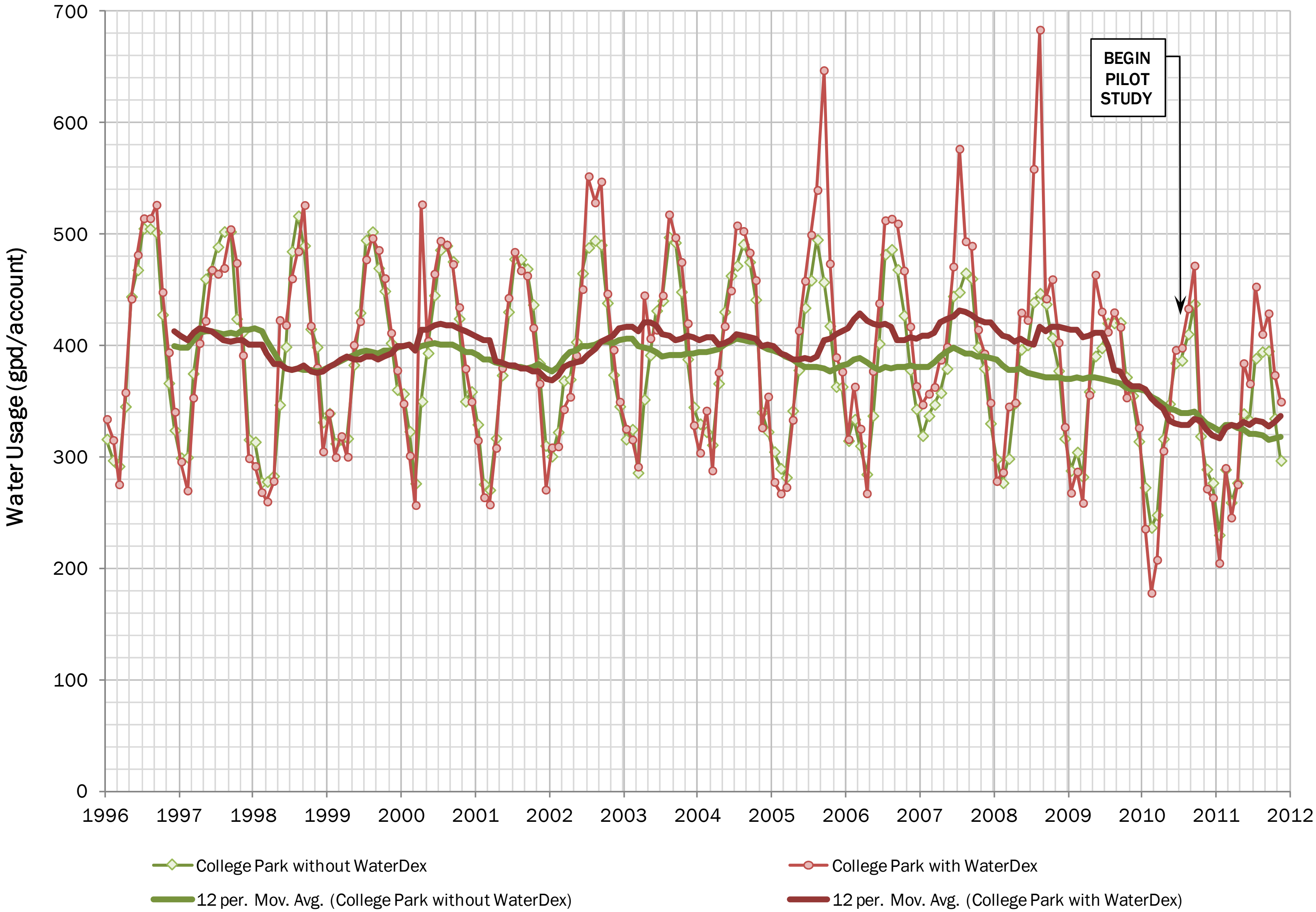

Figure 7. Monthly Water Usage and 12-month Moving Average for WaterDex and Non-WaterDex Customers in College Park

The following observations were made from Figures 4 through 7 (above):

- WaterDex users used more water than non-WaterDex users prior to the Pilot Study, likely due to what is know as a volunteer bias, or a self-selection bias (see Section 4.1).
- Water demand was fairly stable between 2002 and 2009 for both WaterDex and non-WaterDex users.
- Both WaterDex and non-WaterDex users had a decline following the deepening recession and the water rate adjustment that occurred in 2009 (see Section 4.1).
- The WaterDex users decline was more pronounced than the non-WaterDex users in both communities, even though both groups experienced the similar external conditions such as weather, economy, and rate changes.
- The Colony and College Park customers exhibit similar water usage patterns.

Based on these observations, it was decided to perform a statistical analysis to evaluate changes in water use for both WaterDex and non-WaterDex users and to quantify the observed savings.

3.3 Statistical Analysis

Water usage for both The Colony and College Park communities were similar. Therefore, the statistical analyses worked with the combined populations, making no differentiation between the two. Monthly water usage for the test group (WaterDex users) and the control group (non-WaterDex users) was divided into two periods:

- **Pre-installation:** from January 2002 to March 2010, ending just before IRWD began distributing WaterDex devices.
- **Post-installation:** from August 2010 to November 2011, beginning just after the last WaterDex device was distributed.

Statistical analyses would focus on the differences in water usage before and after installation. It is evident from the graphs presented in the previous section that the WaterDex customers had higher water usage than the non-WaterDex customers. This is likely due to a volunteer, or self-selection bias; in other words, the customers who volunteered to take part in the Pilot Study may have done so because they are concerned with reducing their already above-average water usage. However, it should be noted that his type of self-selection would be atypical; volunteers for adopting new technologies are often highly water conscious customers. Nevertheless, the evident bias precludes the use of some statistical methods because the WaterDex customers are not an unbiased random sample of the full group of customers. Alternatively, the pre- and post-installation water usage data was analyzed as two independent groups.

Data Distribution and Practical Outliers. Average water usage over the duration of the pre- and the post-installation periods was calculated for each of the accounts in the WaterDex and non-WaterDex groups. The distribution of the data was examined using histograms as shown in Figures 8 and 9.

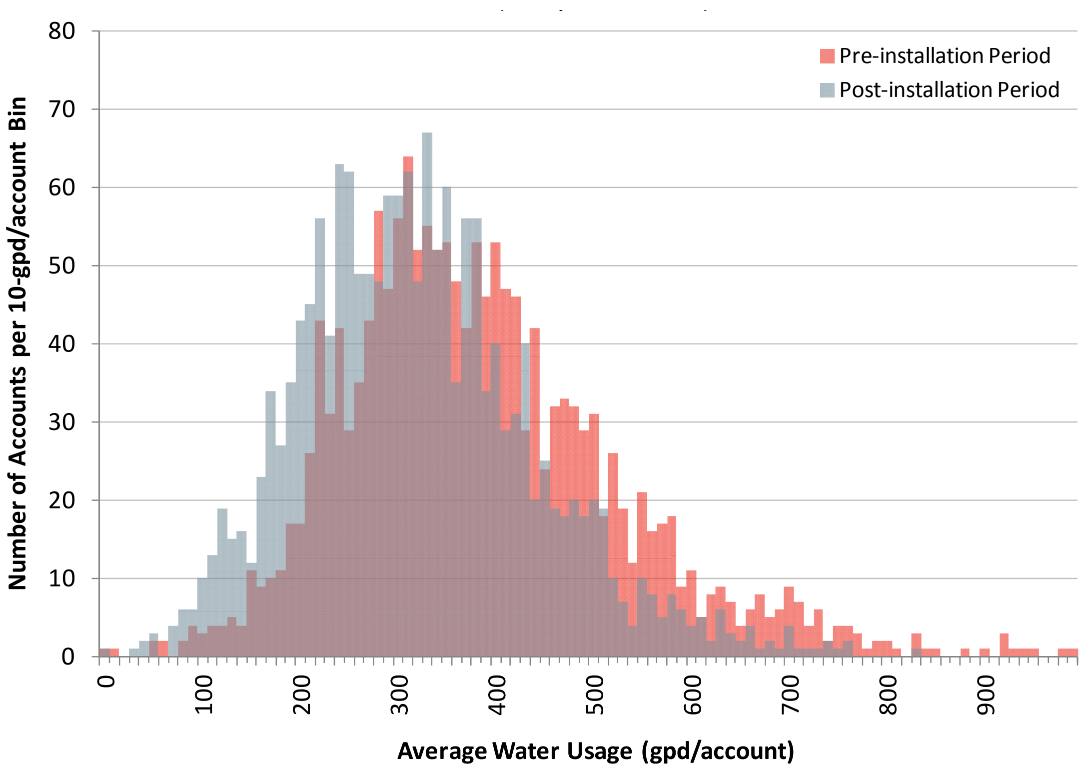

Figure 8. Distribution of Pre- and Post-installation Non-WaterDex Accounts (1,671 total accounts)

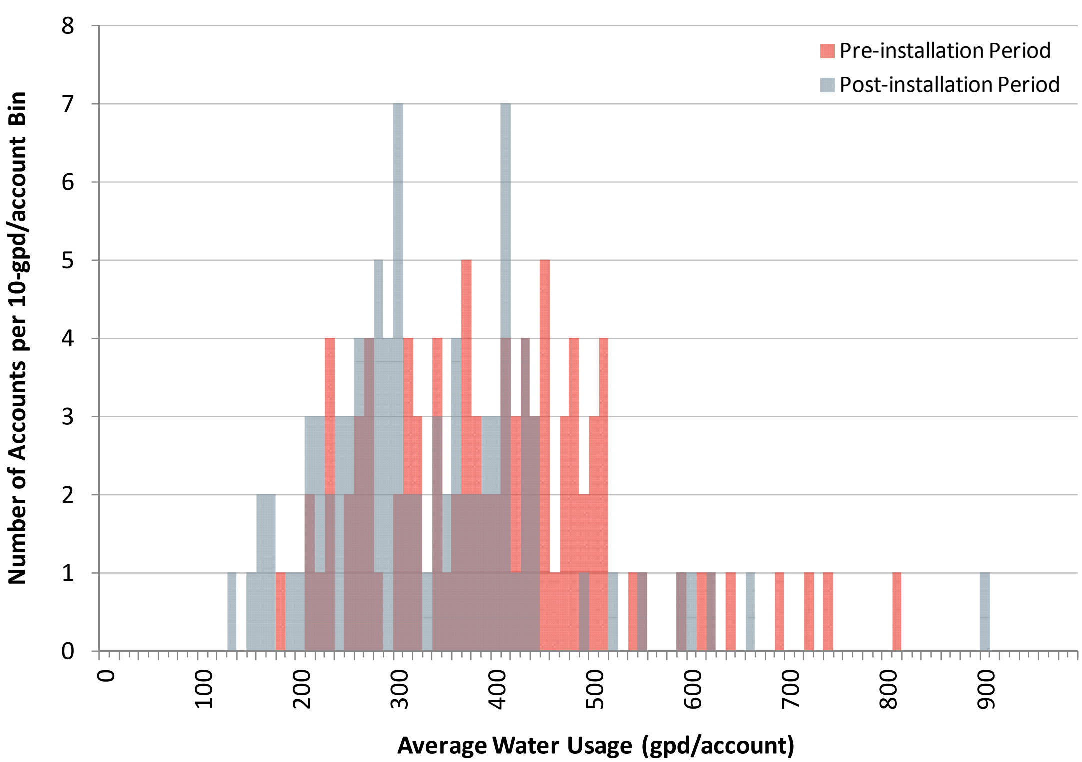

Figure 9. Distribution of Pre- and Post-installation WaterDex Accounts (93 total accounts)

Figures 8 and 9 show that the data is slightly skewed, with a prominent right tail. This is not uncommon for water usage data where the majority of customers have below-average water demands. However, some of the average water usage values seemed unusually high or low and were likely the result of atypical circumstances. Therefore, accounts less than 50 gpd/account and above 800 gpd/account were removed as practical outliers. Table 1 summarizes the number of outliers removed from each group.

Table 1. Practical Outliers Summary

Group	Non-WaterDex Customers		WaterDex Customers	
	Number used to Test for Normality	Practical Outliers Removed	Number used to Test for Normality	Practical Outliers Removed
Pre-installation	1644	27	91	2
Post-installation	1666	5	92	1

After the practical outliers were removed box-whisker plots of the distributions were created to provide a side-by-side comparison of all four groups (Figure 10).

