LANDSCAPE WATER CONSERVATION PROGRAMS: EVALUATION OF WATER BUDGET BASED RATE STRUCTURES

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by

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PREFACE

Conservation programs targeting landscape water use will take on increasing importance in the future. Water budget based rate structures have been identified as one of the most promising programs to achieve cost-effective water savings, community acceptance, and water agency support. With the current strong levels of interest, there is a corresponding need for quantifying the program impacts and for identifying the factors that have contributed to their success.

The Metropolitan Water District of Southern California sponsored this evaluation to provide answers to the above questions. This report documents a broad evaluation of four landscape conservation programs using multiple research methods. This research should be of interest not only to conservation staff and other interested parties at the four participating agencies, but also to agencies who are contemplating the introduction of water budget based rate structures in their service areas.

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Tom Ash	Irvine Ranch Water District
Joe Berg	Municipal Water District of Orange County
Ted Haring	Eastern Municipal Water District
Steve Hedges	Municipal Water District of Orange County
Francie Kennedy	Capistrano Valley Water District
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Although the PAC members contributed to this document, the authors are responsible for any remaining errors.

SUMMARY

This evaluation examines innovations in landscape conservation programs at four different locations. These innovative programs differ from each other in many respects, but all are similar in combining multiple interventions: ET_o-based water budget allocations, conservation pricing, and customer outreach programs. The relationship between customer assistance and water rates has been empirically established in other studies[1]. Landscape efficiency programs that work must address the fundamental connections between conservation and rates: customer motivation, program financing, public acceptability, and industry support. On top of this, landscape efficiency programs can play a needed role in developing drought management plans to cope with the water shortage emergencies that are a fact of life in the arid West.

Objectives

This research has the following three objectives:

1. **Process Evaluation:** Identify and describe the water budget-based rate structures, the local context, and how these programs evolved. Identify and describe the factors contributing to the successful design, implementation, and operation of water budget-based landscape conservation programs (Chapter 2 and Chapter 6).

2. **Impact Evaluation:** Evaluate program impacts, including customer satisfaction (Chapter 3), water savings (Chapter 4), and cost-effectiveness (Appendix D).

3. **Guidelines and Recommendations:** Provide guidance and recommendations to assist other agencies in developing effective water-budget based landscape conservation programs (Chapter 5).

Methods

To conduct the evaluation, a series of research tasks has been completed, each of which has produced different kinds of insights. The process evaluation tasks include a *mail-out customer survey* and *in-person agency interviews*. The impact evaluation tasks, building upon the understanding gained from the survey and interviews, include a *water use analysis* and *cost-effectiveness analysis*. Though each research task is distinct, the findings from any one task can overlap with multiple project objectives:

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[1]Chesnutt, T.W., C.N. McSpadden, and D.M. Pekelney, *What is the Reliable Yield from Residential Home Water Survey Programs?*, Presented at the AWWA Conference in Anaheim CA, June 1995.

Customer Survey - A brief survey of customer perceptions of program strengths, weaknesses, customer satisfaction, and suggestions for improvement was directly mailed to all participating customers.

In-Person Interviews - Focused interviews were conducted with agency staff responsible for implementation, board members, green industry professionals, and other interested parties to determine program success, factors important in success, weaknesses, strengths, and areas for improvement.

Water Use Analysis - Using historical account level water use records and multiple CIMIS climatic measures, climate-adjusted estimates of water savings were developed.

Cost-Effectiveness Analysis - Using results of the water use analysis, a cost-effectiveness analysis was conducted.

Findings

Program Descriptions and Interviews

A prominent finding from the interviews was the importance of flexible and adaptable program design: each of the programs were modified over time to improve their performance and to respond to customer feedback. A short list of adaptations would include new or modified customer outreach and education programs, changes to billing systems, refinements to the water budget calculation, changes to administrative procedures for handling customer complaints, and targeting top water users for moisture sensor programs.

Another important finding from the interviews was the great degree of satisfaction expressed by most water agency staff and board members with the water-budget-based rate structures as an effective and fair water conservation tool. Many of the staff members began as skeptics, but after surmounting the practical hurdles of implementation came to believe that the benefits more than matched the costs incurred. Board members often stressed the increased perception of fairness and reduction in constituent complaints.

Customer Survey

The survey was fielded in August and September of 1996 and sent to 1,113 customers at the four participating agencies, of which 170 customers (15.3 percent) returned surveys. In terms of conservation program performance, customer ratings were favorable overall; that is, customers felt that these programs were clear and understandable, responsive to customers, effectively promoted conservation, and were efficient at administration and paperwork. For example, 37 percent of those who responded to the question reported that the conservation programs were very good to excellent in terms of their ability to be clear and understandable. Another noticeable pattern

among these program performance questions was that about one quarter of those who responded rated the programs fair to poor.

The results of customer satisfaction with the multi-tier rate structure, customer outreach/education, and water budget programs were more mixed. Customers reported that, all things considered, they were somewhat more net dissatisfied than net satisfied with their multi-tier rate structures (16% = 39%-23%). "Net satisfied" refers to customer responses that are either satisfied or very satisfied, and "net dissatisfied" refers to customers who are either dissatisfied or very dissatisfied. The difference between net satisfaction and net dissatisfaction for the water budget programs is smaller; at 4 percent it is within the sampling error. The difference for customer outreach/education is smaller still, and therefore, also within sampling error. The results support the hypothesis that tiered rate structures alone are not popular among customers and that complementary programs, such as outreach and education, are important to reduce financial impact on customers and assist customers in meeting clear water conservation goals. The "stick" needs to be accompanied by the "carrot" to result in satisfied customers.

Water Use Analysis

The water use analysis was conducted in three steps: raw water use comparison, including correction for customer characteristics, climate correction, and structural models of the conservation program interventions. The raw water use analysis required careful data analysis to assure the validity of the water consumption measures. Otay Water District experienced a 20 percent decline in water applied to landscapes, Irvine Ranch experienced a 37 percent decline, and Capistrano Valley experienced a 35 percent decline between the pre- and post-program periods. Changes in customer characteristics can make important differences in the estimated savings rates. For example, long-term customers showed a smaller decline in mean water use, about 25 percent; newer customers tended to come on line with lower application rates. Simple models to control for climate reduced the estimated change in raw water use from approximately 25 percent to 22 percent.

