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**SUBJECT: STANFORD BUDGET-BASED WATER RATES PROJECT**

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## Executive Summary

Our team partnered with the Redwood City Public Works Department through a service-learning class in the Urban Studies Department at Stanford University. Our group was asked to (1) analyze the effectiveness of the budget-based rates program implemented in January 2009 with large landscape irrigation customers and (2) provide recommendations regarding expansion of the budget-based rates program to residential customers. Individualized water budgets have been calculated and provided to large landscape irrigation customers since 2002; however, the City incorporated this concept into a rate structure to combine education with a strong price signal in 2009 to further manage demand. Water conservation is important in Redwood City not only due to weather variability, but also because the City's only source of potable water is the San Francisco Public Utilities Commission and supply is not expected to increase over time.

Our team sought to measure success in terms of both aggregate water savings and customer perceptions of the program with respect to the program goal of achieving at-budget water use year-round. We searched for areas in which the program might improve and used these insights to develop a set of recommendations to improve the current program and facilitate implementation with residential customers. We utilized a multi-pronged approach:

### ➤ **Data Analysis**

The City provided our team with a spreadsheet of customer information, historical water use, and water budget data for 2001-2011. We created a database and wrote a number of queries to examine different patterns and relationships in the data. For purposes of this analysis, our team defined over-budget as the difference between usage and budget. The calculation used for over-budget in the provided spreadsheet gives a lower-bound at 0, discounting under-users. We found the City's water conservation program to be successful at reducing water demand gradually and consistently since 2001, with the largest reductions in water use occurring in 2003 and 2008. Thus, it is unclear whether water savings in 2009 and 2010 are part of a long-term trend or due to the implementation of the budget-based rates program in January 2009. It is likely that many factors are attributable to the success of the City's water conservation program.

Some interesting findings include:

- Since 2001, total water use has decreased by 28% and over-budget potable water use has decreased by 91%, currently only 3% over-budget.

- Commercial properties, HOAs, and properties employing landscapers typically overuse, while schools typically underuse. Churches, parks, and Caltrans typically use water at-budget.
- Lack of customer engagement (as defined by having an email address on file) is correlated with smaller users that use water over-budget. We show that these users seem wholly unaffected by the budget-based water rates program.

#### ➤ **Customer Survey**

To analyze customer perceptions and understanding of the program, our team developed a survey comprising multiple-choice and open-ended questions. We created a web site to host the survey and sent a personalized link to take the survey to all customers with an email address. We also called every customer without an email address to try to distribute a link to the survey. We received a 7% response rate out of 180 people surveyed. The survey focused on: customer and property information, customer understanding of the program, perceived fairness of the program, customer efforts to conserve water, usefulness of the program tools, and feedback on potential areas for improvement. Our main findings are:

1. Customer understanding of the program is limited.
2. Customers have difficulty planning for variable water budgets based on changing real-time weather data.
3. Customer contact information is outdated.

#### ➤ **Case Studies**

To inform our recommendations, our team researched similar programs through online research, phone interviews, email interviews, and a literature review. Although there are many different ways to implement a budget-based rates program, we found that Redwood City is generally implementing best practices.

#### ➤ **GIS Analysis**

The City also provided our team with historical water use data for residential customers, which we used to spatially analyze water use patterns in Redwood City. We hypothesized that overuse may be correlated with parameters such as income and slope. Although we cannot draw any definitive conclusions from this analysis, the maps and discussion are included for informational purposes.

Based on the information gathered from the data analysis, customer survey, GIS analysis, and case study research, our team developed four core recommendations for program

improvement. The first two recommendations are heavily centered on customer engagement and education; the last two recommendations stem from ideas encountered in our case studies and literature review. Our four core recommendations are:

➤ **Recommendation # 1 - Customer engagement**

Encourage customers to engage with the program by offering incentives to provide email addresses and log on to the web portal. Focus engagement and education efforts in the summer months when overuse is highest.

➤ **Recommendation # 2 - Address customer concerns with billing based on real-time weather data**

Address customer concerns regarding being billed based on variable weather conditions by tracking the accuracy of budget projections. If these projections are found to be generally accurate, then this is just a customer education issue. If the projections are generally inaccurate, then the City should consider changing the way projections are calculated or not providing them at all. Another option would be to eliminate real-time weather conditions from water budget calculations.

➤ **Recommendation # 3 - Grant program to encourage innovative water conservation**

Implement a grant program that would allow customers to apply for funds to cover water conservation projects that are not covered by the rebate program. This would provide flexibility for the customers with particular needs and encourage innovation.

➤ **Recommendation # 4 - Recognition program**

Create a recognition program and use social marketing to encourage customers to conserve water. We recommend implementing a program that does not have many requirements to increase participation and reduce City resource requirements.

We thank the City for the opportunity to submit these recommendations for your review. Although we have found the conservation program to be successful, we believe our recommendations will aid further progress toward achieving at-budget water usage year-round and will improve customer perceptions of the program.

## Introduction

The City of Redwood City, California began an aggressive water conservation program in 2001. This included calculating individualized outdoor water budgets for its large landscape irrigation customers and providing this information to customers for educational purposes. This concept was then incorporated into a rate structure through the water budget-based rates program in January 2009. Budget-based water rates are determined by customer-specific “need” during a given billing cycle, which can be calculated separately for both indoor and outdoor water use. The definition of “need” varies between municipalities, but outdoor calculations generally consider landscape type, landscape area, and real-time weather conditions while indoor calculations include business needs and household size. Redwood City’s Program, administered by the Redwood City Public Works Department, is currently in place for outdoor water use at large landscape irrigation sites, like commercial properties, parks, homeowners associations (HOAs) and golf courses. The City is planning to implement this budget-based rate structure with residential customers in the future, which will begin as a voluntary program.

The goal of Redwood City’s budget-based water rates program is to incentivize customers to use water at their “budget” year-round. It is undesirable for customers to use water in excess of their budget because this is wasteful. It is also undesirable for customers to use water under their budget because this would be detrimental to the health and vitality of City landscapes. Data analysis of historical water consumption reveals that Redwood City is approaching at-budget annual potable water use, a tremendous step toward sustainable resource management. Our analysis of customer perceptions, however, reveals that despite significant education and outreach efforts by the City, further work remains to be done. This might hold strong implications for program expansion to residential customers. Our recommendations address possible avenues for educating current and future customers, as well as increasing customer engagement with the program.

## **Purpose**

As a team of Stanford University students working with the Redwood City Public Works Department, our goal with this program was threefold: (1) assess the effectiveness of the existing program, (2) assess customer perceptions and understanding of the existing program, and (3) make recommendations about improving the current program and expanding the program to include residential accounts. We began our investigation in March 2011 and our findings are included in this report.

## Approach

To assess the existing program, we were provided per billing-cycle data on budget, use, and overuse for each customer. With this information, we assessed various combinations of data ranging from the change in total use over time to potable-only customer water use for each individual month in 2009.

The second step, soliciting customer feedback, helped us focus on useful information. We created a seven-part online survey targeting customers already involved with the program, contacting them via database e-mail addresses. Additionally, we followed up by phone with those customers who had no email address listed in the system. The focus of the survey served to gauge customer understanding of the program, while also providing detailed critiques on various aspects of the program. The survey addressed a variety of topics, from an evaluation of the online assistance tools to a self-report on the value of water conservation.

Finally, we undertook a literature review, created geographic information system (GIS) maps, and applied customer feedback to make recommendations for a potential residential program expansion. Given that budget-based water rates are a relatively new practice, the literature review was brief; however, we supplemented the research with multiple case studies. Further, we used GIS to spatially analyze current residential usage in an attempt to correlate overuse with neighborhood or terrain, potentially revealing budgeting inequities.