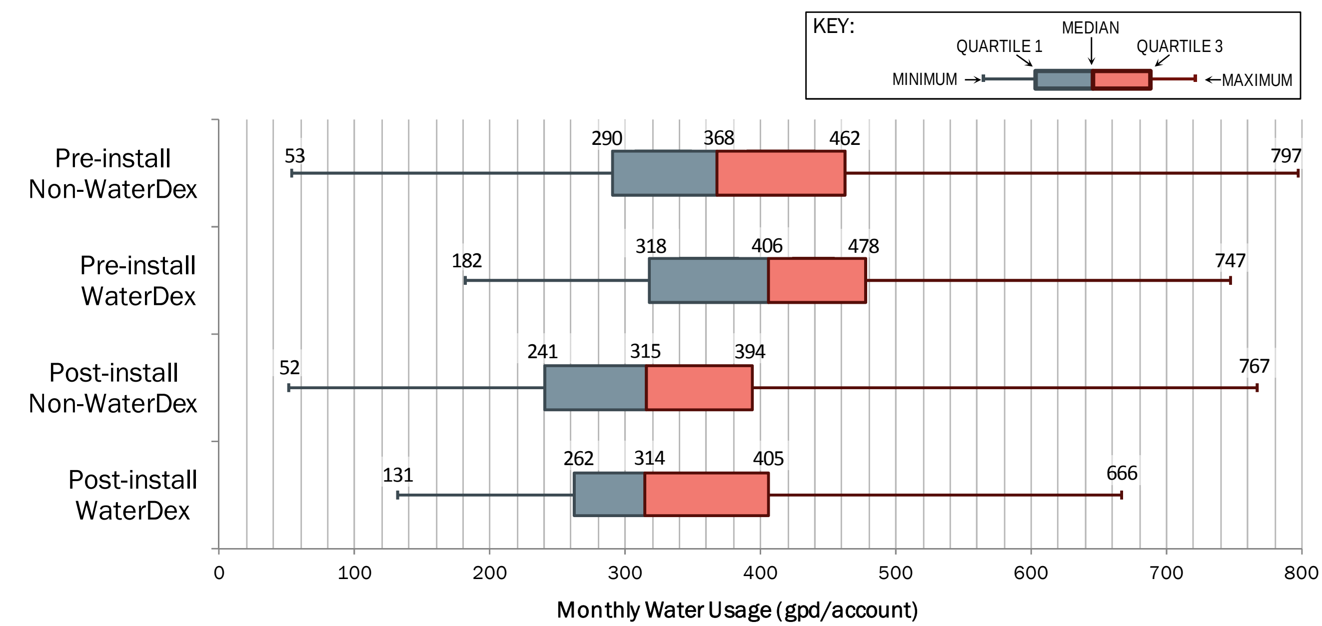

Figure 10. Box-whisker Plots of Pre and Post WaterDex and Non-WaterDex Customer Water Usage (outliers removed)

Test for Normality. The preferred method for comparing data would be to use a common parametric method such as the student's *t*-test. However, a key assumption of the student's *t*-test is that the data are normally distributed. The data were tested for normality using the Lilliefors goodness-of-fit test within a statistical software package called ProUCL[2]. Results from the normality testing are shown in Figures 11 and 12.

[2] ProUCL is a software package developed and distributed by the U.S. Environmental Protection Agency (EPA) for use in statistical analyses of environmental data. More information is available at: http://www.epa.gov/esd/tsc/software.htm.

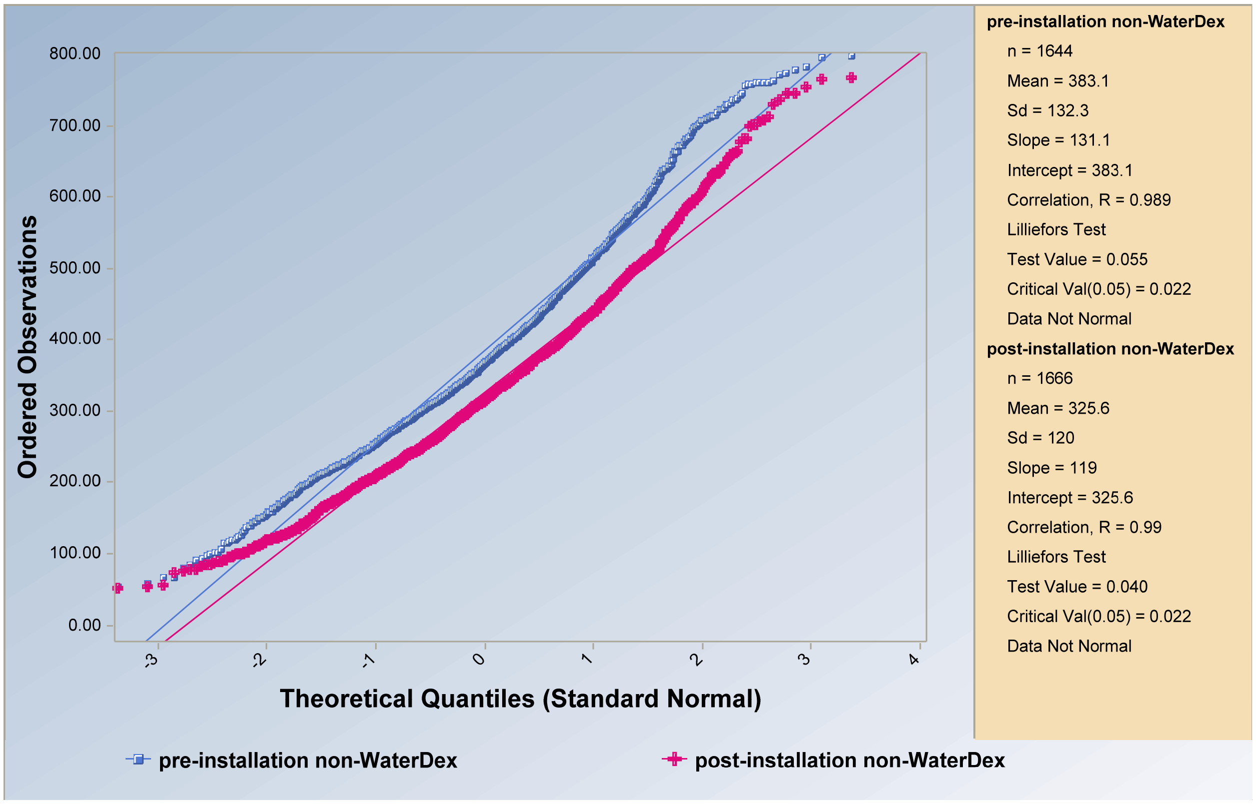

Figure 11. ProUCL Output Graph Showing Normal Q-Q plots for the Non-WaterDex Data Populations

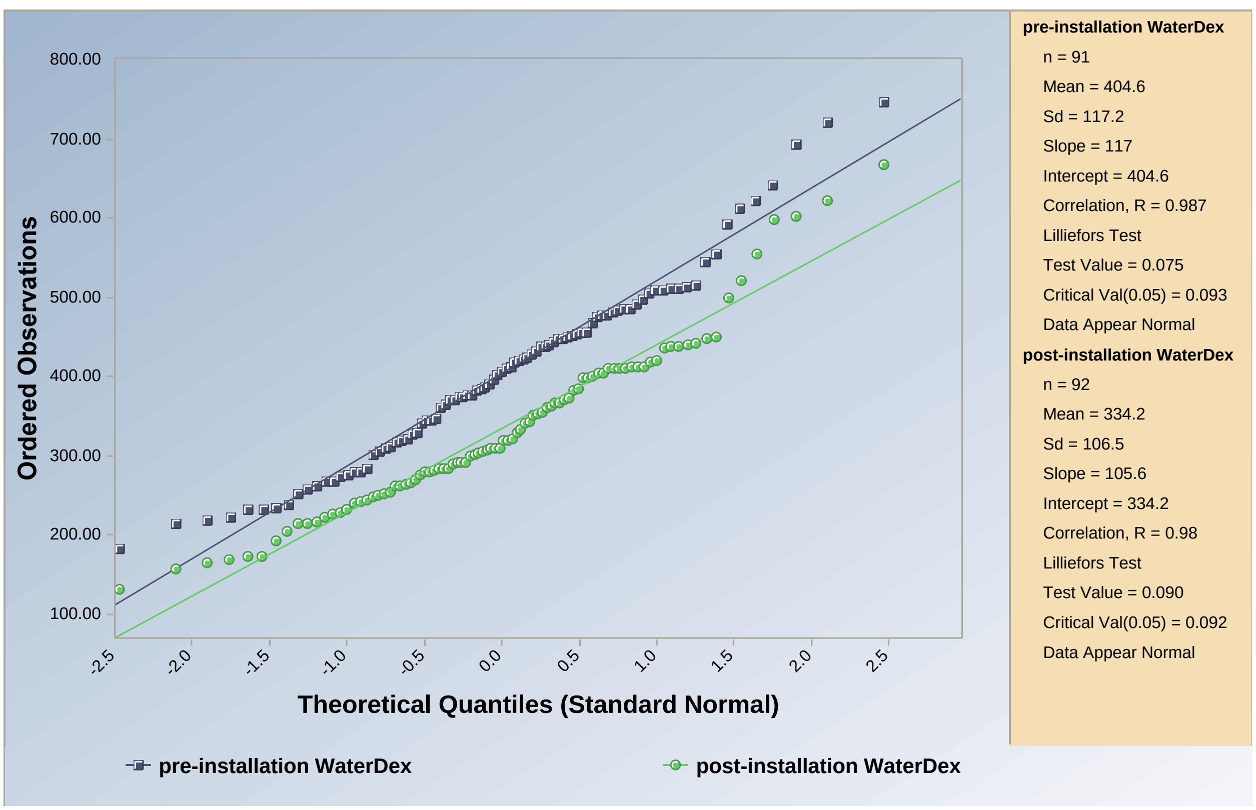

Figure 12. ProUCL Output Graph Showing Normal Q-Q Plots for the WaterDex Data Populations

As shown in Figure 11, the non-WaterDex data populations failed the test for normality at 95 percent confidence. This result suggests that a nonparametric method[3] would be a more appropriate approach to comparing the data.

Statistical Comparison of Two Groups. The graphical analysis described previously suggested that the selected WaterDex customers started out as higher users before receiving the WaterDex devices, but then closed the "gap" after installation. The purpose of this analysis is to quantify the differences (i.e., the "gap") between WaterDex user group and non-WaterDex user group before and after installation of the devices. Assuming both of the groups experienced similar external factors (more discussion in Section 4), the change in differences represents the savings produced by the use of the WaterDex devices.

BC used ProUCL to perform statistical comparisons between the WaterDex and non-WaterDex customers. ProUCL provides several methods for comparing two independent groups including the Wilcoxon-Mann-Whitney method, also known as the Wilcoxon, or sign-rank test. The Wilcoxon-Mann-Whitney test is a nonparametric statistical hypothesis test used to assess whether one of two independent groups tends to have higher values than the other (Helsel and Hirsch, 2002).

Using ProUCL's standard terminology, the WaterDex customers were designated as "site" and Non-WaterDex customers were designated as "background." The terms are nothing more than labels and do not imply anything other than a direct comparison of the two datasets. In its simplest form, hypothesis test is set up to determine if the "site" values are greater than the "background" values at a specified level of significance. The hypothesis test can be modified with the addition of a substantial difference[4] value. The substantial difference is essentially added to the background values such that the test is then used to determine if the "site" values are greater than the "background" values plus the specified substantial difference.

BC analyzed the water usage data by performing statistical comparisons of independent groups as follows:

- Compare the pre-installation water usage rates for the non-WaterDex users with the pre-installation water usage rates for the WaterDex users and estimate the substantial difference between the two groups.
- Compare the post-installation water usage rates for the non-WaterDex users with the post-installation water usage rates for the WaterDex users and estimate the substantial difference between the two groups.

BC's established null hypothesis asserts that the mean/median water usage rate for the WaterDex users is greater than or equal to the mean/median water usage rate for the non-WaterDex users plus an estimated substantial difference. If the test fails to reject the null hypothesis (i.e., accepted) then the water usage rate for the WaterDex users is confirmed to be higher than the water usage rate for the non-WaterDex users plus the substantial difference at the specified level of significance (e.g., 95 percent confidence). If the null hypothesis is rejected, then the substantial difference value was too large.

BC ran a series of hypothesis tests incrementally increasing the substantial difference value until the null hypothesis was rejected. The highest substantial difference tested without rejecting the null hypothesis became result. Table 2 provides the estimated substantial difference values based on a range of confidence intervals.

[3] Nonparametric methods do no require knowledge of the underlying distribution of the data (Helsel and Hirsch, 2002).
[4] The substantial difference, $\boldsymbol{S}$, is the estimated difference in mean/median between two populations and an estimator for the true difference, $\boldsymbol{\Delta}$.

Table 2. Results from Wilcoxon Statistical Analysis

	Pre-install		Post-install		Pre minus Post Percentages
	Substantial Difference (gpd/account)	Percent of Pre-install non-WaterDex median	Substantial Difference (gpd/account)	Percent of Post-install non-WaterDex median	
Direct Difference in Population Medians	38.0	10.3%	-1.2	-0.4%	10.7%
Substantial Difference 99.9% Confidence	67.3	18.3%	46.4	14.7%	3.6%
Substantial Difference 99% Confidence	57.0	15.5%	37.2	11.8%	3.7%
Substantial Difference 95% Confidence	47.8	13.0%	29.2	9.3%	3.7%
Substantial Difference 90% Confidence	42.8	11.6%	24.9	7.9%	3.7%

The estimated substantial differences in Table 3 represents the upper confidence interval, which is why the higher confidence levels the greater the substantial difference.