The estimates from the complete "intervention" structural model, with climate correction, suggest that the combined intervention of water-budget based rate structures and customer outreach programs in Capistrano Valley had the following effects on the structure of water demand:

- Average water demand was reduced;
- The seasonal peak demand was also reduced, though to a lesser degree than average daily demand;
- Customer demand became more responsive to evapotranspiration; and
- Customer demand became less responsive to rainfall.

Recommendations for Successful Programs

Based on interviews conducted at the four agencies, the research team put together a list of factors that influence the success of the landscape water conservation programs. This list of factors is expressed in the form of recommendations for agencies in the development of similar programs in other service areas:

- **Coordinate Internally First.**
- **Develop Sustained Commitment to the Program by Board and Staff.**
- **Water-Budgets are seen as "Fair."**
- **Focus on Information Systems Requirements in the Beginning.**
- **Be Strategic about Timing of the Program.**
- **Target Any Additional Revenue to Conservation Programs.**
- **Design Appropriate Tiers for the Rate Structure.**
- **Motivate the Program with Ethical *and* Economic Arguments.**
- **Create a Win-Win Program for the Agency and its Customers.**
- **Be Responsive to Customer Concerns.**
- **Show the Customer How to Save Money with Conservation.**
- **Educate, Educate, Educate!**
- **Prioritize Conservation.**
- **Utilize Horticultural Science.**
- **Communicate Well and Often.**

Each of these recommendations is explained in detail in Chapter 5.

Cost-Effectiveness Analysis

A cost-effectiveness analysis was conducted for a prospective landscape conservation program in a service area that includes 2000 acres of irrigated landscape in the program, 2 acres per customer, and 1000 customers with separate landscape meters. From the agency perspective, the present value of net benefits is positive for the retail agency, customer, and wholesale agency service area perspectives. For the total society perspective, the benefits quantified thus far do not exceed the costs; however, many important benefits are not included, such as reduced street damage, reduced paint damage, esthetic value of improved landscape quality, reduced root damage, and a range of reduced environmental damages.

TABLE OF CONTENTS

TABLES

FIGURES

CHAPTER 1. INTRODUCTION

In the past, attempts to improve landscape water use efficiency have met with ambiguous success. Programs targeting landscape water use tread on sensitive ground. Residential landscaping has often been thought of as an integral part of customers' lifestyle and conservation programs were a threat to their perceived quality-of-life. Home owner associations and real estate management companies also viewed conservation programs as a potential threat to property values. Programs that saved noticeable amounts of water won no friends in the finance departments of the water agencies. Water efficiency audits were perceived as mere public relations. Furthermore, customers had little incentive to follow through on recommended efficiency improvements.

Customers who did accomplish water savings found a surprise when one of California's drought emergencies hit. In some water agencies, mandatory curtailment programs required all customers to reduce water consumption by a set proportion. Those having the misfortune to conserve early were punished for their foresight—these customers were asked to save an additional amount of water. Landscape water conservation could be a very risky business all the way around.

1.1 Landscape Water Conservation Programs

There have been recent efforts to design and implement a new generation of water saving, cost-effective, and fair landscape conservation programs. Though these programs were originally created in the crisis atmosphere of a drought emergency, they have continued due to their customer acceptance and water saving effectiveness. These landscape conservation programs share a unifying characteristic—linkage of customer bills to a water budget. A water budget is an amount of water required by landscape, as determined by the best available horticultural science. Water consumption within the water

budget is billed at a lower water rate than water consumption beyond the water budget. Because the water budgets are customer-specific, they have achieved greater customer acceptance. By permitting greater levels of water consumption, albeit at a higher price, these programs preserve customer choice. Widespread customer dissatisfaction with mandatory water curtailments, in fact, was a major part of the impetus behind the creation of water budget-based programs.

These programs have also been supported by agency-provided landscape audits, customer outreach, or education programs. When compared to implementation of any one program alone the water budget-based conservation programs, by coupling strong customer incentives to a concrete individual target of water efficiency (i.e., the water budget), simultaneously achieve water savings **and** customer satisfaction.

1.2 Study Objectives

Three objectives drive this research:

1. **Process Evaluation:** Identify and describe the water budget-based rate structures, the local context, and how these programs evolved. Identify and describe the factors contributing to the successful design, implementation, and operation of water budget-based landscape conservation programs (Chapter 2 and Chapter 6).

2. **Impact Evaluation:** Evaluate program impacts, including customer satisfaction (Chapter 3), water savings (Chapter 4), and cost-effectiveness (Appendix D).

3. **Guidelines and Recommendations:** Provide guidance and recommendations to assist other agencies in developing effective water budget-based landscape conservation programs (Chapter 5).

1.3 Study Design

Given the differences among the four programs, a single cookie-cutter evaluation approach is inappropriate. The landscape conservation evaluation documented in this report employs multiple data collection efforts and analytical methods to address each of the

study objectives. Table 1.1 below depicts the connections between objectives, data, and methods.

Table 1.1 - Study Objectives, Data, and Methods

Study Objective	Focus	Data Sources	Analytical Methods
1.Process Evaluation	Program Design Implementation	• Agency documents • Structured interviews • Customer survey	• Description • Qualitative assessment • Summary
2.Impact Evaluation	Customer Satisfaction	• Structured interviews • Customer survey	• Descriptive statistics • Qualitative assessment • Summary
	Water Savings	• Customer billing records • Weather data	• Descriptive statistics • Statistical modeling
	Cost-Effectiveness	• Program cost estimates • Water savings analysis	• CUWCC Guidelines for Cost-Effectiveness Analyses
3.Guidelines and Recommen-dations	How to design, implement, and evaluate	• Structured interviews • Customer survey • Water savings analysis • Cost-effectiveness analysis	• All the above

The study methods can be described in more depth.

- **Mail-out customer survey.** A cover letter, survey instrument, and follow-up post card were mailed to each of the separately-metered landscape customers in the water-budget based programs. The survey polled customers about their site characteristics, their knowledge of the rate structure, their views of program impacts, and their satisfaction with their agency's landscape conservation programs.

- **Structured In-person agency interviews.** In-person interviews were held at each of the four study sites with a broad range of individuals. The interviewees, each of which was asked a series of questions regarding the relevant landscape conservation program, included water agency conservation staff, board members, green industry professionals, and other interested parties.