## Current Program Assessment

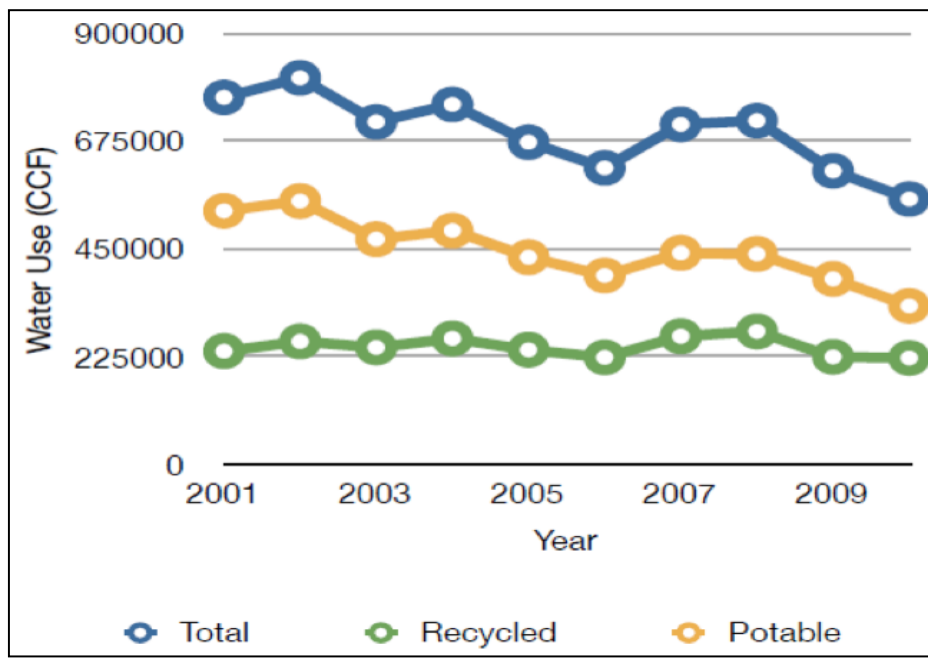
A primary goal of the project was to analyze the effectiveness of Redwood City's current budget-based water rates program. The Public Works Department maintains a database containing detailed customer information and water usage history. Using this data, our team sought to gain insights into the current state of water usage in Redwood City, the impact of the budget-based water rates program, and areas in which the program might improve. These insights would form the basis for recommendations regarding potential residential implementation and modifications to the current program.

### Method

The City provided us with a spreadsheet containing customer water usage and budget data for each water meter and each billing cycle in units of hundred cubic feet (CCF) of water from 2001 through March 2011 (Appendix A). We were also provided information regarding business type, customer contact information, and landscaper contact information when available. Due to the size of the data and the complexity of the questions we sought to answer, analysis through a spreadsheet program was not feasible. Consequently, we reformatted the data into a structure compatible with Structured Query Language (SQL) and imported it into a SQLite database (Appendix A). Using this database, we designed and executed a series of queries to analyze the data and probe deeper upon encountering potentially actionable results (Appendix A). We plotted the results of these queries using the software 'Numbers', including many not detailed in this report (Appendix A).

For purposes of this analysis, our team defined over-budget as the difference between usage and budget. The calculation used for over-budget in the provided spreadsheet gives a lower-bound at 0, discounting under-users. We believe a true measure of overuse in a community accounts for both over- and under-users.



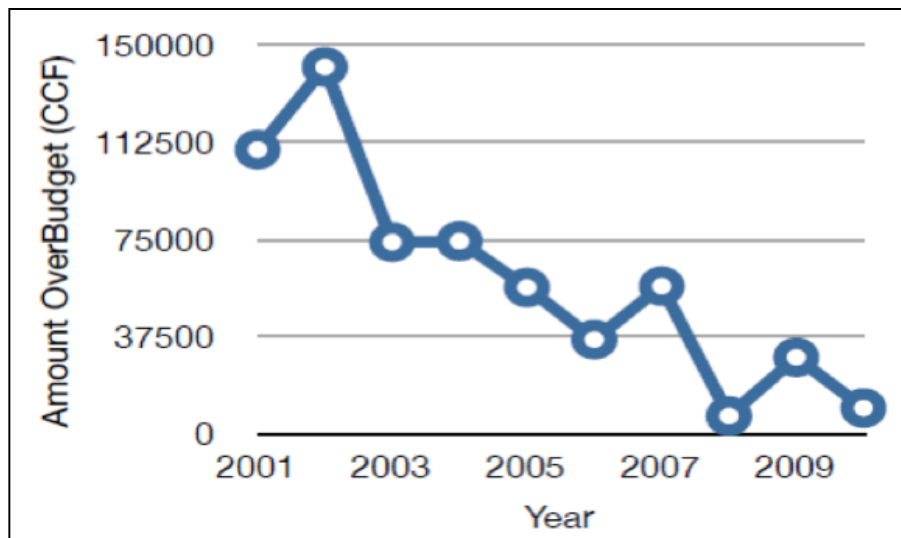


**Chart 1. Components of Redwood City water use.**

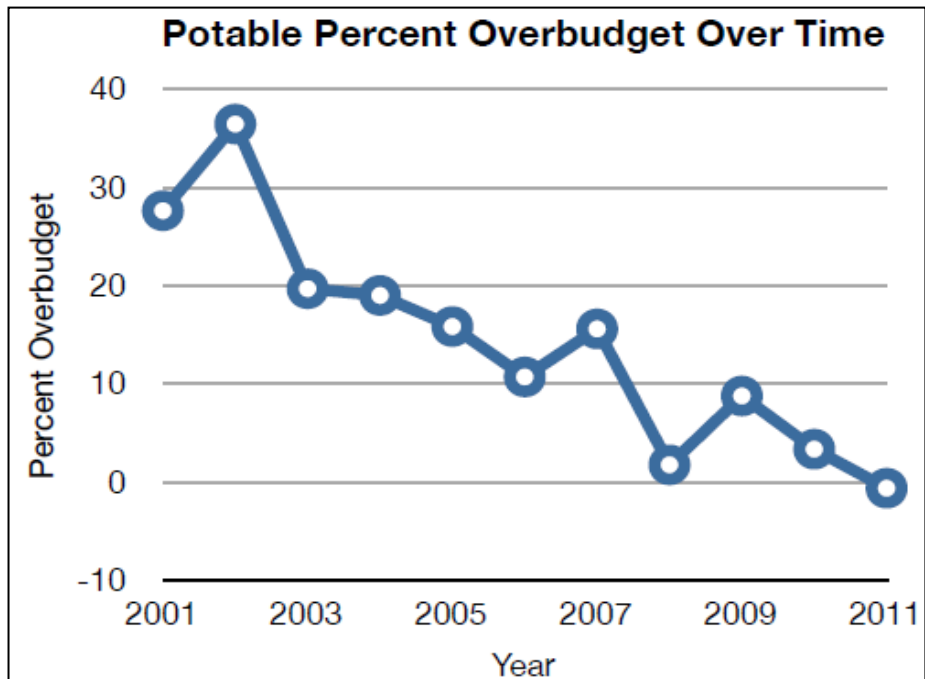
### Data Analysis

Initially, we focused on overall water usage characteristics. From Chart 1, it is clear that overall water use has decreased significantly. From 2001 to 2010 (the most recent full year), Redwood City achieved an approximately 28% reduction in total water use. Over 93% of this decrease is due to reduction in potable water usage. These outcomes are consistent with the goals of the program, which are to achieve at-budget potable water use and to not discourage recycled water use.

While a drop in potable water usage is desirable, the primary goal of the program is to achieve at-budget usage. Consequently, we analyzed progress toward this goal over time, detailed in Charts 2 and 3. From 2001 to 2010 (the most recent full year), Redwood City achieved a nearly 91% reduction in over-budget use by potable-only water users (the target of the program). This trend includes an almost 93% reduction in usage from the 2002 peak. In 2010, water use was only 3% above budget, compared to almost 28% in 2001. Thus far in 2011, the city is under-budget.