- **Pre-installation:** WaterDex customers use more than non-WaterDex customers plus a substantial difference of 47.8 with 95% confidence (alpha=0.05). Dividing the estimated substantial difference by the median pre-installation non-WaterDex customer usage results in a difference percentage of approximately 13 percent.
- **Post-installation:** WaterDex customers use more than non-WaterDex customers plus a substantial difference of 29.2 with 95% confidence (alpha=0.05). Dividing the estimated substantial difference by the median post-installation non-WaterDex customer usage results in a difference percentage of approximately 9.3 percent.

Comparing the results between the pre-installation and post-installation periods, we can infer at a 95% confidence level that the WaterDex devices have saved an additional 3.7% beyond other underlying conservation factors.

Average Water Usage Pre- and Post-Installation. BC also examined the differences in pre- and post-installation values to estimate the decreases observed during the Pilot Study. Table 3 summarizes the results for both WaterDex and non-WaterDex users using both mean and median as the measure of central tendency.

Table 3. Summary of Net Differences in Pre and Post-Installation Water Usage

Measure of Central Tendency	Group	Pre-install Water Usage (gpd/account)	Post-install Water Usage (gpd/account)	Difference in Water Usage (gpd/account)	Percent Decrease from Pre-installation to Post-installation
Mean	WaterDex	404.6	334.2	70.4	17%
	Non-WaterDex	383.1	325.6	57.6	15%
			Net Difference:	12.8	3.3%[a]
Median	WaterDex	405.7	314.1	91.6	23%
	Non-WaterDex	367.7	315.3	52.4	14%
			Net Difference:	39.2	11%[a]

a. Calculated as a percentage of pre-installation non-WaterDex water usage.

Looking at the mean water usage during the pre- and post-installation periods, the WaterDex users decreased approximately 70 gpd/account, or 17 percent. The non-WaterDex users decreased approximately 58 gpd/account, or 15 percent. The net difference, or difference in the decreases, is approximately 13 gpd/account, which equates to 3.3 percent of the pre-installation non-WaterDex usage. Similar calculations using the medians results in a net difference of 39 gpd/account, or 11 percent of the pre-installation non-WaterDex usage.

The 3.7 percent difference estimated through hypothesis testing is smaller than 11 percent net difference based solely on the medians. This is because the former result accounts for the full data sets rather than just looking at the median value. Although the Wilcoxon-Mann-Whitney hypothesis testing is a non-parametric method, it does account for the spread of the data using the ranks of the values. The spread of the data, which is shown in Figures 8 and 9 to exhibit substantial overlap, reduces the differences that can be confirmed by statistical methods at a specified confidence interval.

4. Discussion

This section discusses the results of data analyses. Section 4.1 describes factors influencing water demands prior to and during Pilot Study period. Section 4.2 provides a summary of findings.

4.1 Factors Influencing Water Demands

There are a number of factors influencing customer awareness and water demand patterns near or during this study's timeframe, including:

- **Summer 2006 to Spring 2011:** dry years with drought and regulatory cutbacks on supplies to Southern California along with regional drought messaging, though not for IRWD customers specifically
- **October 2008 to November 2011:** economic recession
- **July 2009:** adjustments to water budget-based rate structure, resulting in reduced customer allocations
- **April 2010 to August 2010:** distribution and installation of WaterDex devices
- **November 2011:** end of post-installation period for Pilot Study

Water Rates. A key motivator to participate in the WaterDex study was likely the change in IRWD billing rate structure in the year prior to the beginning of the Pilot Study. Background on the history of IRWD's water budget rate structure is provided in Attachment C. Table 4 provides the changes in rates since the 2000/2001 fiscal year.

Table 4. Historical IRWD Rates for Potable Water, Residential Customers

Tier	Use as Percentage of Allocation	Water Usage Rates ($/CCF)											
		Fiscal Year 11/12	Fiscal Year 10/11	Fiscal Year 09/10	Fiscal Year 08/09	Fiscal Year 07/08	Fiscal Year 06/07	Fiscal Year 05/06	Fiscal Year 04/05	Fiscal Year 03/04	Fiscal Year 02/03	Fiscal Year 01/02	Fiscal Year 00/01
Low Volume	0-40%	0.91	0.91	0.91	0.91	0.82	0.75	0.72	0.67	0.59	0.53	0.48	0.48
Base Rate	41-100%	1.22	1.21	1.15	1.07	0.98	0.91	0.88	0.83	0.75	0.69	0.64	0.64
Inefficient	101-150%	2.50	2.50	2.33	2.14	1.96	1.82	1.76	1.66	1.50	1.38	1.28	1.28
Excessive	151-200%	4.32	4.32	4.65	4.28	3.92	3.64	3.52	3.32	3.00	2.76	2.56	2.56
Wasteful	>200%	9.48	9.48	9.30	8.56	7.84	7.28	7.04	6.64	6.00	5.52	5.12	5.12

In summary, with the recent change in allocation occurred in July of 2009, IRWD has estimated that or single family customers with default indoor and outdoor (0.03) acres, an estimated average annual allocation reduction was 24 percent. As landscape acreage increases, the total percent reduction in annual allocation slightly decreases, (i.e., if landscape area is 2,500 square feet, annual average reduction is 23 percent; if it is 4,000 square feet, the overall annual allocation reduction is 22.5 percent). The two communities included in this Pilot Study had relatively small lots at less than 0.25 acres and less than 2,500 square feet, of landscaping according the customer feedback survey and IRWD pre-installation survey.

Dry Year Conditions. Another potential motivator was the significant and on-going media attention regarding the dry conditions and drought restrictions. A summary of the drought actions taken by others and IRWD included the following:

- IRWD did not declare a drought, and did not implement any rationing or water use restrictions within its service area during the recent California Drought.
- IRWD residents were most likely exposed to regional drought messaging and media.
- Metropolitan Water District of Southern California (MWD) adopted an allocation plan for Municipal & Industrial imported water in February 2008.
- MWD announced the need for implementation of the allocation plan in April 2009, with an actual implementation date of July 1, 2009. These were passed through to IRWD by Municipal Water District of Orange County (MWDOC), although the imported water reductions did not affect IRWD's reliability.
- There was significant regional media discussing the drought promoting water conservation during this time. IRWD did produce articles on its website and billing newsletters during this time stating that IRWD did not need to implement any restrictions due to IRWD water resource planning efforts and IRWD long-term approach to water conservation, being Always Water Smart.
- MWD lifted its restrictions and restored full water service allocations to all of its member agencies in April 2011.

Local Economy. One way to examine the local economic decline within IRWD's service area is to review the total number of residential accounts in the IRWD service area (both Single Family and Multi-family) along with the percentage growth. The lower growth rates between 2008 and 2010 are evidence of the recession. While other regions have still exhibited little or no growth, IRWD's increase in number of accounts in 2011 suggests that economic recovery is underway locally.

Table 5. Recent Growth Rates in IRWD Residential Accounts									
Accounts	2003	2004	2005	2006	2007	2008	2009	2010	2011
Residential	73,481	75,422	77,423	79,460	81,673	83,112	83,500	84,295	86,336
Percent Growth	--	2.64%	2.65%	2.63%	2.79%	1.76%	0.47%	0.95%	2.42%

WaterDex Customers as Higher Users. While it is challenging to dissect the motivators for reducing water demand, the WaterDex users began the Pilot Study as above-average users relative to their neighbors. This suggests that they may have been more-easily influenced by the above-described external factors, just as they were motivated to participate in the Pilot Study. Nevertheless, both WaterDex and non-WaterDex customers saw the same general influences over the same period. Therefore, it is assumed that a considerable portion of the decline in usage for the WaterDex customers is attributable to the WaterDex device.

4.2 Summary of Findings

The WaterDex device appears to have been successfully accepted, installed and performed during the observation period of August 2010 through November 2011. This observation is based on the review customer feedback survey and analysis of historical billing data.

Based on the review of the customer feedback survey from 51 of the 93 participants in the WaterDex Pilot Study, the following was observed:

- Nearly two-thirds of responders were “satisfied” or “very satisfied” with the performance of the device.
- Nearly half of responders used the device to adjust their irrigation schedules on a weekly basis.
- Over one-third of the responders used the device to adjust their irrigation schedules on a monthly or seasonal basis.
- Of those customers who might be willing to purchase the device, most were willing to pay less than $100.

An interesting finding from the feedback survey is that more information offered by the manufacturer who was purposely constrained to limit interaction with the customers, may help increase the satisfaction level and efficacy of the device. Another interesting finding is that the vast majority of customers have spray irrigation on medium water use landscape types (i.e., shrubs). A cursory review of the aerial photography using Google Earth illustrates that the landscape of these properties were all heavily planted with turf grass.

Based on the analysis of billing data from all the non-WaterDex customers within both The Colony and College Park villages compared to the WaterDex customers, the following has been observed:

- Initial scatter of the plots of the data illustrated a subset of low water use customers that were found to be smaller zero lot line properties using reclaimed water that were omitted from further analysis.
- Using the average monthly water usage data for each population of WaterDex compared to Non-WaterDex customers based on a 12-month moving average trend lines illustrated a clear difference between historical usage and usage during the study period. The WaterDex customers had a noticeable decline in water use that was a departure from the control group of their neighbors.
- There is evidence of a statistically significant difference between the WaterDex and non-WaterDex water usage based on Wilcoxon-Mann-Whitney nonparametric hypothesis testing, which indicated that the WaterDex devices saved an additional 3.7 percent beyond other underlying conservation factors.
- The net difference between the mean water usage of WaterDex compared to non-WaterDex groups was approximately 13 gpd/account, or 3.3 percent of the pre-installation non-WaterDex usage.

- The net difference between the median water usage of WaterDex compared to non-WaterDex groups was approximately 39 gpd/account, or 11 percent of the pre-installation non-WaterDex usage.

Both the graphical and statistical analyses indicate that in the years preceding the Pilot Study the WaterDex customers were higher users relative to the non-WaterDex customers (a effect likely due to volunteer bias). It is also evident that both WaterDex customers and non-WaterDex customers were influenced to reduce their demands in recent years, likely due to a combination of factors (see Section 4.1). However, WaterDex customers showed a greater reduction in water usage when compared with non-WaterDex customers over the same time period; ultimately, reaching very similar water usage rates during the post-installation period. Assuming that both group were similarly influenced by external factors (i.e., rates, climate, economy), then it can be concluded that the WaterDex devices provided additional water savings in the range of 3 to 4 percent.

In general, findings of this study suggest that the WaterDex device is not only easy to use, but provides water savings in addition to other factors contributing to recent declines in water usage. Assuming the device provides 4 percent average annual water savings, the average customer could save 13 gpd[5], or about 4,700 gallons per year (gpy). These savings are approximately equivalent to the 5,000 to 6,000 gpy saved from a clothes washer rebate incentive when replacing a standard machine with a Consortium for Energy Efficiency (CEE Tier 3) machine.

5. Recommendations

Given the findings of this Pilot Study on the potential water savings from this WaterDex device, it is further recommended that IRWD take the following steps:

- Refine the savings estimates of this study by extending the analysis to include the removal of accounts that have documented acceptance of rebates for devices other than WaterDex device.
- Refine the evaluation to focus on WaterDex customers who provided positive feedback in the customer feedback survey. For example, statistical analyses could focus on narrower subsets such as "satisfied" customers who modified their device on daily, weekly or monthly timeframes.
- Pursue additional funding to increase the sample size in future deployment of the device; consider implementing in the new neighborhoods with randomized letter invitations to participants (removing the self-selection bias).
- Perform a cost-benefit analysis on the device including a sensitivity analysis to understand the thresholds for cost effectiveness for future investment by IRWD or other agencies.
  - Assume a useful life for device (such as five years) and compute benefits to IRWD (based on their avoided cost of water) and to the customer (based on water bill savings, assuming a reduction in use in the third or fourth tier).
  - Identify the level of rebate that can be justified for the device and the resulting payback from the customer's perspective.
- Consider offering the device to a larger group of customers and test again the water savings due to the device in the absence of a drought, recent water rate increase and deepening recession. Use these results, as appropriate, to justify large-scale implementation.

[5] Based on the post-installation non-WaterDex usage rate of 326 gpd/account for The Colony and College Park customers.

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Attachment A

Initial Pilot Study Design Report

WATERDEX REMOTE CONTROL EFFECTIVENESS PILOT STUDY DESIGN REPORT

Prepared for

Irvine Ranch Water District
Irvine, California

March 2, 2010

WATERDEX REMOTE CONTROL EFFECTIVENESS
PILOT STUDY DESIGN REPORT

Prepared for

Irvine Ranch Water District, Irvine, California

March 2, 2010

Project No. 138430

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DRAFT WATERDEX REMOTE CONTROL EFFECTIVENESS PILOT STUDY DESIGN REPORT

1. INTRODUCTION AND STUDY OBJECTIVES

Brown and Caldwell has prepared this Draft WaterDex Remote Control Effectiveness Pilot Case Study Design Report for Irvine Ranch Water District (IRWD) to assist with their preparations for field testing of a new irrigation remote control device in a pilot case study. The purpose of this study design report is to present the study methodology and recommendations for implementation of the case study.