- **Water use analysis.** For each of three agencies having water-budget-based rate structures, the research team analyzed historical account-level water use records. Careful data analysis was conducted to compare raw water use before and after implementation of the landscape conservation water-budget based programs. A higher resolution statistical analysis was conducted for one agency, to control for potential biasing effects—including changing climatic conditions and customer behavior—and to explain how differences in methods can produce different answers.

- **Cost-effectiveness analysis.** Results from the water use analysis and customer survey on program costs were utilized to conduct a cost-effectiveness analysis of a prospective conservation program with characteristics similar to the four study agencies. Multiple perspectives were considered, including the customer, the retail agency, the wholesale agency service area, and the total society.

1.4 Report Overview

Chapter 2 - Program Descriptions and Interviews describes the four study sites, their water districts, and customers. Chapter 2 then evaluates the process by which these programs were created, implemented, and adapted. This process evaluation includes:

- a discussion of the impetus for creation of the programs;
- an description of how the programs were initially designed;
- an evaluation of how they programs were implemented; and
- an evaluation of how the programs evolved and adapted.

Chapter 3 - Customer Survey describes the survey of landscape customers that was used to collect data on site characteristics, conservation actions, and customer satisfaction. The results of the customer survey contribute to both process and impact evaluation.

Chapter 4 - Water Use Analysis describes the method and results of the analysis of historical water use data collected from agency billing systems. Though much of this material is necessarily technical, this chapter takes pains to clearly communicate the problems and processes of a water use evaluation. Readers not interested in the technical details should simply read the chapter introduction and summary. The water use analysis documents how the water use patterns of participating customers have changed. The question of how much of this change in water use is solely attributable to the rate structure and how much is due to other conservation efforts is necessarily ambiguous.

The next chapter, *Chapter 5 - Cost-Effectiveness Analysis*, identifies and values, to the extent feasible within the context of this study, costs and benefits of a landscape conservation program that might be undertaken by an agency in the future. The motivation for this analysis is to show agencies considering this type of program how to weigh the costs and benefits and how to tailor such an analysis to their circumstances.

Chapter 6 - Recommendations summarizes the findings of the process and impact evaluations. The qualifications and caveats to these findings are documented. The recommendations include a set of recommendations to water managers considering adopting water budget based rate structures. To inform subsequent evaluations, the last section presents recommendations for conducting evaluations of water-budget-based rate structures. Chapter 6 is followed by a list of references.

Appendix A: Survey Method and Complete Results contains more detailed information related to the customer survey. *Appendix B: Documents Reviewed* lists the documents reviewed in the course of this research project that relate to the four participating agencies. *Appendix C: Interview Protocol and Sample* contains the procedure for conducting the in-person interviews.

CHAPTER 2. WATER BUDGET-BASED LANDSCAPE CONSERVATION PROGRAMS

Chapter 2 introduces the four service areas that participated in this study. The four participating service areas include the Otay Water District in San Diego County, Capistrano Valley Water District and the Irvine Ranch Water District in Orange County, and Eastern Municipal Water District in Riverside County. This chapter describes characteristics of the four service areas, describes the drought emergency in the early 1990's in Southern California, and describes each landscape conservation program. Drawing on agency documents and the structured in-person interviews of agency staff, this chapter lays out the origins of the landscape conservation programs, the structure of their water budget-based rate structures, how the programs were implemented, and how these programs adapted over time to changing circumstances. By providing this information, other conservation planners can draw on the collective experiences of these four programs to design and implement water budget-based conservation programs best suited to the characteristics and requirements of their own service territories.

2.1 Overview—Four Service Areas

The four service areas are striking in both their differences and in their similarities. Table 2.1 shows that geographic size of the service areas range from 15 square miles to 555 square miles. Population ranges from 30,000 to nearly 400,000. Despite this variation, each of the agencies expect significant to high growth potential in population, economy, and potential demand for water resources.

Table 2.1 — Characteristics of the Four Agencies

Characteristic	Capistrano Valley Water District	Eastern Municipal Water District	Irvine Ranch Water District	Otay Water District
Area	15 sq. miles	555 sq. miles	119 sq. miles	129 sq. miles
Population (1990)	~30,000	~395,000	~130,000	~100,000
Location	Orange County	Riverside County	Orange County	San Diego County
Growth prognosis	Growth Potential	High Growth Potential	Growth Potential	High Growth Potential
Number of Accounts	10,000	79,000	51,000	30,000
Annual Water Demand	8,000 AF	58,000 AF	63,000 AF	20,000 AF
Irrigation Customers	4% (accounts) 18% (use)	<1% (accounts) 1% (use)	3% (accounts) 17% (use)	3% (accounts) 17% (use)
Normal Evapotranspiration (ET_o)	45 inches/year	55 inches/year	48 inches/year	48 inches/year

2.2 The Context -- 1990 Drought Emergency

In 1990, California was in the midst of an ongoing drought emergency. Five consecutive "critically dry" years had resulted in a statewide water shortage. Deliveries from the California State Water Project were cut 20 percent; projected future deliveries were even more uncertain. The Metropolitan Water District of Southern California implemented an "Incremental Interruption & Conservation Program" (IICP), that reduced deliveries of imported water to its member agencies.

Confronted with this water shortage, retail water agencies in Southern California scrambled to implement their drought management plans. Most of the water agencies had

already implemented calls for voluntary cutbacks in water use and now, many agencies were considering or implementing mandatory water curtailments to customers. These curtailments were often based on a customer's prior use. To illustrate the gravity of the situation, even more drastic measures were being considered. One portion of the San Diego County Water Authority's water emergency plan called for a ban on turf grass watering. It was within this climate of urgency that water agency staffs began casting around for innovative solutions to the problem of how to allocate scarce water supplies during a drought.

2.3 Otay Water District

The Otay Water District, lacking local water supplies to buffer the impact of water delivery cutbacks, had few alternatives but to directly pass along cutbacks to their customers. The water district's customers had strongly communicated the unfairness of mandatory curtailments based on prior use—water efficient customers would be punished the most. Landscape professionals and representatives of the green industry had very clearly expressed their opinion of the possibility of a county-wide ban on turf grass watering: "Don't tell us what we can or can't water. Tell us how much water we can have and let us manage it as professionals."[1] The water district staff took this statement as the point of departure for developing a more sensible approach to coping with the drought emergency.