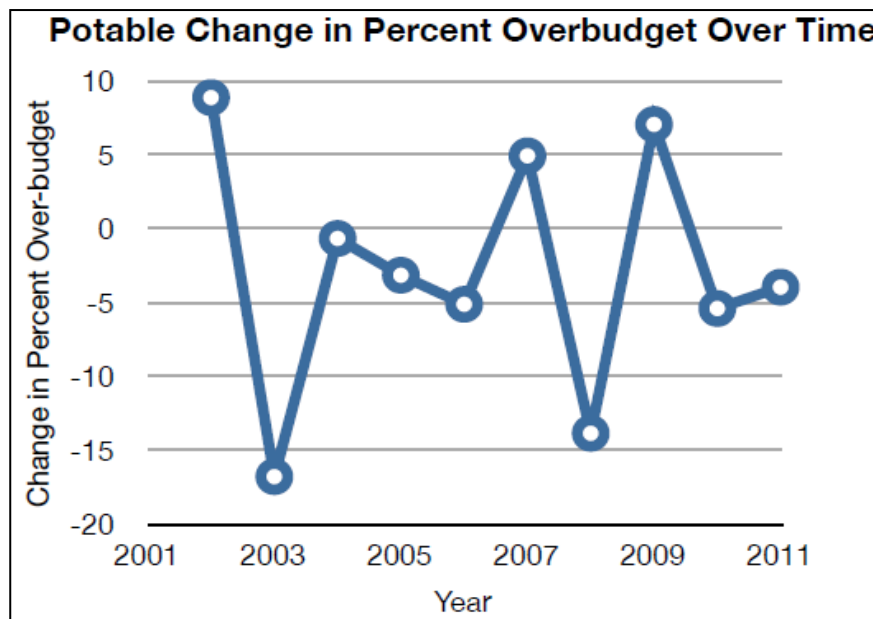


**Chart 2. Total amount over-budget by potable-only water users.**



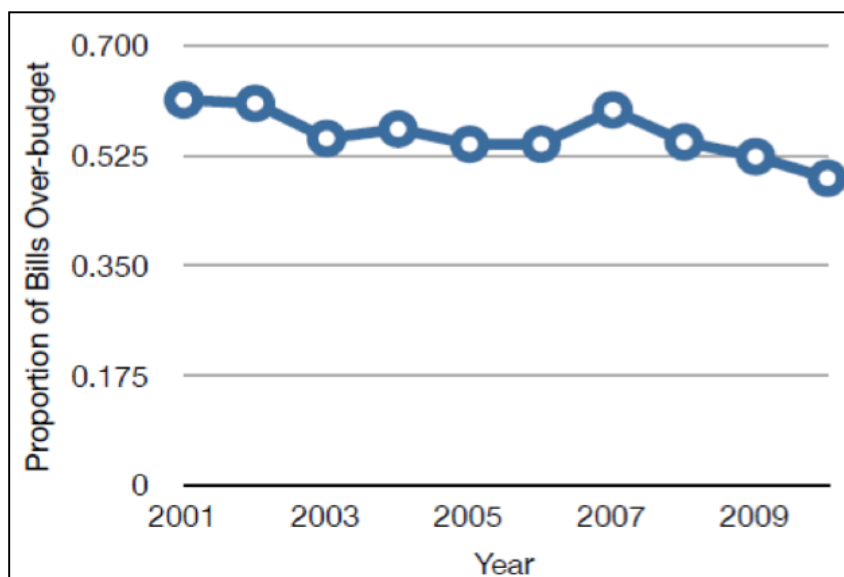
**Chart 3. Percentage over-budget by potable-only water users.**

A further goal of our analysis was to ascertain the source of change in water conservation practices. It is desirable for the implementation of the budget-based water rates program to be correlated with a significant reduction in over-budget usage, speaking to the program's ability to alter user behavior. From charts 1, 2, and 3, it appears that water conservation is a long-term trend not necessarily attributable to any single action. As shown in Chart 4, the largest percentage declines in overuse were in 2003 (17%) and 2008 (14%), prior to the introduction of the program. The 2008 reduction in usage may be attributable to increased awareness due to a statewide drought and increased outreach at many levels of government, reflecting the power of awareness in reducing usage. However, the maintenance of the gains achieved in 2008 may be due to the introduction of the program.

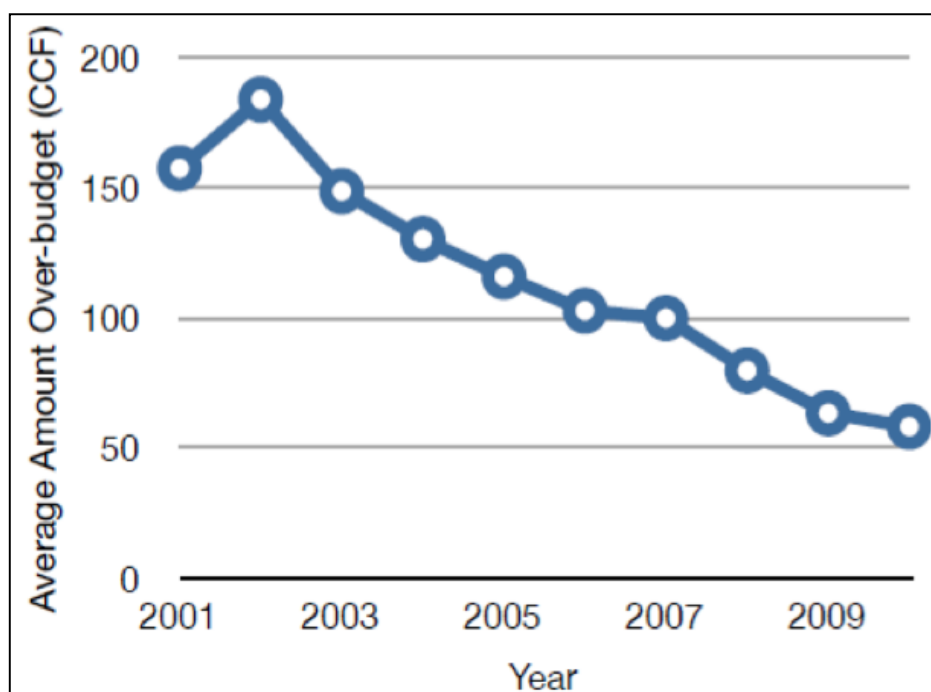


**Chart 4. Change in percentage over-budget by potable-only users.**

Interestingly, the frequency of overuse has only dropped by about 12% between 2001 and 2002, detailed in Chart 5. In the same time period, the average volume of these overuses has decreased by almost 63%, reflected in Chart 6. This may be due to a program structure incentivizing consumers to irrigate as closely as possible to their stated budget, a desired effect of the program. However, these both also appear to be in line with long-term trends.