1.1 Introduction

IRWD provides water, reclaimed water, and sewer service to Southern Central Orange County communities including all of the City of Irvine, parts of the cities of Tustin, Costa Mesa, Newport Beach, Lake Forest, and Orange, and unincorporated portions of Orange County. The IRWD service area encompasses an area of approximately 179 square miles and serves a population of over 300,000. IRWD has historically been a leader in the region in implementing water conservation programs including tiered rate structures, pilot testing irrigation controllers, and educating customers about water conservation.

The largest sector of potable water use in the IRWD's service area is single family residential demand with 51,395 accounts using an average of 23,214 acre-feet in 2008. Residential outdoor water use makes up approximately 58 percent of the annual demand of single family residential water demand in IRWD's service area and, as a result, is a prime target for conserving water. Historically, IRWD has targeted water savings in residential outdoor demand using innovative water budget rate structures and pilot testing of new devices. Previous IRWD testing on weather-based irrigation controllers indicated customer feedback that some controllers were complicated to program and upkeep, and that the cost and maintenance fee may be prohibitive, therefore, pilot tests performed to date have not resulted in wide-spread implementation.

IRWD has identified a new irrigation technology, called the WaterDex Remote Control, a device that may prove to be more user-friendly and less cost for attaining outdoor water savings in the single family residential sector.

1.2 Pilot Case Study Purpose

IRWD is currently planning a pilot case study to evaluate potential water savings using the WaterDex Remote Control manufactured by RockRose Technology (Figure 1). The WaterDex Remote Control conserves water used for irrigation by scaling the irrigation schedule up or down based on evapotranspiration (ET) indices. The homeowner manually adjusts the WaterDex Remote Control inside the home on a daily, weekly, or monthly basis based on ET indices available online (daily or weekly) or by using the standard IRWD Recommended Irrigation Calendar (monthly). This pilot case study performed by IRWD will be the first field test of the WaterDex Remote Control. Currently, the plan is to have one hundred units of the prototype WaterDex Remote Control manufactured for this pilot case study. More information on the WaterDex Remote Control can be found online at: www.waterdex.com.

Figure 1. WaterDex Remote Control
Source: http://www.waterdex.com/

1.3 Study Objective

The objective of this WaterDex Remote Control Effectiveness Pilot Case Study is to quantify outdoor water savings among residential customers resulting from installation of the WaterDex Remote Control at a statistically significant level for IRWD. The initial concept for the planned pilot project is for 100 WaterDex Remote Control devices to be installed and controlled by existing IRWD customers in a selected "village" within the larger IRWD service area over a 12-month period.[1]

The optimal "village" for the case study has two recommended characteristics: 1) a population less than 1,000 accounts where the achievable confidence interval would be independent of sample size if 100 WaterDex Remote Control devices are available for the study; and 2) location within the Central climate zone which is the most dominant climate zone in the IRWD service area and, therefore, results may more relevant to a larger portion of the service area. After reviewing data on various "villages" with these characteristics "The Colony", located within the Walnut Village planning area, was selected for the case study. The Colony has 930 single family residential customers and is located in the Central climate zone of IRWD service area.

This case study design report has been developed to help IRWD gauge whether implementing the current planned installation of 100 WaterDex Remote Controls in The Colony over the 12-month study period would result in statistically significant outdoor water savings data.

1.4 Lessons Learned from Past Studies

A previous IRWD pilot program (IRWD, 2001) investigated an early generation of weather-based smart controllers that, once programmed, automatically adjusted the irrigation schedule. The 2001 program found that participants reported either improvement or no change in the appearance of their landscapes over the course of the study. All participants found the smart controllers to be convenient once set-up. During the study, however, some customers would mistake problems with their landscapes/vegetation to the ET

[1] The study was initially focused on determining the required sample size for implementing the study across the entire IRWD service area. The calculated sample size for an acceptable confidence interval significantly exceeded the number of WaterDex Remote Control devices available for the study, therefore the scope of the pilot study was refocused on a "case study" approach. The initial analysis results are provided in Appendix A.

Controller. This pilot program also proved to be labor intensive for IRWD staff to implement and some of the participants later discontinued use of the controller.

A recent statewide study of weather-based smart irrigation technologies in California (Aquacraft 2009) showed mixed results from customers regarding if they would continue use of and costs associated with automatically adjusting weather-based smart controllers after the pilot study.

Overall the studies stress the importance of customer education prior to and during the pilot test. A record of overall cost savings over the course of the pilot test (compared with pre-installation) may also be convincing to study participants. A summary of recent smart controller studies around the United States was published by U.S. Bureau of Reclamation (USBR, 2009) and available online:
http://www.usbr.gov/waterconservation/docs/WaterSavingsRpt.pdf

2. PILOT CASE STUDY DESIGN

2.1 Case Study Design Methodology

Water savings will be measured across The Colony, located in the Walnut Village planning area within the Central climate zone. Water savings will be quantified for each study participant by comparing pre- and post-WaterDex Remote Control installation water use, with calculations performed to estimate outdoor water savings. Based on the goal of IRWD to have a "real world" approach to this project, a fully randomized sample across The Colony was determined appropriate for the study design. The following section describes the methodology for selecting the pilot case study sample size, which is also provided as a flow chart in Figure 2.

2.1.1 Total Number of Qualified Customers

The study design was initiated by identifying the total number of customers within The Colony with single family detached homes, which was equal to 930. Exclusion criteria were applied to these 930 residential customers in order to qualify customers for the pilot project. The following exclusion criteria were applied:

- Customers with less than 1,300 square feet of landscape
- Customers without 12 months of pre-installation history.
- Customers with zero water usage for any month within 12 months of pre-installation history.
- Landscape only accounts or dedicated meter residential accounts.

IRWD applied these exclusion criteria to their customer database, which reduced the total number of potentially eligible participants to 905.

Participants can be selected randomly or systematically (e.g., matched or paired samples) depending on the objectives of the study. For the purposes of this pilot case study, a random sample drawn from potential study participants is recommended. Advantages of selecting a random sample are:

1. Elimination of bias introduced by pre-informed selection (e.g., selection of customers with water use above their water budgets which may "artificially" show significant water savings). A random sample approach would target a "typical" customer within The Colony and present average water savings across The Colony.
2. Sample size requirements are smaller for random samples, as compared to paired samples. Since IRWD plans to target 100 customers, random sample design is better suited to meet IRWD needs in terms of the level of detail for quantifying water savings during the pilot project. Additionally, budget and staffing constraints to support a larger sample group were considered against the additional benefits of a larger sample size.
3. Random sampling is better suited for meeting IRWD goals for the pilot case study, i.e., whether using WaterDex Remote Controls results in significant water savings within the Central climate zone. If the goal was to determine whether certain locations for installation of WaterDex Remote Controls are better than others (e.g., certain climate zones, type of landscape, etc.), then a different approach would be required to meet the study objectives.

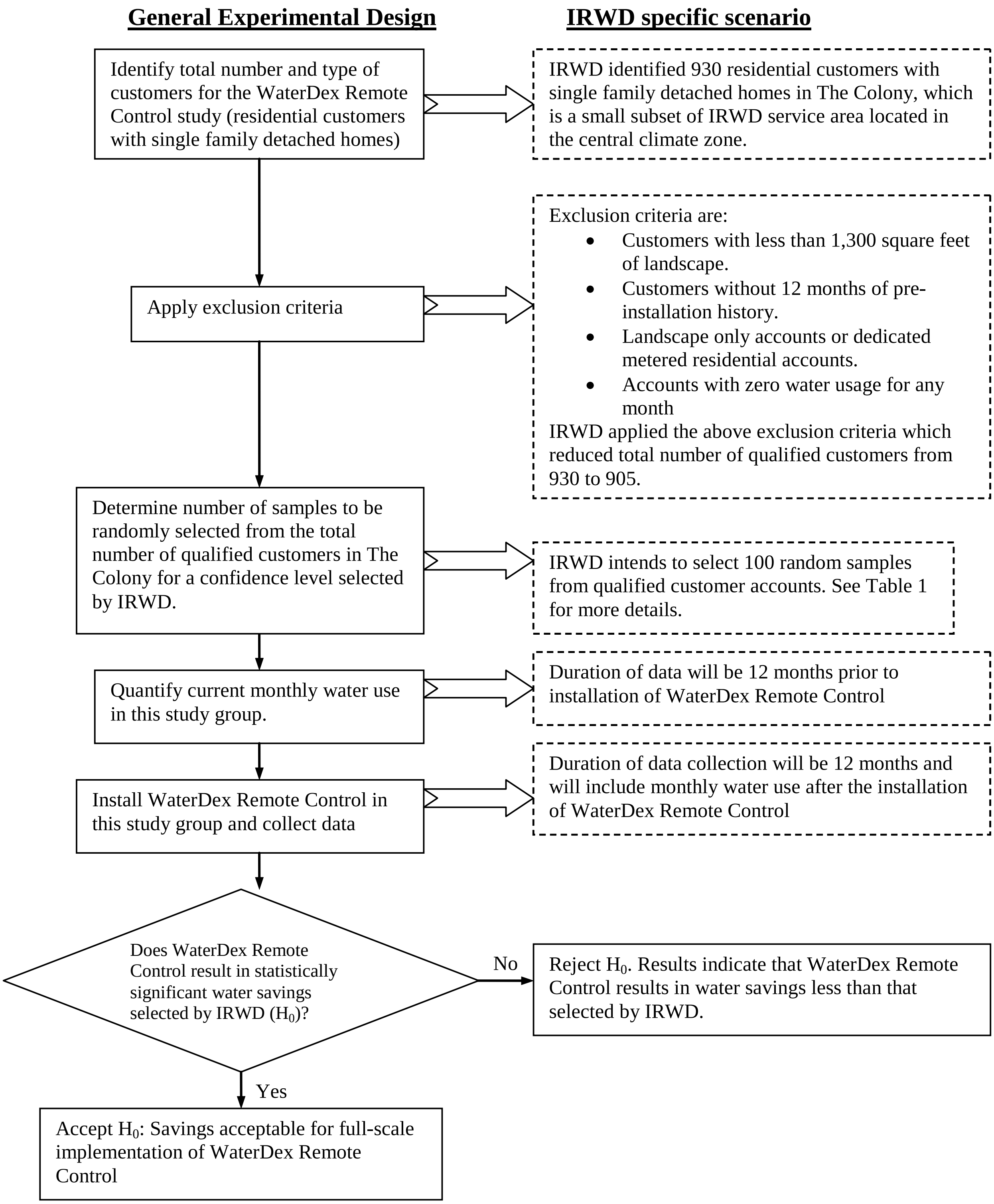

Figure 2. Flow Chart Describing Study Methodology

2.1.2 Sample Size Requirements

The pilot case study sample group will be randomly selected from potential study participants within The Colony to detect various levels of water savings. This section presents sample sizes required for various confidence level scenarios, including the current pilot case study plan to test WaterDex Remote Controls at 100 single family residences in the Colony.

When dealing with large populations such as entire IRWD service area, the sample size is determined using the normal approximation to the binomial distribution. This approximation is very accurate when the population is large, and the sample size is small (sample size is less than 10 percent of population size)[2]. However, when using smaller populations such as The Colony, IRWD would require a far smaller sample size for a given accuracy than that calculated using the normal approximation to the binomial. The eligible population of The Colony is 905, which means that a sample size of 100 represents 11 percent of the population. To determine the sample size which is approximately 10 percent or greater than the population size, normal approximation to the hypergeometric distribution is used (see Equation 1 – Anderson et al., 2006).

$$n \geq \frac{N z_{\frac{\alpha}{2}}^{2} pq}{\left[E^{2}(N-1) + z_{\frac{\alpha}{2}}^{2} pq\right]}$$ ………………………………..Equation [1]

Where,

n = sample size (equal to 100 residential connections in the Colony)

N = population size (equal to 905 residential connections in the Colony)

z = z-score of the desired confidence interval (equal to 1.96 for a 95 percent level where $\alpha = 0.95$);

p = population proportion (i.e. proportion of the population with a desired characteristic, in this case proportion of the population that will have the expected outdoor water savings after the installation of WaterDex Remote Control. Equal to 0.5 (or 50 percent) if unknown)

q = 1-p

E = accuracy of sample proportions. $E = z_{\frac{\alpha}{2}}\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$ where $\bar{p}$ = 0.5 and z = 1.96 for a 95 percent level. Then for n = 100, E = 0.098. This means that with a sample size of 100, IRWD can detect specific water savings in sample proportion with an accuracy of ±9.8 percent with a 95 percent confidence level.

[2] Because IRWD decided to use a small subset of their study population to obtain statistically significant results (see Section 1.3), the sample size formula changed from the initial analysis (see Appendix A for sample size calculations for the full IRWD service area).