2.3.1 Program Development

Otay had separately metered irrigation accounts, and staff were able to determine that these customers constituted three percent of the accounts but 17 percent of total

[1]This paraphrased quote is attributed to a respondent at a public hearing to review water emergency plans in San Diego County.

water use. These irrigation customers had communicated their disapproval of mandatory cutbacks in terms that left little room for misunderstanding. The district staff, comparing notes with other agencies, came up with the germ of the idea for a water-budget-based allocation. A Task Force was formed to solicit input from green industry professionals and experts to determine a method for defining an appropriate amount of water--that is, a water budget—for commercial irrigation accounts. The Task Force met periodically over the next year to construct a program that tied water budgets to rates.

The Task Force based on weather, evapotranspiration rates, and plant water-demand data, arrived at an allocation of 48 inches per year. This allocation was thought to be both simple and an upper bound on the water needs of even thirsty plants. The 48 inch allocation would be reduced in drought emergencies depending upon the severity of water cutbacks: a Stage 1 drought would imply a reduction to 44 inches per year while a Stage 4 drought would imply a reduction to 36 inches per year. The annual allocation was translated into a monthly allocation by a fixed seasonal pattern that followed evapotranspiration in a normal year--giving more water in the summer and less in the winter. Customers using less than their allotment were allowed to "bank" up to 12 inches of the unused water; banked water could be applied to any future over-use. In addition, the next billing period was given as a grace period for customer's to make-up any over-use not covered by banked water. Finally, the Task Force recommended fairly stiff penalties for customers that continued to exceed their water budgets. The first overage resulted in a warning letter to the customer. The second overage resulted in a surcharge of 100 percent assessed against the excess units. The third overage resulted in a surcharge of 400 percent and the fourth and subsequent overages resulted in a surcharge of 800 percent. This proposed method was field tested using a test group of landscapes to assess its practicability.

2.3.2 Program Implementation

In March of 1992, the Otay Water District adopted an ordinance to implement the monthly water allotments to irrigation accounts. The two principal administrative hurdles

identified by OWD staff during the interviews were the changes needed to the customer billing system and the collection of irrigated area data from the water district customers. By the time the ordinance was formally implemented in June, 1992, a fairly extensive reprogramming effort (approximately six staff-months) to the customer billing system had been completed. The "banking" feature of the allocation system was a special complication in addition to the timing of customer notification, grace period, and assessment of surcharges. A letter to irrigation customers requesting a statement of irrigated area had been sent out as part of the Task Force study. Approximately 70 percent of the customers responded to the data request; nonrespondants were assigned a default water allocation (7 CCF per month). There were ongoing problems with the quality of customer-provided area data.[2]

Revenues from penalties went into a separate budget account; these revenues have been used to fund Otay's conservation programs.

2.3.3 Evolution of the Otay Program

The major change to the program as originally designed was the adoption of a one-time procedure for refunding assessed penalties to customers who brought their irrigation system into compliance for three successive months. Otay staff strongly supported this additional opportunity for customers to fix inefficient irrigation systems: "We are not in the business of collecting penalties; we simply want to avoid water waste." Customer-reported irrigated area remained a problem; in some cases, OWD staff had to make site visits to ensure proper area measurement. Most customers, when notified of over-use were able to make needed corrections. OWD provided on-site water audits to requesting customers to facilitate compliance with the ordinance.

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[2]A typical mistake was reporting of the lot area without accounting for slopes at the site; a horizontal lot length is shorter than the hypotenuse formed by the slope.

2.4 Capistrano Valley Water District

The Capistrano Valley Water District represents an interesting contrast to Otay. Rather than implementing an ordinance, CVWD, with approval from an advisory committee, began a water-budget-based rate structure for commercial irrigation-only accounts in 1991 that was later adapted for residential customers in 1992.

2.4.1 Program Development

The technical details of the water budget for irrigation-only accounts were developed by staff from materials at hand; this initial program was fine-tuned over time. CVWD began by applying an allocation of 4.9 CCF per thousand square feet of irrigable area (35.2 inches per year) in March of 1991 for irrigation-only accounts. The monthly allocation came from a fixed normal evapotranspiration pattern--with higher allocations in the summer and lower allocations in the winter. Table 1 provides the initial rate structure.

Table 2.2 - CVWD Rate Structure

Tier Name	Use	Rate
Tier 1	0 to 100 percent of allocation	$ 0.83 CCF
Tier 2	100 to 200 percent of allocation	$ 1.04 CCF
Tier 3	more than 2X allocation	$ 1.30 CCF

2.4.2 Program Implementation

Reprogramming to the billing system data base was performed in-house. Staff felt that the effort was significant but not unreasonable: "It was fun to do, so it was fairly easy." CVWD staff also noted the difficulties in collecting and validating consistent measures of customer irrigation area. Staff mailed an information request to customers and

put the resulting information into a database. Staff verified these data directly with customers when questions arose. Interestingly, the expansion of the water-budget-based rate structure to residential customers presented fewer problems of irrigation area definition; CVWD obtained consistent measures of parcel size and building footprint from a real estate information service at relatively low cost (a few thousand dollars.) Staff recommend this approach for other water agencies considering landscape-based water allocations.

Customer complaints resulted in a site visit, a reread of the water meter, a recheck of area measurement, and water efficiency recommendations. Staff later used a time-of-use data logger to record real-time water consumption for problematic accounts; this more precise measurement helped identify leaks and convince customers of the reality of ongoing water consumption. Additional customer outreach programs included the *Protector del Aqua* workshops and professional CII audits by an independent engineering firm.

2.4.3 Evolution of the CVWD Program

In July 1992, based on U.C. Riverside research on the water requirements of plants in coastal climate zones, the water allocations were reduced to 27.7 inches per year (3.85 CCF per 1000 square feet per bimonth).[3] In 1994, new billing system software was installed and a monthly billing period was adopted. In July 1995, the actual number of days in the billing period was incorporated into the allocation calculation. In July 1996, the recorded evapotranspiration in the month (taken from a recently established local weather station), rather than the seasonal average evapotranspiration was incorporated into the allocation calculation. This change in evapotranspiration measure resulted in an

[3] *Suggested Water Requirements for Warm- and Cool-Season Grasses*, University of California Riverside, for the Los Angeles Department of Water and Power, the Municipal Water District of Orange County, the San Diego County Water Authority, and the Metropolitan Water District of Southern California. This five-year turf grass study formed the basis for the widely distributed MWD brochure "Take a day off."

increase in the outdoor allocation to 36 inches per year. Staff were very pleased with this last refinement and strongly recommend that other water agencies use actual local evapotranspiration for allocation calculations from the beginning of a program.