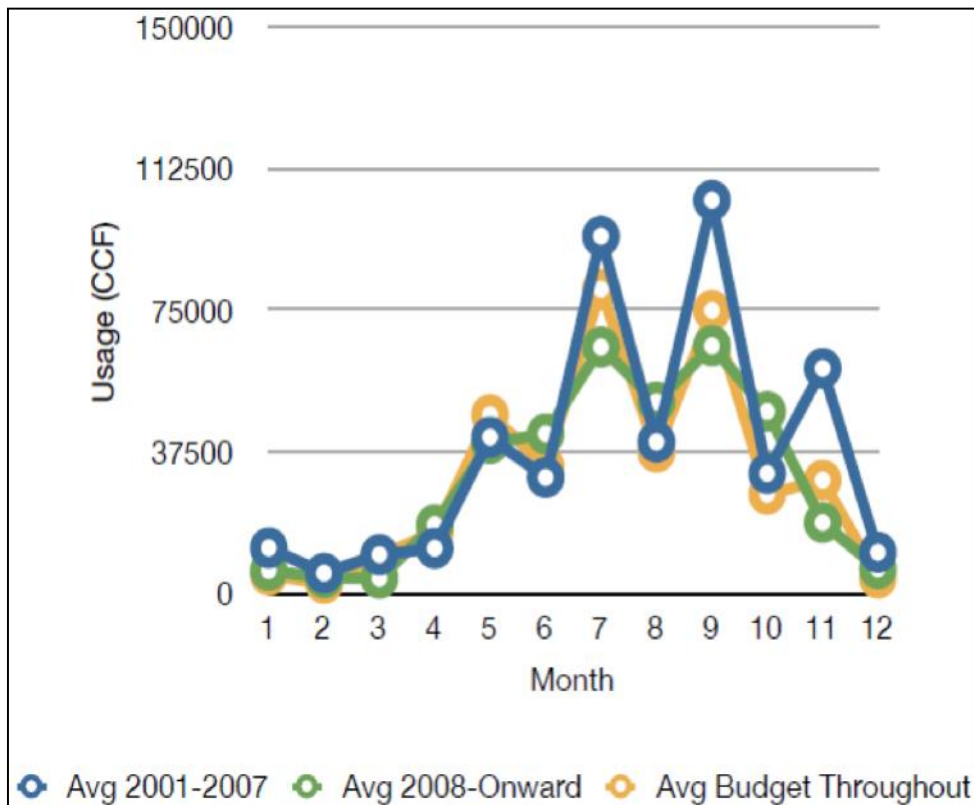
**Chart 5. Proportion of potable-only water users bills with over-budget usage.**



**Chart 6. Average amount over-budget by potable-only water users.**

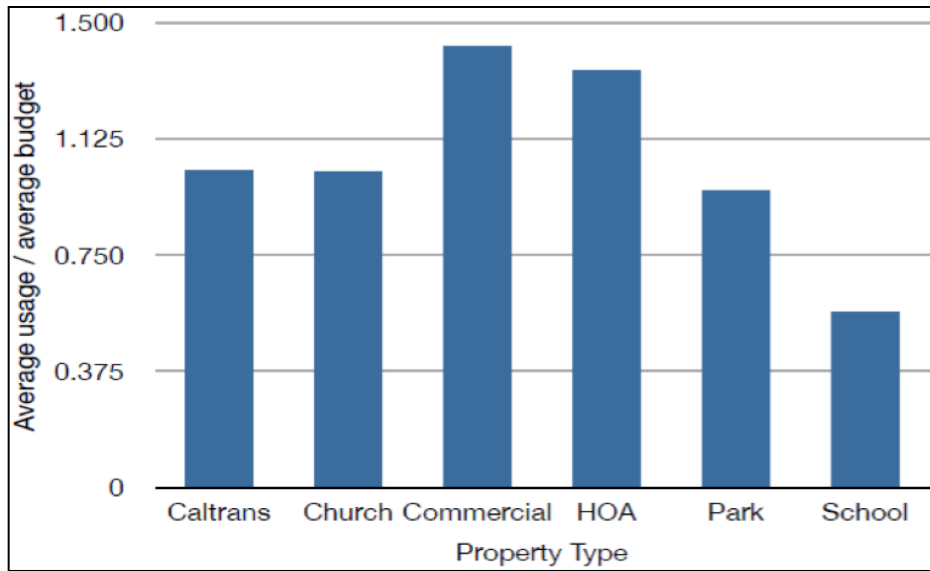
Continuing with the previous observation, a further desired outcome of the budget-based water rates program is at-budget usage throughout the year. Volatile usage patterns characterized by high levels of overuse and underuse are undesirable. To isolate the effects of increased

awareness in 2008 and the implementation of the program, we divided the data into two periods: 2001-2007 and 2008 to present. Usage throughout the year based on these data subdivisions is detailed in Chart 7. It appears that the budget-based rates program has induced a smoothing effect on usage, in line with the desired outcome. Previous overuse peaks in July and September have been marked by substantial under-use. However, the months surrounding those periods (June, August, and October) are now marked by overuse exceeding previous levels. At present, overuse is highest in June, August, and October.



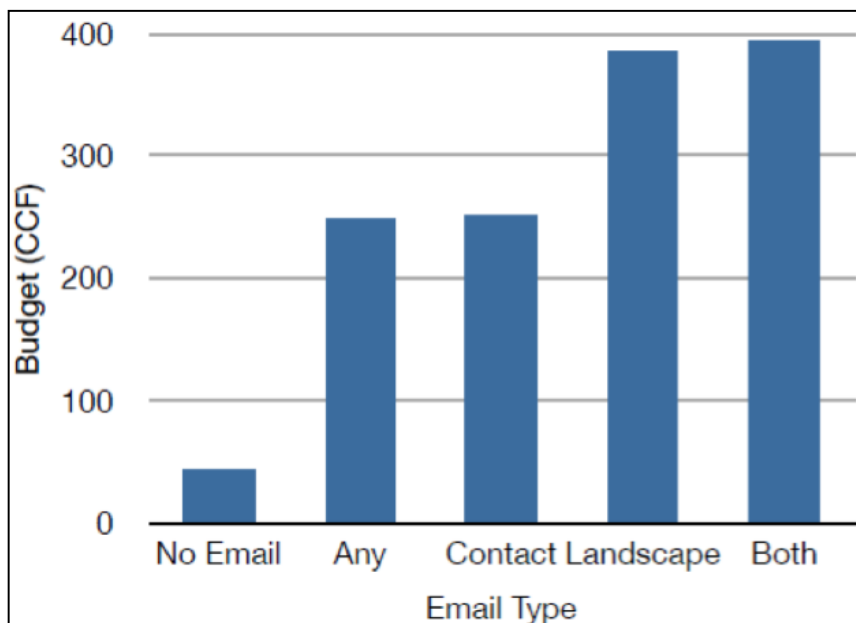
**Chart 7. Average potable-water and budget by month.**

Additional analysis examined the impact of property type on usage patterns, detailed in Chart 8. Schools were the only property type characterized by substantial underuse (45%). Churches, parks, and Caltrans all irrigated at roughly at-budget rates. Commercial properties and homeowners associations (HOAs) were characterized by large amounts of overuse, at 35% and 42% respectively.



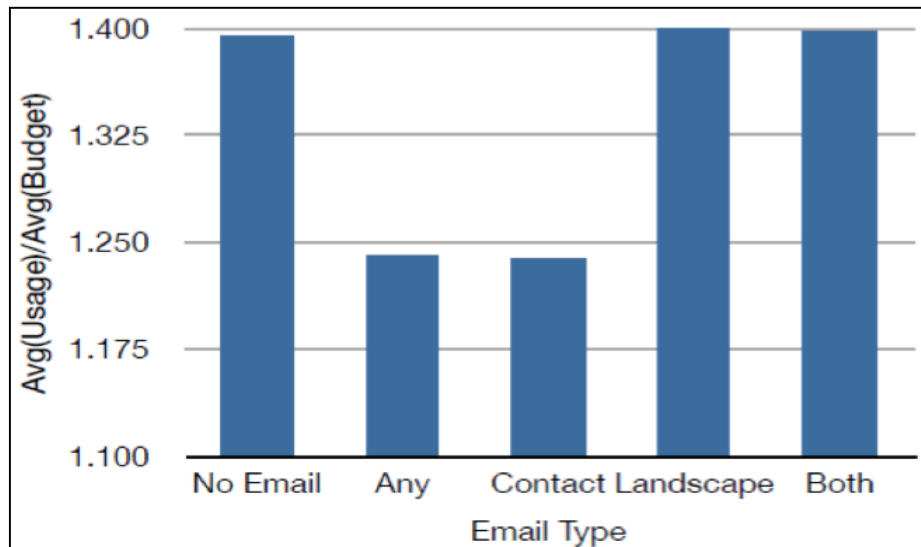
**Chart 8. Average usage / average budget based on property type.**

Further analysis sought to study engagement of users with the program and the subsequent impact of engagement on usage. For purposes of this study, we considered a user to be engaged if they provided an email address. The presence of an email address implies that they've logged into the water usage portal at least once. Our analysis revealed that engagement is highly correlated with budget size, detailed in Chart 9. Users without an email address on file have a far smaller average budget (43.8 CCF) than those with an email address on file (248.7 CCF). Even larger budgets were associated with having a landscaper email address on file.