The underlying assumption behind random selection is that a random sample is representative of the population at large; in this case average outdoor water savings observed in 100 single family residences installed with WaterDex Remote Controls is representative of average outdoor water savings in total number of potential study participants in The Colony. The certainty (or the lack of it) in moving from random sample to the population is quantified using a confidence interval. A 95 percent confidence interval indicates that there is a 95 percent probability that the average outdoor water savings would fall within a given range in the population at large. Two factors may influence the width of the confidence interval:

- **Sample Size:** For a fixed confidence level, as the size of the random sample increases to be closer to the population size, the width of the confidence interval decreases, indicating that there is a greater level of confidence that the average water savings in the random sample is representative of the population at large.
- **Confidence Level:** For a fixed sample size, as the confidence level decreases, the width of the confidence interval decreases. For example, for a sample size of 100, the width of confidence interval would be narrower at 80 percent confidence level compared to the case when confidence level is 95 percent.

The confidence interval for a smaller population is calculated around the population proportion. Interpretation of confidence interval is based on percentage of the population that will have average outdoor water savings reported from the case study. For example, a 95 percent confidence interval is interpreted as "IRWD is 95% confident that percentage of residential customers in the Colony that will have outdoor water savings reported from the 100 WaterDex Remote Controls is X (lower confidence interval) to Y (upper confidence interval) percent."

$$\overline{p} \pm z_{\frac{\alpha}{2}} \sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$$ ……………………………………..Equation [2]

In Equation 2, $\overline{p}$ is the proportion of 100 samples where specific outdoor water savings was observed that was acceptable to IRWD (e.g., if 50 out of 100 samples showed outdoor water savings acceptable to IRWD, say less than or equal to 10 percent, then $\overline{p}$ is equal to 0.5), z is the z-score of the desired confidence interval (equal to 1.96 for a 95 percent level where $\alpha = 0.95$), and n is the size of random sample (equal to 100).

Based on the above discussion, selecting a required sample size does not guarantee specific water savings at the end of the pilot project. It does, however, help IRWD make statistically sound decisions on whether savings are acceptable for full-scale implementation based on certain trade-offs (such as lower confidence level, or a wider confidence interval).

2.1.3 Null and Alternative Hypothesis for Decision-Making

This section describes null and alternate hypothesis for accepting or rejecting certain water savings results as shown below. The null and alternate hypothesis was determined based on our conversations with IRWD on outdoor water savings anticipated from installing WaterDex Remote Control.

> Null Hypothesis (H_0): WaterDex Remote Control results in statistically significant outdoor water savings (minimum water savings pre-defined by IRWD) in The Colony.

Alternate Hypothesis (H_A): WaterDex Remote Control does not result in statistically significant outdoor water savings (below minimum water savings pre-defined by IRWD) in The Colony.

2.1.4 Assumptions

Equation 1 assumes that the distribution of pre-WaterDex Remote Control outdoor water use data is similar to post-WaterDex Remote Control outdoor water use and are normally distributed. This means the distributions would take on the approximate shape of a bell curve. An illustration of this concept is provided in Figure 3. The black curve represents existing water use distribution. The blue curve represents an average percent reduction in water use after installation of WaterDex Remote Controls. Sample size calculations assume that the standard deviation of samples before and after WaterDex Remote Control installation are equal.

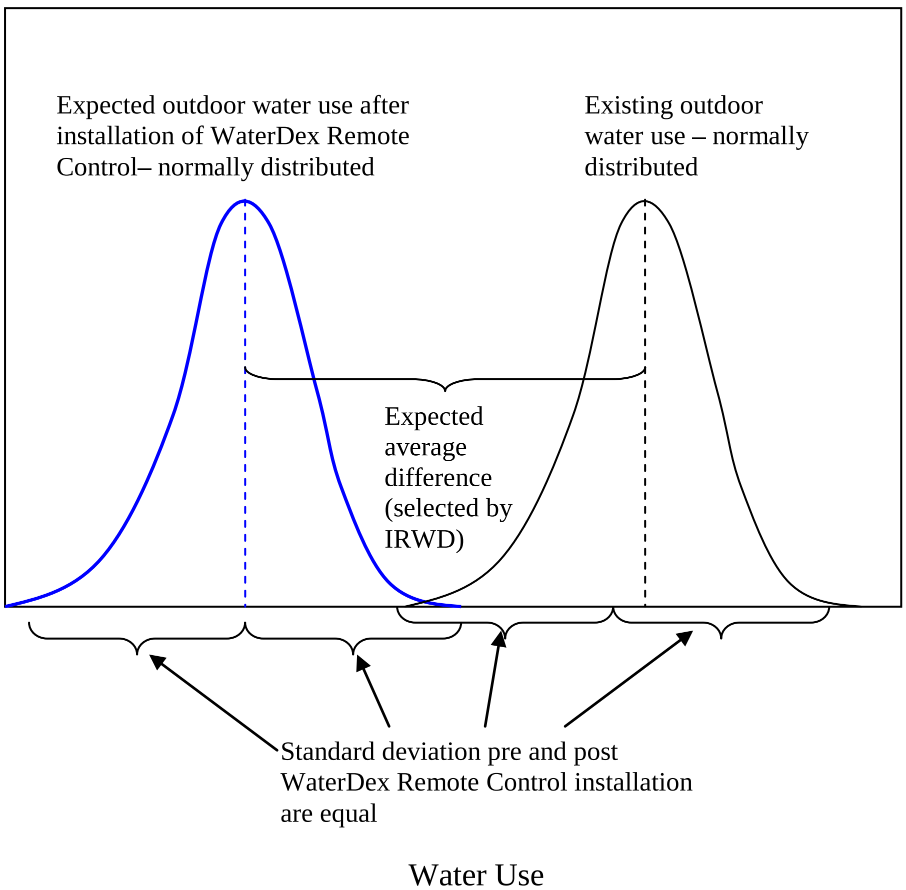

Figure 3. Graphical Representation of Sample Distribution - Pre and Post WaterDex Remote Control Installation (Figure not to scale)

2.1.5 Sample Size Calculation Results

Table 1 shows results from sample size calculations for various confidence levels. As shown in this table, a larger sample size is required for a higher confidence level. If IRWD uses a sample size of 100, then it can detect specific outdoor water savings with an accuracy of ±9.8 percent with a 95 percent confidence level (E = 0.098). This means that with a sample size of 100, if IRWD observes 10 percent or greater reduction in outdoor water savings in 50 or more samples out of 100 samples (p = 0.5), then IRWD can conclude that WaterDex Remote Control results in average outdoor water savings of 10 percent at the 95 percent level (Accept H_0) in 50 ±9.8 percent of residential customers in the Colony from which the random sample is drawn. Given that 100 percent of the participants may not be viable for post analysis, it recommended that IRWD enroll additional participants in the study above the minimum sample size requirement to reach the stated goal.

Table 1. Sample Sizes Required for Various Confidence Levels

Desired Confidence Interval	Sample Size Requirement
95%	90
90%	66
85%	51
80%	41

3. RECOMMENDATIONS FOR PILOT CASE STUDY IMPLEMENTATION

This section provides recommendations for IRWD and WaterDex actions for successful implementation of the pilot case study, including recommended post-study data analysis.

3.1 IRWD Actions

The role and responsibilities for IRWD for implementation of the pilot case study include the following:

- Customer Recruitment
- Pre-qualification Survey and Acceptance
- Customer Service
- Data Collection
- Post-Study Survey
- Final Data Analysis
- Timeline

Each of these implementation actions is described in subsections below.

3.1.1 Customer Recruitment

A prime goal of implementation of water conservation devices is for customers with high water use and large lots to become engaged in using ET indices to manage their landscape irrigation. Based on common experience noted in several water utilities, this customer sector can be challenging to reach. It is recommended that the pilot case study random sample be recruited from various lot sizes via direct contact with residents in The Colony (e.g., phone, mail or email) using an invitation letter or phone script that includes a prequalification survey. Some suggestions for marketing messaging to motivate customers may include the findings from the California Urban Water Conservation Council (CUWCC) 2007 Landscape Marketing Study, available online at: http://www.cuwcc.org/resource-center/technical-resources/landscape-marketing-survey.aspx

It is recommended that the survey be sent to approximately twice the number of study participants desired in the final selected sample size and that customers be offered the controller on a "first come, first served basis." It is also recommended that IRWD over-recruit for the study to the extent that budget allows such that participants who need/want to drop out do not result in a study without statistically significant findings.

Given that a 95 percent confidence level is desired by IRWD, then recruiting 100 residents leaves 10 customers that can drop out or be excluded from the study in post-analysis while maintaining the required sample size for this confidence interval. It is recommended that IRWD consider recruiting 120 participants in the case study in case greater than 10 customers drop out or are excluded during post-study analysis; more description is provided on the benefits of subscribing additional participants in the following section. Given this is more than 1 in 10 accounts in The Colony, IRWD may need to resort to more aggressive recruiting such as door hanger campaign. If this is the case then careful attention to maintain the randomness is necessary (e.g., door hangers should be distributed in a short timeframe within a few days) such that every customer has an equal chance at participating and enrolling.

3.1.2 Pre-qualification Survey (Exclusions) and Acceptance

Prior to the final participant selection, customer-specific variables will be surveyed using the pre-qualification survey. Recommended pre-study information to be included in the pre-qualification survey include the following:

- Number of occupants
- Historic watering habits
- Landscaped area to be watered (to be verified by IRWD)
- Any preconceived ideas on irrigation controllers
- Baseline indoor use related to level of efficiency of plumbing fixtures and appliances (refer to End Use Study to cross reference any same participants)

The exclusion criteria applied to the study that need to be confirmed prior to acceptance into the pilot case study include:

- Customer resides outside of The Colony.
- Customers with less than 1,300 square feet of landscaped area
- Customers without 12 months of pre-installation history (i.e., customers residing in the Lake Forest Area, Santiago Canyon, and Orange Park Acres do not have 12 months of history on a metered rate).
- Customers with zero water usage for any month within the 12-month pre-installation history.
- Customers without an automatic irrigation timer.
- Customers with Smart Controllers or other weather controllers already installed.
- Landscape only accounts or dedicated metered residential accounts.

An option for IRWD if over-recruiting is to provide WaterDex Remote Controls and monitor any "additional" accounts, particularly if the customers have larger lots in order to understand how larger customers might use and implement the device. During the post analysis it would be determined if the population sample was skewed towards too many larger lots through selective over-subscribing of larger customer property owners and careful tracking of which accounts fall into the "random" sample (up to 120 accounts enrolled) and which accounts were "added" above the 120 accounts for more data. When analyzing the final water savings, these "added" large lots (and potentially very large savings) may be excluded as not the "average customer" experience with the device. Including these customers' observed savings would skew the results if used in the post-study evaluation of the controller savings in the pilot case study. However, while not used in the overall savings calculations, it is recommended that these customers be included in the actual report findings at the end of the pilot case study.

Some other considerations for pre-screening information that may exclude customer participation are:

- Make and model of irrigation timer(s) currently installed to validate if any foreseen conflicts with WaterDex Remote Control (would also help validate if a certain types does not work well or takes more customer service than other brands);
- Anticipated move to new location within the 12-month study period;
- Anticipated changes in customer occupancy in 12-month study period (e.g., student going away to college, additional person(s) moving in);
- Planned change in landscape design (plant selection, hardscape, addition of a pool, other irrigation upgrades);
- Extended vacations planned (e.g., longer than two week average assumption per household);

- *Optional*: Occurrence of a leak that has been repaired in the past 12 months before the study period or needs to be repaired prior to study start (will lead to artificially higher estimated savings attributed to the controller); and
- *Optional*: Level of knowledge of existing irrigation schedule (more knowledge is better as it will test the device and not commingle modifications to the scheduling upfront, although using ET may increase watering for deficit irrigating customers).

These variables may be used in the future to compare with pilot project results and as a basis for decisions geared towards implementation of a full-scale installation program. Once the surveys from potential participants have been analyzed, IRWD will determine the final acceptance criteria for customer's admission into the program. Formal letters of acceptance or declination with the reason stated should be mailed to each customer requesting to participate. Prior to acceptance it is recommended that the metered use history of each customer be checked to confirm no anomalies in the past 14 months (review more than 12 months in case the customer does not install the device immediately) that would exclude their data in the post-evaluation. The acceptance letter being sent could coincide with the delivery of the controller in addition with instructions on how to inform IRWD with the date that the device was installed.

3.1.3 Customer Service

Brown and Caldwell recommends outlining a clear protocol for the level of customer service that will be offered customer participants for consistency of results balanced against meeting "real-world" application and customer service by IRWD. Some considerations for customer services needs include:

- Hosting a Webinar (and/or Town Hall Meeting in The Colony) with WaterDex which might include the following topics:
  - Purpose of study and significance of participant involvement
  - Functionality of the device
  - Where to get ET data and how to apply it
  - Where and how they can get assistance during the study
  - Installation guidance
  - Troubleshooting
  - Frequently asked questions and feedback mechanism during the study (perhaps start a blog on IRWD's or WaterDex's website with a login for participants?)
- IRWD Customer Surveys. If some participants get them or have already had them, where some have not, this would mimic more real-world conditions. However, the lack of consistency among customer support will lead to variability in the study findings that ultimately may lead to a mixed results in terms of validating the water savings from the WaterDex Remote Control itself. The more that customer service is consistent across the participants, the higher the validity of the study findings.