2.5 Irvine Ranch Water District

In June 1991, IRWD adopted an increasing block rate structure. Approximately one year later, IRWD implemented a customer outreach program to facilitate landscape customers' ability to conserve water.

2.5.1 Program Development

IRWD initially developed tiered rate structures and landscape conservation programs in response to the drought. The MWD's IICP program, in particular, influenced IRWD in their decision to create a strong conservation program. The agency faced rate penalties if their demand exceeded MWD drought allocations. Although drought response was the initial motivation, IRWD soon viewed the rate structure as a long term water management tool.

IRWD's Board and staff felt that the steep block rate structure demonstrated their commitment to an effective water conservation program. The belief was that small changes in price would not effectively get customers to respond. Given the price inelasticity of water, staff felt that a steep rate structure with a high price in the high tier was necessary to put conservation on high-water-using customers' "radar screen."

Agency staff also cited a principle-based management style that emphasizes water conservation and sound natural resource management as a motivating factor; the conservation programs were motivated by the desire to "do the right thing."

In developing the program, IRWD sought to fulfill the goals and the philosophy of the agency:

- **No Mandatory Rationing.** The Board wanted a "self-policing" program that would not restrict supply to customers. If customers needed or wanted excess water, they should be able to buy it, albeit at a high price.
- **Win-Win.** IRWD sought to make the incentives of agency and customer point in the same direction: towards conservation.
- **Fairness.** The agency sought to have those wasting water pay for conservation. Those who used water above allocations should also pay the high costs of marginal supply. The agency should not penalize customers who conserve with arbitrary cutbacks or extra costs. Conserving customers should benefit from the low volume tier rates.

2.5.2 Program Implementation

The rate structure took a year of planning, including extensive efforts at modify the billing system. IRWD implemented a two-tiered rate structure in February 1991 that responded to the MWD rate change, but did not require extensive reprogramming of the billing system. By June 1991, reprogramming of the billing system allowed for implementation of the more involved five tiered rate structure. Agency staff justified these efforts by pointing out that the tiered rate structure would be an ongoing program–not just a drought response.

The new rate structure was applied to residential as well as landscape customers, and it is informative to compare the responses of the two groups. For *residential* customers, the most difficult challenge was overcoming opposition to the term "abusive" selected to indicate the highest of the penalty tiers. The word was selected to convey a very strong message and to stimulate action on behalf of those using water over their allocations. The strategy worked, stimulating strong and often emotional reactions. In the period immediately after the introduction of the tiered rate structure, IRWD received more complaints about the word "abusive" than about the high rates associated with this category. The agency views complaints as an opportunity to target customer service, which includes strong efforts to explain how the program is based on science and to educate customers about how they can conserve water and save money. The staff sought to turn critics into supporters.

In contrast to the immediate and strong response of *residential* customers, *landscape* customers did not respond nearly as much–perhaps because landscape personnel are often not those who pay the water bill. The delayed response and large potential for savings prompted IRWD to develop Operation Outreach, a customer service program targeted specifically at irrigation customers. This program, described below, demonstrates what IRWD staff cite as their management style: Provide customer service and be flexible in the means to achieve those ends.

IRWD's increasing block water rate structure assigns each meter an allocation of water for each billing period. If the customer uses up to 40 percent of their allocation, they pay a rate less than the "base rate." For water use up to 100 percent of allocation, they pay the base rate. For water use above the allocation, they pay sharply increasing rates as shown in Table 2.3. This block rate structure rewards those with low water use and penalizes those with high water use.

Table 2.3 - IRWD Rate Structure

Tier Name	Use	Rate
Low Volume	0 to 40 percent of allocation	3/4 Base Rate
Conservation	41 to 100 percent of allocation	Base Rate
Penalty	101 to 110 percent of allocation	2 X Base Rate
Excessive	111 to 120 percent of allocation	4 X Base Rate
Abusive	above 120 percent of allocation	8 X Base Rate

Before putting in the new rates, the agency had already separately accounted for fixed and variable costs. The commodity charges of the rate structure are applied toward variable costs–the costs for each additional unit of water. Monthly service charges are applied toward IRWD's fixed costs. This separate accounting undermines the argument that conservation threatens the operating budget and allows the agency to reduce commodity charges as less water is needed from MWD. Revenues from the penalty,

excessive, and abusive tiers go into in a separate budget to fund only conservation efforts, including the subsidy for the low volume tier, reclaimed water conversions, and the outreach program.

Since the allocations depend on landscaped area at each site, IRWD measured each site at the outset of the program. They collected information from site plans, customers, and they hired part-time landscape architects and students to walk sites. The process of collecting this information took place over a period of six to eight months.

2.5.3 Evolution of the IRWD Program

By mid-1992, staff identified an ongoing problem with a subset of landscape irrigation customers. A substantial number of irrigation customers (30-50 percent) saw their water use reach the abusive tier during some months. Two changes resulted: improved measurement of water allocations and a directed customer outreach program. IRWD's Operation Outreach program began in November 1992 with the purpose of supporting the customer's ability to conserve and move out of the abusive tier. The elements of the program include education materials, site walks, 50% rebates for irrigation controllers and equipment, 50% zero interest loans, monthly meter monitoring, free soil probes and free landscape irrigation seminars in Spanish and English. Operation outreach contributed an important part of the agency's effort to establish a constructive relationship with customers. In 1993 and 1994, the rate structure and Operation Outreach were believed to have been responsible for large drops in landscape water use.

The rate structure has evolved over time in IRWD's efforts to make the water bill reflect more closely actual water use and water needs, rather than general assumptions. Initially, IRWD used 12 monthly average evapotranspiration rates to set allocations. Staff first changed the allocation to use monthly CIMIS data before changing to weekly CIMIS data. IRWD calculates the allocations per billing period based on the weekly CIMIS weather station and crop coefficients developed by the University of California for tall fescue turf grass to account for the large variations in weather and vegetation that influence landscape

water needs. Each Monday, IRWD updates their billing system with the current CIMIS data and adjusts billing rates accordingly.