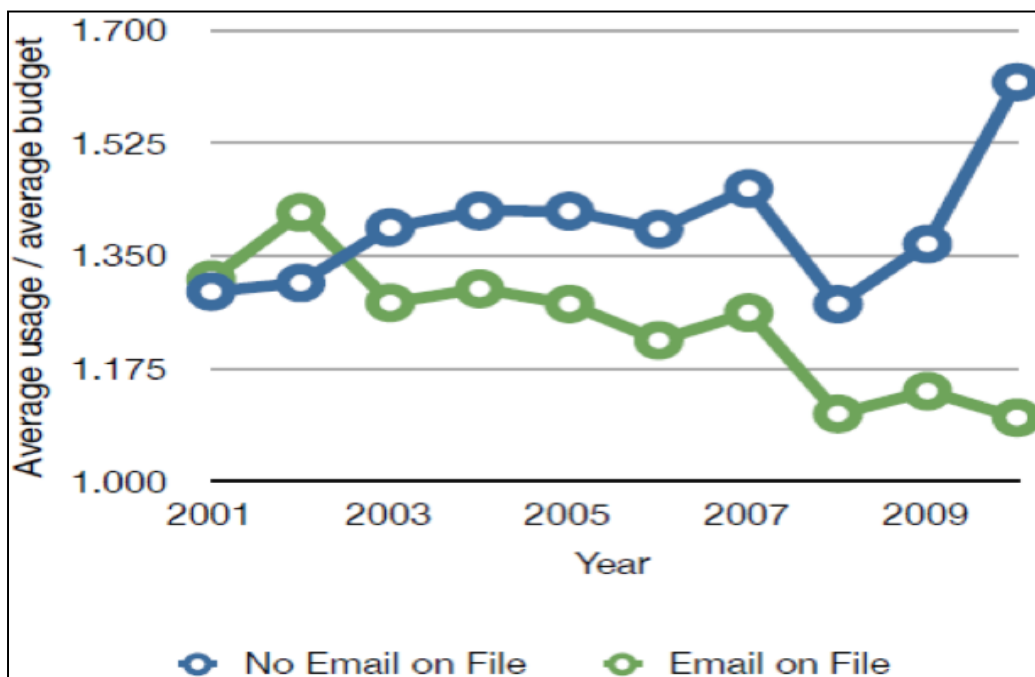
**Chart 9. Budget size based on email.**

We further discovered that engagement is correlated with reduced overuse. Users without an email address on file use roughly 15% more over-budget than users that do, detailed in Chart 10. However, users with a landscaper email address on file used roughly at the level of unengaged users. Further analysis revealed no correlation with budget size and overuse, indicating that overuse may be a consequence of landscaper use rather than property size.



**Chart 10. Average usage / average budget based on email.**

Digging deeper, we found that unengaged users seem wholly unaffected by the implementation of the budget-based water rates program, shown in Chart 11. While engaged



**Chart 11. Average usage / average budget over time based on engagement.**

users have maintained the gains achieved in 2008, unengaged users have reverted to overusing at higher rates than ever before. This speaks to the power of engagement in impacting water conservation habits.

## Conclusions

Water conservation in Redwood City is part of a long-term trend, and the city is clearly making great progress toward stated conservation goals. Since 2001, water usage has decreased by 28% - a change attributable almost entirely to a reduction in potable water usage. Potable-only water users have decreased over-budget usage by 91% since 2001 and are currently only 3% over budget. While the largest reductions in usage occurred in 2003 and 2008, the maintenance of these gains might be attributable to the implementation of the budget-based water rates program. The program seems to incentivize at-budget water usage, in line with desired outcomes. Analysis suggests the program has induced a smoothing effect on the water demand curve and altered months of typical overuse. Additional review revealed that commercial properties and HOAs typically overuse at the highest rates, while schools typically underuse. Churches, parks, and Caltrans typically irrigate at-budget. We also found a correlation between employment of a landscaper and overuse.

Further, study of user engagement revealed a high correlation of engagement with budget size as well as engagement with reduced overuse. Additionally, we showed that unengaged users seem wholly unaffected by the budget-based water rates program. Level of engagement might be reflective of the opportunity cost of consciously altering water usage behavior. Since the monetary penalty for overusing on large properties is high, this opportunity cost is overcome and users become engaged. Penalties on smaller properties may be insufficient to adequately incentivize engagement, potentially necessitating alternative methods for discouraging overuse behavior. These insights might be most relevant to a potential residential implementation, considering property sizes and corresponding budgets will be substantially lower than in the current program.

Additionally, flexibility is important in maintaining program effectiveness in a changing environment. To inform decisions about the evolution of the budget-based water rates program into the future, it is imperative to leverage analytics. The database of customer information and water usage history accessible by the public works department is the only way to truly monitor program progress over time as well as assess the impacts of decisions affecting usage. Layering various analytical queries on top of this data would provide decision-makers with real-time,



actionable data as well as allow community members to monitor progress toward stated goals. As a corollary, database information is critical for all aspects of the budget-based water rates program. Consequently, it is critical that this information is maintained at a high level of quality and accuracy. Moving forward, frequent updating and maintenance of database information should be a program priority.

# Customer Perceptions Assessment

## Method

To evaluate customer perceptions of the program, our team developed a survey<sup>1</sup> in collaboration with City staff containing multiple-choice and open-ended questions. We created a database and web site in order for customers to take the survey online. A personalized link to the online survey was sent to each email the City provided in the customer data spreadsheet, including the email addresses of the primary contact and landscapers. We sent out a total of 120 emails and called the 60 customers that did not have an email address on file. For those with only a phone number, we offered to do the survey together over the phone or to send a link to the online survey by email.

The survey focused on:

- Customer and property information
- Customer understanding of the program
- Perceived fairness of the program
- Customer efforts to conserve water
- Usefulness of the program tools
- Feedback on potential areas for improvement

We received twelve survey responses out of the 180 attempts, an approximately 7% response rate. A cause of the low response rate may be that many of the email addresses are not direct links to the person responsible for managing outdoor irrigation. Interestingly, we found that survey response is highly correlated with lot size and a history of overuse. In other words, the customers who responded to the survey were those customers who experienced the highest penalty charges and would benefit most from changes to the program. The remainder of this section will discuss survey results, bearing in mind that respondents are not necessarily a representative sample of program users.

## Multiple-Choice Survey Questions

The multiple-choice section revealed a few interesting items. All of the respondents were aware of the budget-based rates system, which is expected given that they were willing to take time to fill out the survey. Half of the respondents expressed the program was unfair and five said that they did not know if the program was fair. All those who said they did not know were

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<sup>1</sup> You can view the online customer survey at <http://www.stanford.edu/~toddbbran/cgi-bin/comSurvey.php?email=toddbbran@stanford.edu>

either general property managers or bill payers. The reasons they see the system as unfair will be discussed in the open-ended section. Ten out of twelve said that they make decisions based on their budget. This reflects what we saw in the data and is a positive finding showing that people do adjust their watering habits based on the need-based budgets they are allotted. Six out of twelve respondents ranked overall satisfaction as three out of five. This shows that after taking their criticisms into account, they are still not opposed to the program. That being said, only one person ranked the program as above average with a four out of five. Finally, when asked if they would be interested in using a similar program at home, seven marked 'No'. This may not be an issue for expanding the program to residential customers because the sample size was very small and many of these respondents may not live in Redwood City.