A critical element to the success of this study is to provide consistent and accurate ET data access to all study participants:

The WaterDex Watering Index can be provided to users in several modes:

1. Standard IRWD Recommended Irrigation Calendar
2. Watering Index by Zip Code (made available online)

3. Recommended Watering Index published by WaterDex daily online or emailed to consumers in the Colony on a weekly basis. Similar to the IRWD ET Controller Study in 2002, IRWD may consider having a small control group of customers receiving Watering Index information strictly in direct mail form (e.g., postcard). This information could then compared to the two other customer groups within The Colony subdivision: (1) those without any support other than normal communications from IRWD (e.g., bill messaging); and (2) the study group with WaterDex Remote Control devices.

The ET indices will be provided to Pilot Project participants via:

- Email
- Phone hotline
- Text
- WaterDex and IRWD websites (need to match up exactly from same source and updated on the same schedule)

Additional areas of customer service that may be discussed in partnership with WaterDex are provided in Section 3.2.

3.1.4 Data Collection

In addition to careful pre-screening and providing consistent customer service, it's important that adequate data be collected for post-study evaluation such that artificially low or high usage may not influence the water demand for that customer during the study period. It is recommended that IRWD consider adding one billing period both pre- and post-installation beyond the 12 month study period for data validation purposes in case some customers bridge meter reading cycles. Also, if the service is on split meter reading rotation, that will need to be factored into the post analysis.

The following is a list of data that would be useful to collect during the study:

- ET data
- Changes in account ownership
- Document any participating customer who receives recommendations from IRWD on irrigation scheduling or landscape changes (e.g. date and type of information provided, Customer Survey performed) that might affect post-study analysis.
- Customer service or technical support provided by either IRWD or WaterDex including the type (e.g., phone, email, etc) and purpose (e.g., installation, ET data, scheduling assistance, etc)
- Blog usage
- Metered demand (consider a billing system flag if possible for high or low usage rates beyond expected limits, and track address to meter reading cycle to line up with the appropriate ET data)

3.1.5 Post-Study Survey

Upon completion of the study, it will be vital to ask the right questions to be able to understand the validity of including each participant's data in the post-evaluation analysis to determine the statistically significant water savings from the WaterDex Remote Control device. The following is a list of survey information that would be useful to collect:

- Confirm the resident still resides and used the device in The Colony housing subdivision.
- Confirm make and model of irrigation timer(s) installed on irrigation system into order to verify any changes from the pre-survey (recommend allowing room for more than one type of timer per residence)

- Confirm date the controller was installed
- Ask if any periods of non-operation for any reason (technology problem, etc. which might be excluded depending on the level of customer service documentation by IRWD and WaterDex)
- Means used for acquiring ET data and feedback on user friendliness
- Changes in landscape
- Occupancy data
- Any changes/upgrades in indoor plumbing fixtures and appliances along with the date of installation (for benchmarking purposes)
- Vacation data
- Experienced irrigation system leak
- Pre-WaterDex Remote Control water application rate compared to theoretical irrigation requirement for that location (calculated from ET and precipitation data in that area) – see Pages 23 and 24 in "Evaluation of California WBIC Programs" study published by Aquacraft, Inc. in 2009 (available online at http://www.cuwcc.org/uploadedFiles/Resource_Center/Products/WBIC/Smart-Controller-Programs-Final-Report-07-01-09.pdf)
- Landscape area
- Willingness to pay for the controller to test different incentives by types (rebate, voucher, manufacturer rebate reimbursed for IRWD verified customers) and amounts ($25, $50, $75)
- Feedback and recommendations for future implementation by IRWD
- Willingness to be a testimonial in IRWD or WaterDex publications

The list of suggested post-survey questions could be further refined as the project is implemented and IRWD staff determines additional useful information for the post-study evaluation or the final study report.

3.1.6 Final Data Analysis

After IRWD has selected participants within The Colony (see Section 2.1.6) and has collected a minimum of 12 months worth of post-WaterDex Remote Control outdoor water use data for each participant, final data analysis would include the following steps:

1. Calculate average water savings for the minimum of 12 months worth of water use data on both pre- and post-WaterDex Remote Control installation for the entire random sample within The Colony.
2. Quantify percent water savings in each of the 100+ samples using data collected in Step 1. Determine percentage of samples that resulted in outdoor water savings targeted by IRWD (e.g., if 50 out of 100 samples resulted in target outdoor water savings of 10%, then p = 0.5).
3. Construct confidence interval for the proportion of the population that is expected to produce the desired outcome from the study (Equation 2).
4. Collect post-study survey information on participants (Section 3.1.5).
5. Remove/categorize data wherever appropriate to eliminate confounding, if any (e.g., categorize data based on landscape area to determine whether landscape area influenced average outdoor water use). As a cautionary note, categorizing data will reduce sample sizes and will in turn reduce confidence levels. Therefore this step is recommended only if IRWD has a reason to think that a particular variable was a major confounder in the data analysis (e.g., "added" accounts above the recommended sample size of enrolled accounts which were larger lot sizes).
6. Calculate average water savings from each category in Step 5 to construct confidence intervals.
7. Make decision on full scale implementation.
8. Publish findings in final study report.

3.1.7 Timeline

A basic timeline for the pilot case study is envisioned to include the following:

- Final study design and implementation plan (2 weeks)
- Development of invitation letter and pre-qualification survey and instructional DVD (2 weeks)
- Customer recruitment within The Colony (3 weeks)
- Customer acceptance analysis by IRWD staff (3 weeks)
- Product delivery arranged and coordinated by IRWD (2 weeks)
- Webinar and/or Town Hall Meeting hosted by IRWD (and blog or other feedback mechanisms) (2 weeks)
- Confirmation of the customer installation date via email with follow-up by IRWD or WaterDex personnel (4 weeks)
- Documentation of study (i.e., pre-and post installation photos for brochures, metered data, customer service calls, etc), response to customer requests, and sending "checking-in" emails (reminders of the study and appreciation of participation, perhaps a customer testimonial) (14 months)
- Post-study survey design and distribution (2 weeks)
- Post-study survey collection and follow-up (6 weeks)
- Post-study data analysis (10 weeks)
- Report on final results (6 weeks)

The final timeline should be established when the design parameters are fixed and the implementation plan is being finalized.

3.2 WaterDex Actions

There are two primary responsibilities for WaterDex for the pilot case study: providing the product and providing customer service support to IRWD.

3.2.1 Product Delivery

It is WaterDex's responsibility to ensure that fully operational WaterDex Remote Controls are available for IRWD. WaterDex will work with IRWD staff to help facilitate product delivery by IRWD. All WaterDex Remote Control devices will be self-installed by IRWD customers.. As a result of WaterDex and IRWD staff not being on-site to assist with the controller set-up, it is imperative that a plan is developed to provide clear definition on how customers will be supported during the study.

3.2.2 Customer Service

WaterDex customer support that may be useful to IRWD includes:

- Information kit
- Installation Instruction Web Video and/or DVD
- Brochure
- Tech support (e.g., blog support)
- Documentation on what and how the customer service was provided by WaterDex to IRWD customers

4. RECOMMENDATIONS FOR POTENTIAL CUSTOMER INCENTIVES

There are two basic ways to incentivize customers to take advantage of upgrades in efficiency, including their adoption of technologies such WaterDex Remote Controls:

1. Use educational and marketing tactics such that they perceive the value of the device (i.e., use testimonials from participants and pre-and post photos WaterDex remote control device usage from the pilot case study in outreach brochures); and/or
2. Offer a financial incentive for a customer to purchase, install, and operate the controller.

Since WaterDex Remote Controls are still a fairly new technology, most other agencies who have performed similar pilot studies strongly recommend including an educational outreach component to the marketing of such devices. IRWD and WaterDex have discussed the inclusion of an online video. A statewide study by the California Urban Water Conservation Council (CUWCC) found that most people would forget or only partially remember educational ads regarding water shortages and/or conservation (CUWCC, 2007). For these reasons, educational efforts should be coordinated directly with the device installation.

In order to assess potential incentives for installation of the WaterDex Remote Control, IRWD may want to add a question to the pre-installation survey to investigate how much customers would be willing to pay for a WaterDex Remote Control.

There are several different means of providing direct discounts on the cost of controller device to encourage participation, such as:

- Rebate
- Voucher
- Limited time manufacturer discount reimbursed for verified IRWD customers at select stores (perhaps a next phase after the pilot case study)

Most utility programs discount a portion of the cost, frequently on the order of 50 percent or less of the cost of the appliance or device) to cost share with the customer. In the case of IRWD, if half of their customers (on the order of 25,000) were to be given a $25 rebate (50 percent of the estimated $50 device cost), that investment would be more than $600,000 in ratepayer dollars. Reimbursement of the full cost or a “give-away” program may be useful for very initial offerings to gain more customer experience beyond the pilot case study phase. However for devices such as the WaterDex, which optimally would be used daily or weekly operation, a part of the purchase paid by the customer might help encourage better customer adoption and implementation of this new technology.

5. REFERENCES

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6. LIMITATIONS

This document was prepared solely for Irvine Ranch Water District (IRWD) in accordance with professional standards at the time the services were performed and in accordance with the contract between IRWD and Brown and Caldwell dated November 11, 2009. This document is governed by the specific scope of work authorized by IRWD; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by IRWD and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Further, Brown and Caldwell makes no warranties, express or implied, with respect to this document, except for those, if any, contained in the agreement pursuant to which the document was prepared. All data, drawings, documents, or information contained this report have been prepared exclusively for the person or entity to whom it was addressed and may not be relied upon by any other person or entity without the prior written consent of Brown and Caldwell unless otherwise provided by the Agreement pursuant to which these services were provided.

APPENDIX A: SAMPLE SIZE CALCULATIONS FROM INITIAL STUDY ANALYSIS FOR ENTIRE IRWD SERVICE AREA

APPENDIX A

SAMPLE SIZE CALCULATIONS FROM INITIAL STUDY ANALYSIS FOR ENTIRE IRWD SERVICE AREA

Study Design Methodology

Water savings will be measured across the entire IRWD service area, including all climate zones, for the pilot study. Water savings will be quantified for each study participant by comparing pre- and post-WaterDex Remote Control installation water use, with calculations performed to estimate outdoor water savings. Based on the goal of IRWD to have a "real world" approach to this project, a fully randomized sample across the entire service area was determined appropriate for the study design. The following section describes the methodology for selecting the pilot study sample size, which is also provided as a flow chart in Figure A1.

Total Number of Qualified Customers

The study design was initiated by identifying the total number of customers with single family detached homes and with at least 1,300 square feet of landscape, which was equal to 52,000. Exclusion criteria were applied to these 52,000 residential customers in order to qualify customers for the pilot project. The following exclusion criteria were applied:

- Customers without 12 months of pre-installation history (i.e., customers residing in the Lake Forest Area, Santiago Canyon, and Orange Park Acres do not have 12 months of history on a water budget based metered rate).
- Customers with Smart Controllers or other weather controllers already installed.
- Landscape only accounts or dedicated meter residential accounts.

IRWD applied these exclusion criteria to their customer database, which reduced the total number of potentially eligible participants to 41,836. A second landscape area exclusion criterion was applied, which included only customers whose landscape area was ≤1300 square feet and ≥ 6500 square feet (see Section 2.1.5 for more details). By applying this second landscape area exclusion criterion, the total number of potentially eligible participants for the pilot study is expected to be less than 41,836.

Participants can be selected randomly or systematically (e.g., matched or paired samples) depending on the objectives of the study. For the purposes of this pilot study, a random sample drawn from potential study participants is recommended. Advantages of selecting a random sample are:

1. Elimination of bias introduced by pre-informed selection (e.g., selection of customers with water use above their water budgets which may "artificially" show significant water savings). A random sample approach would target a "typical" customer in the IRWD service area and present average water savings across the entire service area.
2. Sample size requirements are smaller for random samples, as compared to paired samples. Since IRWD plans to target 100 customers, random sample design is better suited to meet IRWD needs in terms of the level of detail for quantifying water savings during the pilot project. Additionally, budget and staffing constraints to support a larger sample group were considered against the additional benefits of a larger sample size.