The calculation of allocations initially used an assumed 30 day average billing period. Because actual billing periods varied from 24 to 40 days, customers might receive to much or too little in their allocation. The program was modified so that allocations were based on the number of days of service. A more general upgrade of the billing system, from bimonthly to monthly billing, also provided more frequent customer communication. Agency staff cite these changes as examples of their willingness to try new ideas if they can improve customer service and be defensible on economic or technical grounds.

IRWD staff and board members believe that their willingness to correct and improve the program over time is essential to its success and effective customer service. When the agency realized the inaccuracy of assuming a fixed 30 day average billing period, IRWD refunded the excess charges accrued under that assumption. IRWD refunded more than $1.7 million for excess use charges over the previous two years, including excess charges that totaled less than a dollar.

The agency uses computers in several ways to support the program objectives. The IRWD computer system monitors water bills and assists staff in sending faxes to customers and their landscape contractors. The agency has also developed software that uses the CIMIS Hotline to determine irrigation schedules on a continual basis.

Although "variances" (site specific exceptions to the allocation method) are a key factor in the public acceptance by *residential* customers, they have not been as important to the *landscape irrigation* customers because fewer landscape sites fall outside normal assumptions. As described above, the landscape irrigation allocation method includes specific information, such as landscaped area, weekly CIMIS data, etc.

On the horizon, further program evolution may include further adjustments for micro climates. Coastal zones tend to be cooler than the rest of the service area. As water savings become more routine, the excess revenue from penalty, excessive, and abusive tiers will continue to shrink. Consequently, Operation Outreach will focus more on ways to better target loans and rebates and add emphasis on education. The agency also stresses

the secondary benefits of conservation as reasons to conserve, such as avoided street damage, peeling paint, and water pollution runoff.

2.6 Eastern Municipal Water District

Eastern Municipal Water District (EMWD) differs from the other sites in several key ways. The first distinction is that the EMWD water-budget based program applies only to new customers. All new customers since the landscape ordinance was initiated in 1992 are in the program. Second, the agency adopted a tiered rate structure in 1993, that they later rescinded.

2.6.1 Program Development

The drought emergency also motivated new conservation initiatives at EMWD. The early drought years coincided with rapid growth in the region, making water supply planning and conservation even more important. Regional planning organizations had estimated that by the year 2015, the population in the EMWD service area will double from its 1990 levels. The Southern California economic recession hit the EMWD service area especially hard. In an area that experienced rapid and uninterrupted growth, the rapid drop in growth shocked the region and left many investors without the population to support their plans.

Since EMWD buys roughly 85 percent of its water from MWD, the IICP cutback sharply affected the EMWD. EMWD staff cited the desire to reduce the reliance on a single supply source and thereby reduce the risk to water supply shortage. The agency's medium term goal is to achieve a 60%-40% split between MWD water and other sources, and its long term goal is a 50%-50% split.

Other factors that have been cited as important motivators of conservation and the water-budget based program include the desire for EMWD to be an industry leader. The conservation ethic and desire to protect natural resources were also cited as strong

motivating factors. The agency emphasizes good relations with customers and the public more generally, and conservation is seen as a vehicle to achieve that objective.

Agency staff have had to come to terms with the reduction in revenues from the drought and the continuing need to cover fixed costs. Potential revenue losses from conservation, though small, were cited as perceived shortcomings of conservation programs.

EMWD's efforts at conservation also include a short-lived tiered rate structure. In the summer of 1993, the EMWD proposed and the Board passed a rate increase in the form of a tiered rate structure. On average, water rates increased 34 percent, with much higher increases for customers in the high tiers. The block rate structure included four tiers with increasing rates.

Following the first billing period under the new rate structure, there was strong public resistance (3,000 calls and 2,500 letters). "People were at the doorstep with torches and pitchforks." The Board rescinded the tiered rate structure and the increases were refunded to all customers. Later that year, the agency passed a uniform rate with an average increase of 23 percent.

A number of reasons have been cited for the resistance to the tiered rate structure. The rate increase took place during the summer, which did not give customers time to adjust before the peak summer demand period. The severe recession also added to the perceived rate impact. Some argue that the agency did not explain the rate changes very well, especially the opportunity to reduce bills by conserving water. This led to the appearance that the agency was insensitive to the needs of the customer. In response to the criticism, EMWD launched a successful effort at public outreach, including workshops in different parts of their service area. In combination with agency cost cutting and streamlining, the EMWD's customer/public relations have been much repaired.

2.6.2 Program Implementation

The EMWD water budget program was implemented in the "Landscape Ordinance" (Ord. 72.11). The landscape ordinance applies to all new separately metered landscape

sites, except sites smaller than 5,000 square feet that can be metered with non-landscape service. The developer of the site must submit a site plan with a diagram of the site, its meters, the irrigation system layout, and other information.

The ordinance includes methods to determine "Estimated Annual Water Use," "Annual Maximum Allowable Water Budget," and "Monthly Maximum Allowable Water Budget." The formula to determine Estimated Annual Water Use differs from the formula to determine Annual Maximum Allowable Water Budget in that explicit application efficiency (AE) and distribution efficiency (DE) terms are not included in the latter, implying their value is one, and the crop coefficient (KC) is fixed at .8. The monthly budgets come from 12 monthly fractions of the maximum annual budget. Staff considers the water budget to be a reasonable goal because of its assumptions for DE, AE, and KC, and because it assumes turf for the entire landscaped area.

The water plans submitted under the water ordinance must show that the Estimated Annual Water Use will not exceed the Annual Maximum Allowable Water Budget. Once the site is in operation, the customer has a four-month establishment (grace) period. After the establishment period, each meter's monthly water use must not exceed its Monthly Maximum Allowable Water Budget. If a project exceeds its monthly budget for two consecutive months, it may be "subject to restriction or discontinuation of the involved water service" until corrected. Before any action is taken, however, EMWD conducts an annual reconciliation to determine if these stringent measures are necessary.

In general, the agency's implementation of the water ordinance has emphasized education, customer assistance, and cooperation over punitive measures. The education and equipment upgrade programs described below show EMWD's strategy of first helping customers achieve their water use allocation. Only after cooperative strategies are attempted are more stringent measures considered.