### **Open-Ended Survey Questions**

All respondents provided insightful answers to the open-ended questions, providing explanations for why certain customers had responded that the program was unfair. The most common complaint explained the difficulty of planning for variable water budgets based on changing real-time weather data. One customer said the Public Works Department should “make budgets a forecast tool not a historical tool”. The customers find it unrealistic to change water timers daily or even weekly based on the weather. Conversely, some customers do not even attempt to reprogram timers on a regular basis. For example, one customer we spoke with said that her homeowners association (HOA) turns the water on in the summer and then off in the winter, with no adjustments in between. This customer was a former President and current Secretary of the HOA and was unaware that a budget-based rates program existed.

An additional critical insight from the open-ended responses is that customer understanding of the program is limited. The program actually already addresses many common respondent concerns. For example, customers suggested that budgets be calculated using CIMIS, rebate programs should be enacted, canopy covers should be taken into account, and that the equation should consider the percentage of water run off before it can be absorbed - all of which Redwood City currently accounts for. Finally, the responses demonstrated that customers are unclear that the budget-based rates program is only for outdoor water use, as opposed to indoor water use. Many customer concerns of unfairness may be a product of a lack of program education.

## **Phone Calls to Customers without Email Addresses**

We called all 60 customers who did not have an email address on file, but did have a phone number. We hypothesized that these customers would be the least informed about the program. We were unable to confirm this because the response rate to the phone calls was low. At least half of the sixty numbers are either wrong numbers or are disconnected and no longer in service. Another quarter was the correct business, but the wrong contact person and we left voice messages for the final quarter. Of the four people we were able to speak with on the phone, two elected to take the online survey.

We learned that the contact information in the customer database is outdated. In a program so reliant on customer awareness, this could be a significant element holding the program back from its full potential. Many of the email addresses on file may be out of date as well, potentially explaining the low response rate to the online survey. As explained before, customer engagement is highly correlated with at-budget water use. Improved customer awareness and engagement would contribute to improving conservation efforts.

## Case Studies

### Method

To inform our analysis, our team researched similar programs through online research, phone, and email interviews, and a literature review. Peter Mayer’s “Water budgets and rate structures: Innovative management tools” provided background on the subject by summarizing budget-based rates programs at thirty locations nation-wide.<sup>2</sup> Based on a phone conversation with Peter Mayer and geographic considerations, our team chose to focus our research on Boulder, CO; Irvine, CA; Santa Barbara, CA; and Capistrano, CA. Evaluations of these programs consisted of billing structures, methodology of water budgeting, program goals, and penalties. We subsequently conducted online research, e-mailed the main contact at the Public Works departments for each city, and followed up with phone calls. During our phone interviews, we asked our contacts about any successes and failures they had implementing budget-based rates and if they had any recommendations for Redwood City.

### Analysis

The objective of the case studies was to seek information that may result in the potential improvement of the current budget-based water system in Redwood City. However, since each program is intrinsically different, it is difficult to accurately compare the programs. The most difficult portion to compare is pricing, since water rates are set to cover the cost of providing the service and thus come with nuances that are location-specific. These include the supply of water available, the cost of transporting water, and the cost and size of the distribution system.

	<b>Tier 1</b>	<b>Tier 2</b>	<b>Tier 3</b>	<b>Tier 4</b>	<b>Tier 5</b>
<b>Redwood City, CA (landscape)</b>	\$3.92 (0-100%)	\$7.84 (101-200%)	\$11.76 (201%+)		
<b>Boulder, CO (all)</b>	\$2.18 (0-60%)	\$2.90 (61-100%)	\$5.80 (101-150%)	\$8.70 (151-200%)	\$14.50 (201%+)
<b>Irvine, CA (landscape)</b>	\$1.21 (0-100%)	\$2.50 (101-110%)	\$4.32 (111-120%)	\$9.48 (121%+)	
<b>Capistrano, CA</b>	\$2.57 (0-6ccf)	\$3.42 (6ccf-100%)	\$5.13 (101-200%)	\$9.42 (201%+)	
<b>Santa Barbara, CA (irrigation, agriculture)</b>	\$1.45 (0-100%)	\$4.90 (101-118%)	\$5.16 (118%+)		
<b>Santa Barbara, CA (irrigation, comm.)</b>	\$4.90 (0-100%)	\$5.16 (100%+)			

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2 Mayer, Peter. (2008) “Water budgets and rate structures: Innovative management tools”.

The rate structures of Redwood City and four similar budget-based rates programs are provided in Table 1. There are several notable points. First, Boulder, CO discounts water use up to 60% of budget. We learned that Redwood City does not enact this practice because they calculate water budgets more accurately. Second, cities send varying degrees of price signals to their customers. Boulder, CO sends the strongest price signal for the 200%+ tier by charging 5 times the base rate, while Redwood City charges 3 times the base rate. Santa Barbara, by contrast, does not even charge double the base rate for use above 100% in the case of commercial customers. Recall that comparing the base structure and the subsequent increases from block to block is the most effective way of analyzing this set of data, since prices are set based on cost-of-service considerations. Lastly, there are different ways to structure the number and size of tiers. For example, Irvine charges almost 4 times the base rate for use above 120% of the water budget. While Redwood City has three tiers, Boulder has 5 tiers and Irvine has 4 tiers. The problem with making these comparisons is that the rate structure for water above 100% of the budget is complicated by the fact that it must take into account the cost of obtaining this added water. Redwood City may take this information and decide that there is precedent to send an even stronger price signal for excessive water use.

Additionally, the case studies and literature review showed that the City has already implemented many best practices. Some examples of recommendations that are already a part of the program include:

- Communicate the basis for the water budget and supply constraint to customers.
- Revenue from water use above 100% of the budget should go directly to water conservation efforts.
- Implement an informational budget program before implementing a budget-based rates program.
- Meter outdoor and indoor water use separately.
- Account for household size in the indoor water budget calculations for residential customers.
- Do not allow customers to self-report information that will be used to calculate their water budget.

Some examples of ideas and recommendations that the City could consider as the program develops include:

- A phone interview with Francie Kennedy, the Water Conservation Manager of the San Juan Capistrano Valley Water District, revealed that a grants program that allows customers to apply for funding for specific water conservation projects may supplement the current rebates program and encourage innovation. San Juan Capistrano Water District does not have a program like this, but there is a nearby regional program.
- If you do implement a recognition program, classify by customer type to avoid inadvertently rewarding customers with small lots, who by virtue of having a small lot use less water.
- Landscape topography is an important parameter since there is more surface area on a sloped site; however, there is not an established way to deal with this when calculating a water budget. A phone interview revealed that San Juan Capistrano Water District will add 15% to the sloped area's budget in response to a customer complaint.
- The City may wish to look to other programs to find new methods of calculating the water budget, both more lenient and strict. In addition to including landscape topography, one site calculates the water budget using cool season turf grass for the budget coefficient as a gesture of generosity to customers. This same site allows no more than 70% of effective transpiration (ET), largely in accord with the recently passed AB1881. Redwood City, alternatively, allows for 100% of ET for turf grass. However, Redwood City does make efforts to account for plant type, specifically for tree canopy. The City accounts for this by measuring the drip line around the tree. Allocating water by plant type allows customers to make smarter choices, forcing them to understand the geographical climate in which they live.

Furthermore, we found information detailing residential customer water use patterns and the most effective ways to engage residential customers. This relates to the findings described in the previous sections of this report, since customer engagement has been shown to be a critical piece of water demand management. Some results from the article include:

- Only 13% of residential respondents found email and web site as effective means of communication.
- Utility bill inserts and TV ads were cited by respondents as best two ways to reach residential customers.