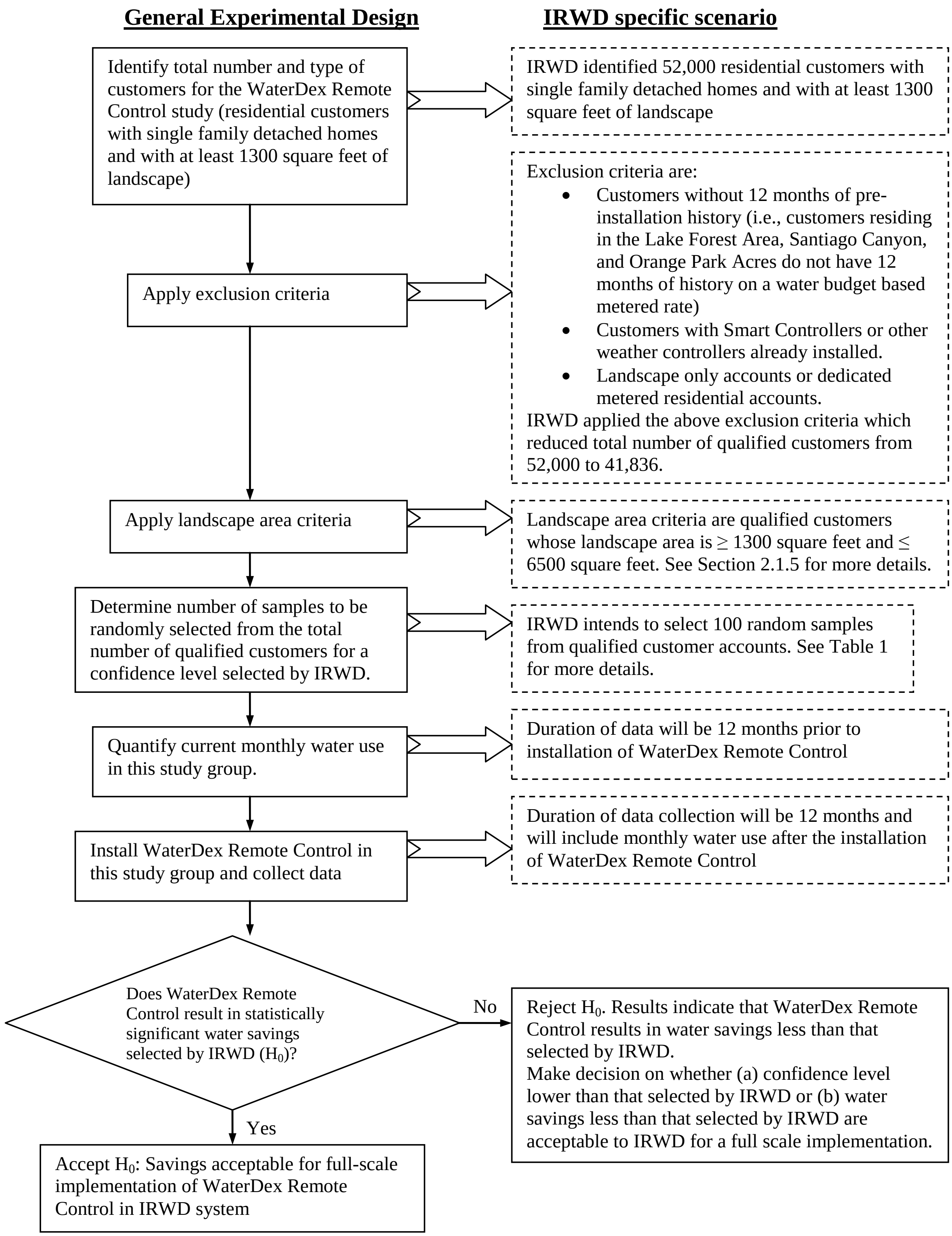

Figure A1. Flow Chart Describing Study Methodology

3. Random sampling is better suited for meeting IRWD goals for the pilot study, i.e., whether WaterDex Remote Controls result in significant water savings overall. If the goal was to determine whether certain locations for installation of WaterDex Remote Controls are better than others (e.g., certain climate zones, type of landscape, etc.), then a different approach would be required to meet the study objectives.

Sample Size Requirements

The pilot study sample group will be randomly selected from potential study participants to detect various levels of water savings. This section presents sample sizes required for various study goal-confidence level scenarios, including the current pilot study plan to test WaterDex Remote Controls at 100 single family residences.

The sample size formula for a one-sided test is given by equation below (Cohen 1977; Muller and Peterson, 1984; Kupper and Hafner, 1989).

$$n \geq \frac{2(Z_{1-\alpha} + Z_{1-\beta})^2 \sigma^2}{\Delta^2}$$ ………………………………..Equation [A1]

Where,

n = sample size

z = z-score of the desired confidence interval and the z-score of the statistical power of the inference;

1-α = probability of accepting H_0 when H_0 is true (probability of not making a false positive decision)

1-β = probability of accepting H_A when H_A is true (power of the test or probability of not making a false negative decision)

σ = the standard deviation of the historical water use

Δ = the size of the change to be detected (the average difference between pre WaterDex Remote Control installation water use and post WaterDex Remote Control installation water use)

The underlying assumption behind random selection is that a random sample is representative of the population at large; in this case average outdoor water savings observed in 100 single family residences installed with WaterDex Remote Controls is representative of average outdoor water savings in total number of potential study participants. The certainty (or the lack of it) in moving from random sample to the population is quantified using a confidence interval. A 95 percent confidence interval indicates that there is a 95 percent probability that the average outdoor water savings would fall within a given range in the population at large. Three factors may influence the width of the confidence interval:

- **Sample Size:** For a fixed confidence level, as the size of the random sample increases to be closer to the population size, the width of the confidence interval decreases, indicating that there is a greater level of confidence that the average water savings in the random sample is representative of the population at large.
- **Confidence Level:** For a fixed sample size, as the confidence level decreases, the width of the confidence interval decreases. For example, for a sample size of 100, the width of confidence interval would be narrower at 80 percent confidence level compared to the case when confidence level is 95 percent.

- **Effect Size:** For a fixed confidence level and sample size, as the size of the change desired to be detected decreases (value of Δ in Equation 1 **above**), the width of confidence interval increases. For example, for a sample size of 100, if IRWD wants to detect both 20 percent and 10 percent reductions in outdoor water use at 95 percent confidence level, the width of confidence interval to observe 10 percent or less reduction would be wider compared to the confidence interval to observe 20 percent or more reduction.

Formula to calculate confidence interval, given average and standard deviation of the random sample is described in Equation A2 (Klienbaum et al., 1998).

$$\overline{X} \pm t_{n-1,1-\frac{\alpha}{2}} \left(\frac{S}{\sqrt{n}} \right) \text{ ....Equation [A2]}$$

In Equation A2, $\overline{X}$ is the average post-WaterDex Remote Control outdoor water use in the random sample, *S* is the standard deviation of post-WaterDex Remote Control outdoor water use in the random sample, *t* is the t-statistic, n is the size of random sample, α is the desired confidence interval (equal to 0.95 for 95 percent confidence interval).

Based on the above discussion, selecting a required sample size does not guarantee specific water savings at the end of the pilot project. It does, however, help IRWD make statistically sound decisions on whether savings are acceptable for full-scale implementation based on certain trade-offs (such as lower confidence level, or a wider confidence interval).

Null and Alternative Hypothesis for Decision-Making

This section describes null and alternate hypothesis for accepting or rejecting certain water savings results as shown below. The null and alternate hypothesis was determined based on our conversations with IRWD on outdoor water savings anticipated from installing WaterDex Remote Control.

Null Hypothesis (H_0): WaterDex Remote Control results in statistically significant outdoor water savings selected by IRWD.

Alternate Hypothesis (H_A): WaterDex Remote Control results in outdoor water savings less than that selected by IRWD.

Assumptions

Equation A1 assumes that the distribution of pre-WaterDex Remote Control outdoor water use data is similar to post-WaterDex Remote Control outdoor water use and are normally distributed. This means the distributions would take on the approximate shape of a bell curve. An illustration of this concept is provided in Figure A2. The black curve represents existing water use distribution. The blue curve represents an average percent reduction in water use after installation of WaterDex Remote Controls. Sample size calculations assume that the standard deviation of samples before and after WaterDex Remote Control installation are equal.

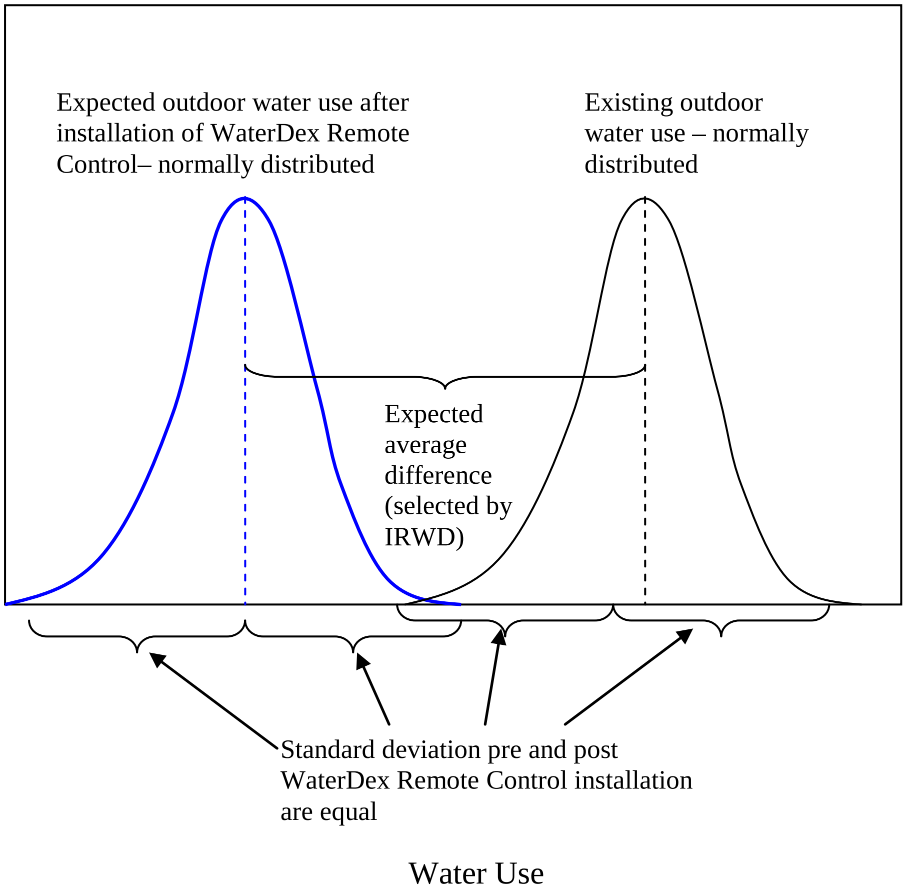

Figure A2. Graphical Representation of Sample Distribution - Pre and Post WaterDex Remote Control Installation

Figure not to scale.

Inputs for Sample Size Calculation

One of the requirements for calculating sample size is to know σ (standard deviation of historical water use) and Δ (size of change to be detected or the average expected difference between historical and post-WaterDex Remote Control outdoor water use). We requested IRWD to provide current water use data as a basis for sample size calculations. IRWD provided data on their outdoor irrigation use in 2008 for 10,670 residential accounts that have available data on the measurement of landscaped area greater than or equal to 1,300 square feet.

Landscape area in these 10,670 residential accounts ranged from 1,300 square feet to 110,100 square feet. The 90th percentile value was 6,261 square feet indicating that 90 percent of the data had landscape area less than or equal to 6,261 square feet. This indicates that 10 percent of the data contained extreme values in the data set that may skew the calculation of average and standard deviation. Therefore values greater than or equal to 6,500 square feet (rounded to 6,500 for simplicity in calculations and recommending landscape area criteria) were eliminated from the data set used to calculate average and standard deviation. It is assumed that outdoor water use in the remaining 9,703 residential accounts (90.8 percent of 10,670 residential accounts) is representative of average outdoor water use within IRWD's service area.

Based on these calculations, the standard deviation of outdoor water use (σ) in 2008 from 9,703 accounts with landscape area ranging from 1,300 to 6,500 square feet is 122 gallons per single family residential account per day. Existing average outdoor water use for 9.703 accounts is 289 gallons per account per day. These values were used for calculating required sample sizes from Equation A1.

Sample Size Calculation Results

Table A1 shows results from sample size calculations for various study goal-confidence level scenarios.. As shown in this table, a larger sample size is required to detect a smaller expected reduction. If IRWD uses a sample size of 100, the minimum average water savings that can be detected at 95 percent level to accept the null hypothesis (H_0) is 20 percent. This means that with a sample size of 100, if IRWD observes average outdoor water savings of 20 percent or greater, then IRWD can conclude that WaterDex Remote Control results in average outdoor water savings ≥ 20 percent at the 95 percent level (Accept H_0) in the entire population from which the random sample is drawn. If water savings are less than 20 percent, then WaterDex Remote Control results in average outdoor water savings < 20 percent in the entire population from which the random sample is drawn (Accept alternative hypothesis H_A). Given that 100 percent of the participants may not be viable for post analysis, it recommended that IRWD enroll additional participants in the study above the minimum of 96 to reach the stated goal.

The width of the confidence interval (Equation 2) would determine the associated uncertainty with the calculations and the width decreases as the size of random sample increases for a specific confidence level. IRWD may make a decision to accept H_0 at a confidence level less than 95 percent if it chooses to observe lower percent reduction in water savings using a sample size of 100.