2.6.3 Evolution of the Eastern Program

The program has not evolved greatly from its original design. One exception is the emphasis on tracking with monthly reports generated from the EMWD computerized billing

system. Each of the program sites is tracked and excessive water use is flagged. Additions to the program include:

- The Moisture Sensor Program. The top 20 percent (by annual water use) of commercial landscape customers have been targeted for the EMWD moisture sensor program. These selected sites have been consistently over their water budget. One important reason cited for the difficulty of achieving the allocation is irrigation staff turnover. The program addresses this problem by installing moisture sensors which shut off irrigation systems automatically. EMWD staff conduct on-site evaluations with technical assistance from a moisture sensor manufacturer.

- Site Evaluations and the Mobile Lab. The San Jacinto Basin Resource Conservation District operates an Irrigation Water Management (Mobile) Lab to improve conservation practices at large landscape and agricultural sites. These activities support the EMWD landscape ordinance by providing on-site recommendations to existing sites. The lab operates the local CIMIS Hotline which also includes frost warnings and a powdery mildew risk index.

- Training and Education. Staff strongly asserts that the water budget program will only be effective if landscapers are knowledgeable and motivated to conserve. As such, staff views the training seminars as an important adjunct to the landscape ordinance. The training seminars are targeted for landscape professionals, not for specific sites, because contractors may change. The seminars are held in the winter when it is easier to attend. Training is needed regarding irrigation equipment installation as well as maintenance.

- Landscape Irrigation Grants Program. EMWD has implemented a grants program, which assists specific sites in achieving landscape irrigation conservation and boosting visibility of the specific project area. The objective of these projects is to promote customer and public awareness as well as conservation. Sites included in the program have included schools and median strips. For some projects, a sign is posted indicating the program sponsors.

- A major response to the future demands on the system has been the development of reclaimed water supply. The agency now uses reclaimed water extensively in the agricultural sector. Reclaimed water is priced considerably lower than potable water and much of the agricultural sector depends on this pricing structure. To meet future demand, reclaimed water will be needed for high value non-agricultural sectors as well. Some have even suggested that the water-budget program be extended to reclaimed water.

2.7 Chapter Summary

This chapter described the four service areas that participated in this study. The local conditions in each service area were critical in how these landscape water conservation programs were developed, implemented, and adapted. The following chapters address the customer surveys (**Chapter 3**), the water use analysis (**Chapter 4**) and the recommendations and guidelines (**Chapter 5**).

CHAPTER 3. CUSTOMER SURVEY

3.1 Survey Introduction

The next component of the analysis focuses on eliciting customer information. The customer survey (see Appendix A), as a small part of the multiple evaluation approaches, was intentionally designed to be short and to the point. Due to time and budget constraints, a mail survey methodology was selected. The sampling methodology involved mailing surveys to all participating irrigation-only customers. Surveys were mailed to the entire target population, rather than a simple or stratified random sample, because of the small size of the target population and the participation of the agencies in reproducing and mailing surveys. The survey was mailed in August 1996, at least three years after the initial implementation of these evolving landscape programs.

The inference that can be drawn from the subset of returned surveys to the population is necessarily limited by the number of surveys returned and the potential for response bias.[1] Inference to agencies outside these four agencies is limited further by the degree to which characteristics and conditions are similar to the present study. The customer survey collected information on:

- Site/customer characteristics;
- Awareness of landscape conservation programs and practices;
- Conservation actions taken as a result of conservation programs; and
- Customer satisfaction and ratings of program performance.

[1] Specifically, the small sample size for each agency will limit the precision of agency-specific inference due to sampling error alone. A potentially larger source of error lies in the unique characteristics of the customers that chose to complete and return the surveys. Appendix A provides estimates of standard errors surrounding mean responses, taken across all returned surveys; these estimates of uncertainty only reflect the sampling error. Because the standard errors in Appendix A omit other know sources of error, they should only be used as a lower bound on an estimate of total uncertainty. Comparisons between agencies, in particular, should be treated with skepticism.

Surveys were mailed to customers with a cover letter explaining the purpose of the study, providing instructions, and assuring confidentiality. The survey contained 19 specific questions and two open ended "write-in" questions. Respondent names were not collected with the survey to maintain anonymity and to promote unbiased responses. The survey was fielded in August and September 1996 and was sent to 1,113 customers at the four participating agencies, of which 170 customers (15.3%) returned surveys. Additional detail about the survey methodology and a complete set of results of the survey can be found in Appendix A.

3.2 Site and Customer Characteristics

The first of the site characteristic variables is the type of site identified by the customer from a list of eight choices. Figure 3.1 shows that the two dominant site types reported are commercial sites and home owners' associations (HOAs). For example, 43 percent of the customers who responded to this question answered commercial site type and 39 percent answered HOA. Some customers reported more than one site type, indicating multiple sites for the customer or multiple purposes for a single site.

On average, customers reported they have a total for all meters of 24.4 acres of irrigated landscape at their sites. Average acreage varied considerably by site type. Although commercial and HOA sites were the most frequently reported sites, they were smaller than other site types–on average, 14 and 21 acres respectively. In contrast, schools averaged 126 acres, parks 94 acres, and medians 53 acres. The one golf course that responded reported 180 acres.

On average, 7 water meters were reported per customer. Of the customers who responded to this question, 43 percent reported only one meter and 67 percent reported 3 or fewer meters. See Appendix A for further detail regarding meters, site acreage, and other variables.

Table 3.1 summarizes the mean reported percentage of each vegetation type. Irrigated turf and bushes/shrubs dominate the landscape areas. Since acreage varies considerably between customers, the mean percent by customer does not give the proper