The City of Redwood City needs to decide if these findings apply, since there is significant geographic variability and implementers must understand their community. This

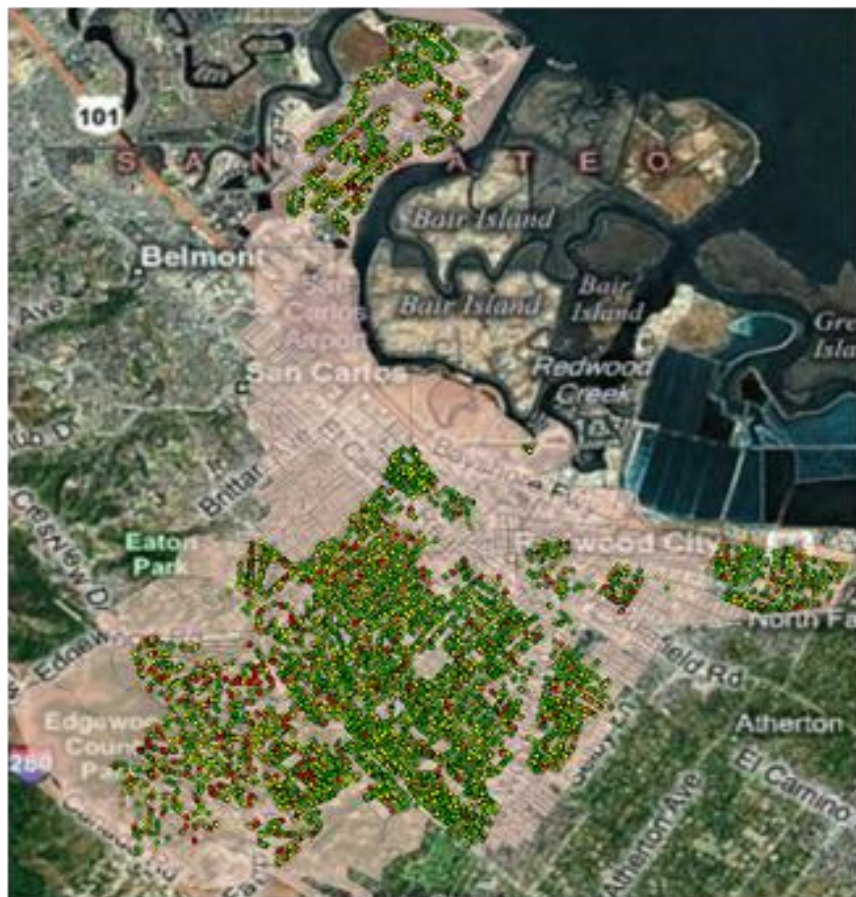
information actually seems contradictory to our findings that having an email address on file is highly correlated with using water at-budget. It is likely, however, that residential customers may need to be targeted using different methods from large landscape irrigation customers. These details can be determined as the City begins implementing the budget-based rates program on a voluntary basis with residential customers.

Although there are many different ways to implement a budget-based rates program, we found that Redwood City is generally implementing best practices. Furthermore, this discussion reveals there are many ways in which the program could be changed or improved to further incentivize water use reductions and improve customer perceptions and understanding.



## GIS Analysis of Residential Water Use

In anticipation of the eventual implementation of a budget-based water rates system for residential properties, we decided to leverage existing water use data relative to the informational budget to find spatial correlations with overuse. Specifically, the data set was compiled from 11,259 households within Redwood City, illustrated in Figure 1. They are spread out among three regions: Redwood Shores at the top (NE), North Fair Oaks to the right (SE), and the Greater Redwood City region at the bottom left (SW). Each residential property is a dot on the map, the range of colors representing its location on the spectrum of water usage. The five colors (dark green, light green, yellow, orange, and red) are each associated with a unique usage tier. Respectively, the tiers range from 0-60%, 60-100%, 101-150%, 151-200%, and 201-913%. The reason for 913% being the top end of the spectrum is that, while uncommon to go past 300%, one of the residential customers uses over nine times their allocated water budget. For the most part, it is least favorable to see users in the red and orange categories. However, it is counter-intuitive and important to note that the dark green region is also unfavorable since it is likely that these customers are under-watering and potentially sacrificing their landscape. In terms of correlative conclusions, it is hard to make any defensible claims about the data at this level of granularity other than the clustering of over-users in the furthest west (bottom left corner) of Redwood City. Our original hypothesis to explain this was that this region, with its irregular street patterns, seems to have a hilly terrain, which could lead to increased runoff. This area



*Figure 1: Individual Overuse by Each Household*



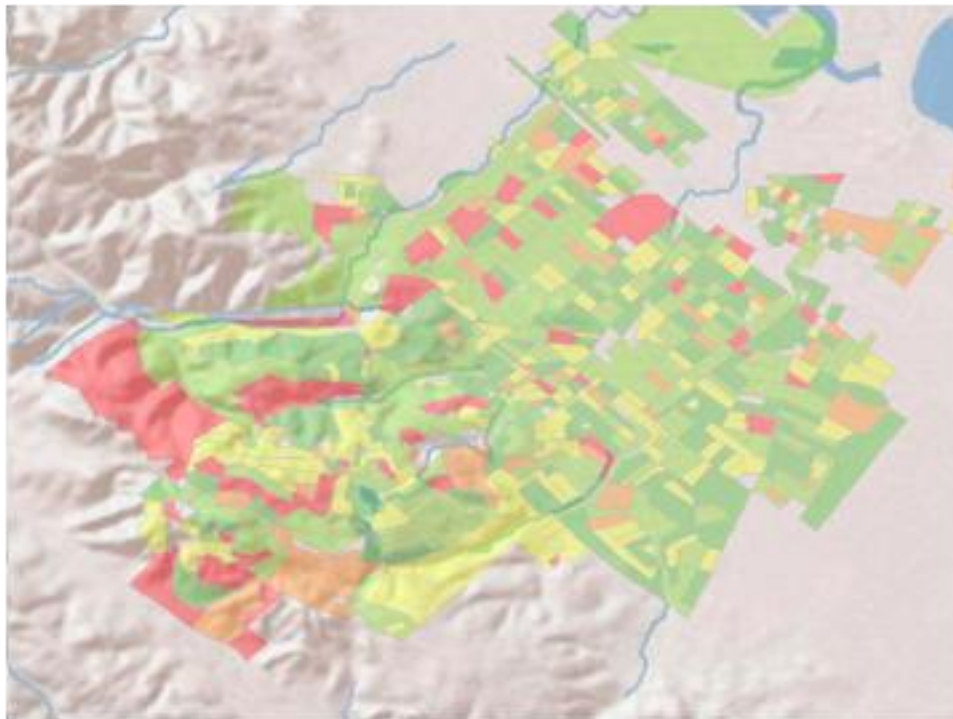
***Figure 2: Aggregated Overuse by Block Group***

slightly misleading, considering that some of these block groups may only have a single customer within it whereas others may be the average of up to forty residences. Similar to our initial results, there is lack of a clear spatial pattern with over-users, which, with respect to the rates program, is a desired water conservation characteristic. While discovering a spatial trend would facilitate the process of targeting problem areas for improvement, the lack of them shows that there aren't any immediate geographic flaws to the system. Potential conclusions to be drawn from this iteration are that the Redwood Shores area of the city seems to be near budget, the core grid at the center of the city seems to be using water at a relatively uniform amount, and there remains a cluster of chronic over-users mixed among a wide variety of other user types in the far west (bottom left corner) of the map.

also seems to be the more expensive, higher-income region of the city wherein it is likely that customers may be less concerned with the fluctuation of their water bill.