Table A1. Sample Sizes Required for Various Pilot Study Goal-Confidence Level Scenarios

Desired Confidence Interval	Sample Size Requirement for Observing Specific Average Reduction in Outdoor Water Savings between Pre- and Post-WaterDex Remote Control Installation			
	For observing ≥ 5% reduction	For observing ≥ 10% reduction	For observing ≥ 15% reduction	For observing ≥ 20% reduction
95%	1534	383	170	96
90%	1216	304	135	76
85%	1024	256	114	64
80%	877	219	97	55

When all 10,670 residential accounts are used for calculating σ and Δ, a sample size of 100 would be able to detect 28 percent or more water savings at 95 percent level. This is because the standard deviation of outdoor water use (σ) in 2008 from all 10,670 accounts with landscape area ranging from 1,300 to 110,100 square feet was 195 gallons per single family residential account per day. This is greater than the 122 gallons per single family residential account per day for 9,603 accounts with landscape area ranging from 1,300 to 6,261 square feet that represent 90 percent of the data. Standard deviation is a measure of how much the data deviate from the mean. Including landscape areas greater than 6,500 square feet increased standard deviation because the upper 10 percent of the data had very high metered water use. Further analysis determined that water use per square feet of landscape ranged from 3.2 to 30.1 gallons per account per day for 90 percent of the data (≤ 6,500 square feet landscape), whereas water use was 31 to 292 gallons per account per day for the remaining 10 percent of the data (6,500 to 110,100 square feet landscape). Therefore, using 90 percent of the data to calculate standard deviation of historical outdoor water use and current average outdoor water use was deemed appropriate. If IRWD decides that using all 10,670 residential accounts is appropriate, then as described above, IRWD would only be able to detect 28 percent or more water savings at 95 percent level with a sample size of 100. If all 10,670 residential accounts are used, sample sizes for various study goal-confidence level scenarios are shown in Table A2.

Table A2. Sample Sizes Required for Various Pilot Study Goal-Confidence Level Scenarios using all 10,670 Accounts

Desired Confidence Interval	Sample Size Requirement for Observing Specific Reduction in Water Savings Between Pre- and Post-WaterDex Remote Control Installation					
	For observing ≥ 5% reduction	For observing ≥ 10% reduction	For observing ≥ 15% reduction	For observing ≥ 20% reduction	For observing ≥ 25% reduction	For observing ≥ 30% reduction
95%	3257	814	362	204	130	90
90%	2581	645	287	161	103	72
85%	2174	544	242	136	87	60
80%	1862	465	207	116	74	52

Final Data Analysis

After IRWD has selected appropriate sample size required for the analysis and has collected a minimum of 12 months worth of post-WaterDex Remote Control outdoor water use data for each participant, final data analysis would include the following steps:

1. Calculate average and standard deviation for the minimum of 12 months worth of water use data on both pre- and post-WaterDex Remote Control installation for the entire random sample.
2. Construct confidence interval for an expected confidence level, both for pre- and post- WaterDex Remote Control data (Equation A2) which would result in average ± limit for the population from which the random sample was drawn.
3. Collect post-study survey information on participants.
4. Remove/categorize data wherever appropriate to eliminate confounding, if any (e.g., categorize data based on landscape area to determine whether landscape area influenced average outdoor water use). As a cautionary note, categorizing data will reduce sample sizes and will in turn reduce confidence levels. Therefore this step is recommended only if IRWD has a reason to think that a particular variable was a major confounder in the data analysis.
5. Calculate average and standard deviation of each category in Step 4 to construct confidence interval for an expected confidence level, both for pre- and post-study WaterDex Remote Control data (see Equation A2).
6. Compare confidence intervals for both for pre- and post-study WaterDex Remote Control data to make decision on full scale implementation.
7. Publish findings in final study report.

Attachment B

BW Research Report

[bw] RESEARCH PARTNERSHIP

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bwresearch.com
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MEMORANDUM

From: **BW Research**

Date: **December 13, 2011**

Re: **Initial Summary of Survey Results**

CUSTOMER RESPONSE RATE

Data collection for the customer survey commenced on November 11, 2011, with the final completed survey collected on December 3, 2011. Fifty-one customers completed a survey (26 by phone and 25 online), yielding a response rate of 60 percent. Customers in the sample with a valid phone number were dialed 11 times by our call center from November 15 through November 28. During the same time period, nine email reminders were sent to customers with valid email addresses.

INITIAL FINDINGS

Customer Satisfaction with the WaterDex Device

Customer satisfaction with the WaterDex device was a modest 63 percent (41% “Very satisfied” and 22% “Somewhat satisfied”). Sixteen percent were neutral ("Neither satisfied nor dissatisfied"), 16 percent were dissatisfied (10% “Very dissatisfied” and 6% “Somewhat dissatisfied”), and six percent declined to state their satisfaction with the device.

Customers who adjusted their WaterDex device on a weekly or monthly basis were more likely to be satisfied than those who never adjusted their device. Also, customers with smaller lawns (499 sq ft or less) were more likely to be satisfied with the WaterDex device than those with large lawns (2,000 sq ft or more).

Recommend Device to Friends and Neighbors

Seventy-one percent of customers would recommend the WaterDex Device to their friends and neighbors (43% “Strongly recommend” and 28% “Recommend with some reservations”).

As might be expected, customers who were “Very satisfied” with the WaterDex Device were more likely to strongly recommend it compared to customers who were somewhat satisfied, neither satisfied nor dissatisfied, or dissatisfied with the device. Also, customers who reported they would pay to purchase the WaterDex Device ($10 to $100) were more likely to strongly recommend it than customers who would not pay $10 for the device.

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Purchasing the WaterDex Device

Sixty-three percent of customers would purchase the WaterDex Device if it cost them ten dollars and close to the majority (47%) would purchase it for 25 dollars. The frequency of customers reporting they would purchase the WaterDex device decreased as the price increased ($50; 27% "Yes (Definitely + Probably)," $75; 12% "Yes," and $100; 2% "Yes").

Customer and Household Profile

- An overwhelming majority of WaterDex customers are home owners (90%).
- Customers have lived in their homes for an average of 15 years (15.35 mean).
- The average household size consisted of approximately four people (3.52 mean). Seventy-six percent reported that their household size has not changed since they installed their WaterDex device.
- The majority of customers (54%) reported a lawn size of at least 1,000 square feet (average 1,242.5 sq ft).
- Of the customers that reported their household income, 78 percent of households earned $75,000 or more over the last 12 months.
- The average number of weeks of vacation for customers in the last 12 months was just over two (2.34 weeks); whereas customers took an average of close to three weeks (2.76 weeks) of weeks of vacation each year over the last five years.

Outdoor Water Usage and Landscaping

- Ninety-four percent of customers reported their lawn to be at least somewhat important to them (35%; "Extremely important," 41%; "Important," and 18%; "Somewhat important").
- Of the four different landscaping and gardening areas examined, 80 percent of customers have medium water use landscaped areas at their home, 49 percent have high water use landscaped areas, 37 percent have low water use areas, and 35 percent have no water use areas.
- Among customers that reported they having water use areas, the vast majority primarily used automatic sprinklers to water (high water use areas: 80%, medium water use areas: 78%, low water use areas: 68%).
- Thirty-one percent of customers had a leak in their irrigation system over the last 12 months and all but one have had the leak fixed.

Attachment C

Summary of Irvine Ranch Water District's Allocation Based Rate Structure

Irvine Ranch Water District's Allocation Based Rate Structure – The Foundation of a Successful Water Use Efficiency Program

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Fiona Sanchez, Water Efficiency Manager
Irvine Ranch Water District
15600 Sand Canyon Avenue
Irvine, CA 92619

SUMMARY

Irvine Ranch Water District (IRWD) is a recognized leader in water use efficiency as evidenced by the District's pioneering water recycling program which began in the late 1960's. Water resource stewardship has been a hallmark of IRWD since its inception. The District set an aggressive tone to promote the efficient use of all water resources beginning in the late 1980's and into the drought of the early 1990's. This effort, which included intensive communication with the various customer groups and some of the first home water audit and ultra low flush toilet programs in the state, culminated in the adoption of an allocation-based tiered rate structure by the IRWD Board in 1991. The rate structure is a foundational tool in IRWD's successful water use efficiency programs, and has resulted in significant water use reductions. Secondary benefits include reductions in urban runoff flows, energy savings and reduced green house gas (GHG) emissions.

The rate structure was instituted to promote the efficient use of water, and is designed to provide customers a significant economic incentive to use the proper amount of water required to serve indoor, landscape, commercial/industrial and institutional demands. This is accomplished by setting a customized "allocation" for each customer account that is based upon a variety of factors such as: irrigated area, daily weather characteristics, number of residents, industrial or commercial business type, and other more unique characteristics such as the presence of a pool, livestock or specialized industrial equipment. Water is then sold to customers under a five tier structure based upon their monthly allocation which varies for landscape use relative to weather patterns. Customers using water within their allocation purchase water in the lower two tiers (including a below cost first tier) and are rewarded with very low water bills. Customers using in excess of their allocation also purchase water in one to three steeply ascending upper tiers, resulting in relatively high water bills and a strong pricing signal for excessive use. IRWD's 2010 commodity rates for each of the five tiers are shown in Table 1.

Table 1

Tier	Rate Per CCF	Use (As a Percent of Allocation)
Low Volume Discount	$0.91	0-40%
Conservation Base Rate	$1.21	41-100%
Inefficient	$2.50	101-150%
Excessive	$4.32	151-200%
Wasteful	$9.48	201% +

Rates Effective July 1, 2010

IRWD also assesses a monthly fixed charge based upon meter size. This fixed charge provides adequate funding for all operating costs other than the water commodity itself and the district's water use efficiency and related programs. As such, IRWD enjoys revenue stability regardless of the amount of water sold or the degree of conservation experienced from customers' water use efficiency practices.

The rate structure not only signals customers when they are over-using water, but also signals IRWD as to which customers need the greatest degree of attention. This two-way communication helps IRWD focus its financial and staff resources efficiently. Customer service is also emphasized. For example, billing adjustments are provided for customers that have over-allocation use related to leaks if the customer shows evidence of the leak repair. In addition, customers that have habitual over-allocation use are contacted by IRWD staff and offered leak detection services, as well as water use efficiency education and assistance.

Revenue from higher tier, over-allocation water use is "reinvested" to fund tailored programs and rebates for long-term improvements in water use efficiency and to support IRWD's urban runoff source control and treatment programs. The rate structure is designed to derive sufficient revenues from the over-allocation use tiers to completely fund these programs. Because a substantial portion of water consumption in southern California is for outdoor irrigation, the rate structure also helps control over-irrigation and the associated generation of pollutant-carrying dry weather runoff which flows into environmentally sensitive creek and estuary systems. The relationship between over-irrigation and urban runoff generation provides an appropriate role and nexus for IRWD's participation in urban runoff treatment and source control programs.

ALLOCATION FORMULA

Allocations are calculated using the following formula:

$$\text{Allocation} = \frac{\text{Kc x ET x LA (acres)}}{\text{Efficiency}} + \text{Indoor Use (if applicable)}$$

Kc = Crop Co-efficient. The relative amount of water needed to irrigate the landscape. IRWD assumes 100% warm-season turf. This ranges from 0.58 to 0.72, with an annual average of 0.65.

ET = Reference evapotranspiration. The amount of water that evaporates into the air and the amount of water that is transpired through the vegetation. Evapotranspiration values are computed daily from IRWD's three weather stations.

Indoor Use = Based on number of people per household for residential accounts. Default number of residents per household for single family is 4. Based on number of employees and business process water for commercial/industrial accounts.

LA = Landscape area in acres. Default acres for single family is 0.03. Variances to increase the irrigated area can be requested and applied.

Efficiency = Application efficiency. This is the efficiency of the irrigation system.

Parameter	Values Adopted 1991	Values Adopted July1, 2009*
Crop Coefficient	100% Cool Season Turf Ranges 0.66 – 0.93 Annual average = 0.80	100% Warm Season Turf Ranges 0.58 – 0.72 Annual average = 0.65
Irrigation Efficiency	80%	71%
ETAF (Annual Average)	1.00	0.92
Outdoor Allocation Percent Reduction	n/a	8%
Indoor Allocation Effective July 1, 2009	75 gallons per person per day	55 gallons per person per day
Default Single Family Allocation Per Day	300	220
Indoor Allocation Reduction Effective July 1, 2009	n/a	26%

Note
*These changes were long-planned in response to changes in plumbing code and other technology. It was entirely coincidental that IRWD implemented the change during the statewide drought and recession.

Overall Percentage Reduction in Allocation
Because of the variability in landscape acreage and ET, which impact the landscape allocation calculation the overall percent reduction is variable. There is a larger percent reduction in the summer winter months when irrigation accounts for a much smaller fraction of the total allocation. For single family customers with default indoor and outdoor (0.03) acres, we estimate the average annual allocation reduction is 24%. As landscape acreage increases, the total percent reduction in annual allocation slightly decreases, i.e. if landscape area is 2500 sq. ft, annual average reduction is 23%; if it is 4,000 sq. ft, the overall annual allocation reduction is 22.5%.