In Figure 2, we have taken the same individual household overuse data and aggregated the water use data into census block groups. Using the same numerical tiers, the color of each polygon is now determined by the total averaged overuse of all the residences within its boundaries. This can be

Figure 3 shows the final spatial depiction of residential water-use in Redwood City. This map focuses solely on the region earlier referred to as Greater Redwood City, excluding Redwood Shores and North Fair Oaks. This illustration of a relief map focuses on elevation, a feature that is insignificant in the almost entirely flat regions of Redwood Shores and North Fair Oaks. This map reinforces our earlier hypothesis that the neighborhood to the far west of Redwood City is the most topographically dynamic. Therefore, the area might be contentious with respect to minimized benefits from rainfall resulting from increased levels of runoff on landscapes situated on slopes. While it would be beneficial to find a relief map at a more micro scale, at this level we can identify a greater proportion of red, orange, and yellow in the lower left diagonal half of the map. This follows logically as it is at this same boundary where the relief map ceases to indicate the presence of elevation-changing physical features. From this map there



***Figure 3: Elevation Overlaid on Aggregated Overuse***

also seems to be a correlation between proximity to streams and riverbeds and users staying near budget. This might be a topic worth delving deeper into, but it could also be coincidence.



## **Recommendations**

### **Recommendation # 1 - Customer Engagement**

Engagement is critical in influencing water conservation decisions, as evidenced by the strong correlation between lack of engagement and over-usage detailed in Chart 10. Consequently, outreach to achieve high engagement levels should be a foundational component of future programs. The greatest gains in water conservation achieved throughout the past ten years have followed periods of highly publicized droughts (2003 and 2008) and corresponding outreach programs, detailed in Chart 4. These conservation gains hold across all users and are typically maintained for future years. This is particularly important for small-budget users where the budget-based water rates program has been thus far ineffective at impacting behavior, as shown in Charts 9 and 11. In a potential residential implementation where the vast majority of users will have relatively small budgets, engagement could prove the single most effective means of achieving conservation goals.

For greatest results, targeted outreach efforts should be conducted immediately preceding the months of highest overuse. At present, those months are June, August, and October. Accordingly, the most effective timing for outreach is throughout May, July, and September. Effective outreach methods targeted toward small users might include setting community water conservation goals and monitoring progress toward them.

Recall that engagement is defined as having an email address on file, which means the customer has most likely logged in to the web site to track their water use. Having an email address on file also enables the customer to receive over-budget alerts and water use reports by email. Since engagement has been found to be critical and contact information shown to be outdated, the City should consider offering an incentive for customers to provide updated contact information in general as well as an additional incentive to provide an email address and log in to the web portal. This would provide the City with valuable information and could be used as an opportunity to educate customers about the budget-based rates program. This is important because the online customer survey results revealed that customers do not fully understand the budget-based rates despite an extensive education outreach program employed by the City. Furthermore, the follow-up phone calls to customers without email addresses revealed that about half of the phone numbers we called were incorrect.

## **Recommendation # 2 - Address Customer Concerns with Billing Based on Real-Time Weather Data**

Redwood City's program calculates a daily water budget based on real-time weather conditions and bills are based on these values. The City also provides predictions of what the water budget will be for any given month based on historical weather data to aid customers in planning for the month. Multiple customers criticized the methodology for billing in the open-ended survey responses. One customer said:

“Make a forecast and stick with it. I cannot be reprogramming every week because it rained too much. Your forecast is not really a forecast. You only forecast for yesterday and today. If I reprogram tomorrow, I already got dinged for over watering. If you follow my charts for the past 5 years, you will see I match your forecast but delayed. I still get dinged for being late to follow the forecast. This is after using the planned amount of water for the whole year.”

Customers expressed an interest in being billed for water based on the projections instead of real-time weather data. This would allow the customers to set their meters without being penalized for unpredictable weather variations.

We are not recommending that the budget-based rate structure be changed, but we do believe that this is a significant customer complaint that should be addressed. The first step we recommend taking is to track the accuracy of projections. The City may even be able to use historical data to check the accuracy of past projections. This would result in one of two outcomes:

- (1) The projections are generally accurate – indicating that this is more of a customer education issue than systemic problem.
- (2) The projections are generally not accurate – indicates the City should consider an appropriate response. Budget projections are information that the City provides to its customers to aid in planning. If it turns out that these projections are generally inaccurate, and therefore not helpful for planning, then it may be time to discontinue providing them to customers or to adjust the way projections are calculated. As suggested by the customer survey responses, another way to deal with this would be to either eliminate or modify the way real-time weather data is incorporated into water budget calculations.

## **Recommendation # 3 - Grant Program to Encourage Innovative Water Conservation**

As suggested by the Water Conservation Manager at the San Juan Capistrano Valley Water District, another demand management strategy could be to implement a grant program that

encourages innovation. There is already an extensive, growing rebate program in place; however, a grant program would give customers the flexibility to submit proposals for water conservation improvements that fall outside the scope of the rebate programs. A percentage of the revenue derived from over budget water use could be set aside into a separate account to be used to fund water conservation proposals submitted by customers. In the open-ended survey responses, one customer complained that upgrading his sprinkler system to the latest technology has not yielded optimal results because his pipes are old. This program has the potential to give customers like this the opportunity to apply for funds to make changes that may not warrant an entire rebate program. The potential drawbacks to this plan are that it would require dedicated water conservation staff time to administer the grants program and accounting staff time to track and distribute funds.

#### **Recommendation # 4 - Recognition Program**

For both the existing landscape irrigation budget-based program and proposed residential rates program, we suggest using social marketing as an inexpensive, simple way to promote water-conscious behavior. This was implemented in the past as the “Model Site Program,” but this was resource-intensive and generated little interest. The requirements for Model Site designation included meeting monthly with City staff to provide results and review direction along with a relatively long list of schematic maps and documentation.

We recommend implementing a less stringent program that could attract a greater number of customers, such as USEPA’s WaterSense program. Launched in 2006, WaterSense is meant to promote water-efficient products, programs, and practices to protect future water supplies. One of the ways it does so is by implementing a WaterSense Partner certification program for irrigation contractors, irrigation designers, landscape irrigation auditors, and golf irrigation auditors. Such partners can then use the WaterSense logo on business cards, brochures, and other marketing materials. Materials for residential customers could include bumper stickers or signage for front lawns.

Rewards could be provided to customers who have stayed within 10% of their water budget



for a given period of time. This is the criteria used by the former Model Site Program. The chosen period of time could be three months, six months or even a year or longer. This program would be easy to maintain and it would make outdoor landscape irrigation, a relatively abstract afterthought in daily life, a more human problem thus making the notion of daily sprinkler-timer adjustments a more reasonable expectation.

## Conclusion

Based on the information gathered from the data analysis, customer survey, GIS analysis, and case study research, our team has developed four core recommendations for program improvement. The first two recommendations are heavily centered on customer engagement and education; the last two recommendations stem from ideas encountered in our case studies and literature review. Our four core recommendations are to (1) engage customers, (2) address customer concerns with billing based on real-time weather data, (3) create a grant program to encourage innovative water conservation, and (4) to create a recognition program.

The first recommendation is crucial since customer engagement (as defined by having an email address on file) is correlated with at-budget use. We recommend offering incentives to customers to provide an email address and to focus engagement and education efforts during the summer months. The second recommendation addresses significant customer concerns revealed by the customer survey. Third, we recommend implementing a grant program would allow customers to apply for funds to cover conservation efforts that are not included in the rebates program. This would provide flexibility for the customers with particular needs. Lastly, a recognition program can utilize social marketing to affect behavior change with little resource input. If a neighbor or a competing business realizes they are not in the program, it would push them to alter their behavior in order to receive rewards. Each of these recommendations will contribute to the achievement of Redwood City's goal of stabilizing water usage year-round and will improve customer perceptions of the program.



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