Figure 3.1

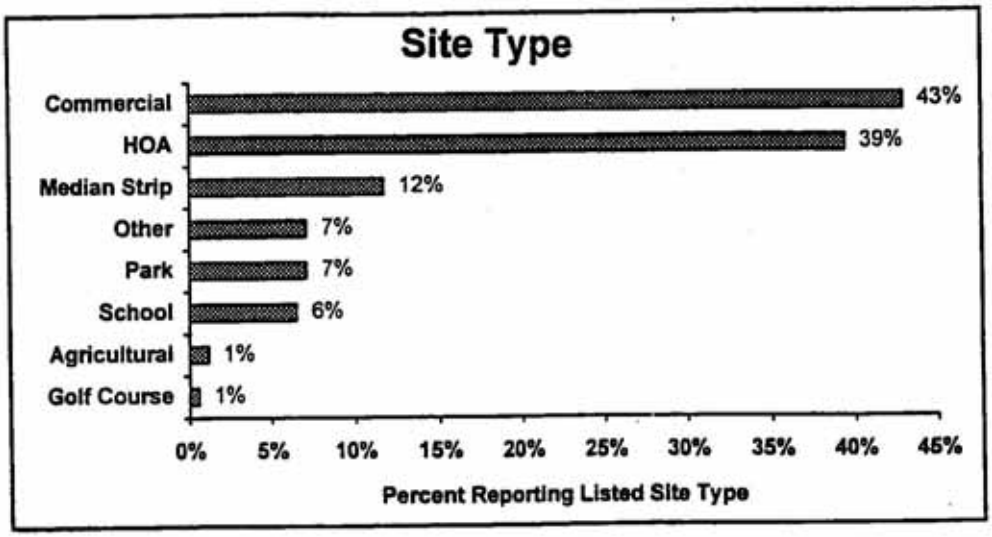


Table 3.1

Vegetation Type

Vegetation Type	Mean Percent by Customer	Mean Percent by Acres
Irrigated Turf	43.1%	58.2%
Bushes/Shrubs	42.4%	26.7%
Non-Irrigated Landscape	2.8%	5.4%
Xeriscape	2.3%	4.3%
Other	5.2%	1.4%
Annual Color	3.2%	1.3%

weight to the larger sites. When the mean percent vegetation type is weighted by acres, we see that irrigated turf, in particular, dominates the landscape among study sites.

Eighty-five percent of respondents reported that at their sites contractors perform the irrigation and other landscape maintenance work. Twenty percent reported that at their sites staff perform irrigation and other landscape maintenance work. Some customers reported a combination of contractors and staff.

Figure 3.2

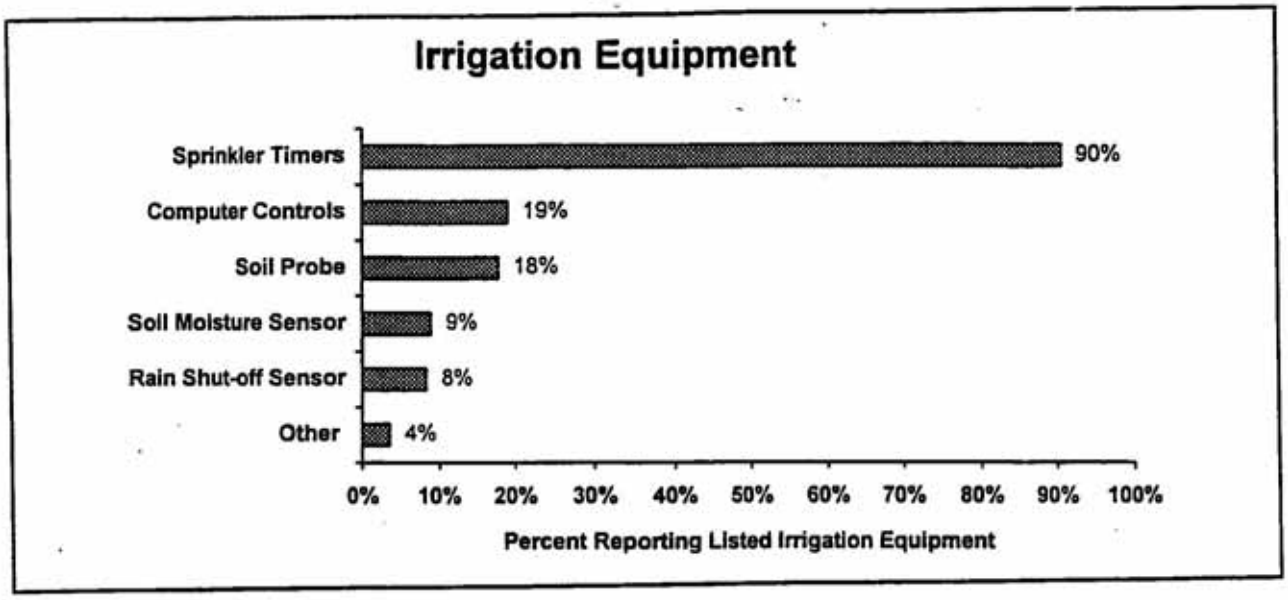


Figure 3.2 shows the irrigation equipment reported in use by customers. Ninety percent of the customers who responded to this question reported sprinkler timers. A much smaller percentage of customers reported using computer controllers and soil probes.

3.3 Awareness

As detailed in the program descriptions in Chapter 2, all four of the agencies have a water budget based landscape conservation program for separately metered sites. Three out of the four agencies have multi-tiered rate structures. To determine the awareness of the conservation programs we calculate the percent of customers who responded to questions correctly and incorrectly. When asked whether they were subject to a multi-tier water rate structure, less than half reported the correct answer and more than 40 percent reported "Don't Know" or did not answer the question (Table 3.2). Awareness of water budget/allocation programs was higher than for tiered rate structures. When asked whether they were subject to a water allocation/budget, above which a higher rate or penalties apply, most customers reported the correct answer.

Table 3.2

Awareness

Response	Multi-Tier Rate Structure	Water Budget
Correct	44%	68%
Incorrect	14%	16%
Don't Know or Missing	42%	16%
Total	100%	100%

Overall approximately 15 percent of customers incorrectly reported whether they were subject to a multi-tier rate structure or water budget/allocation program.

3.4 Conservation Actions

Several survey questions asked customers about their conservation practices, both general actions and those specifically that have resulted from the water budget conservation programs. When customers were asked if they seasonally adjust their irrigation timers, 96 percent of those who responded to this question answered yes. Table 3.3 shows, however, that different customers adjust their timers at very different intervals. Most (80%) of the customers who responded to this question reported they adjust their timers four times a year or more frequently.

When asked whether the water budget/allocation encouraged conservation, 86 percent of the customers who responded to this question answered yes. When asked what actions were taken as a result of the water allocation/budget, 91 percent of customers who responded to this question answered they adjusted irrigation timers. Figure 3.3 shows that more than half of the customers answered that they repaired their irrigation system and half reported that they upgraded equipment.

Table 3.3

Frequency of Reported Timer Adjustments

Adjustment Interval	Reported	Percent
Once a Year	2	1.4%
Twice a Year	27	18.4%
Four Times a Year	39	26.5%
Six Times a Year	19	12.9%
Once a Month	20	13.6%
Twice a Month	18	12.2%
Once a Week	18	12.2%
Once a Day	4	2.7%
Total	147	100.0%

Figure 3.3

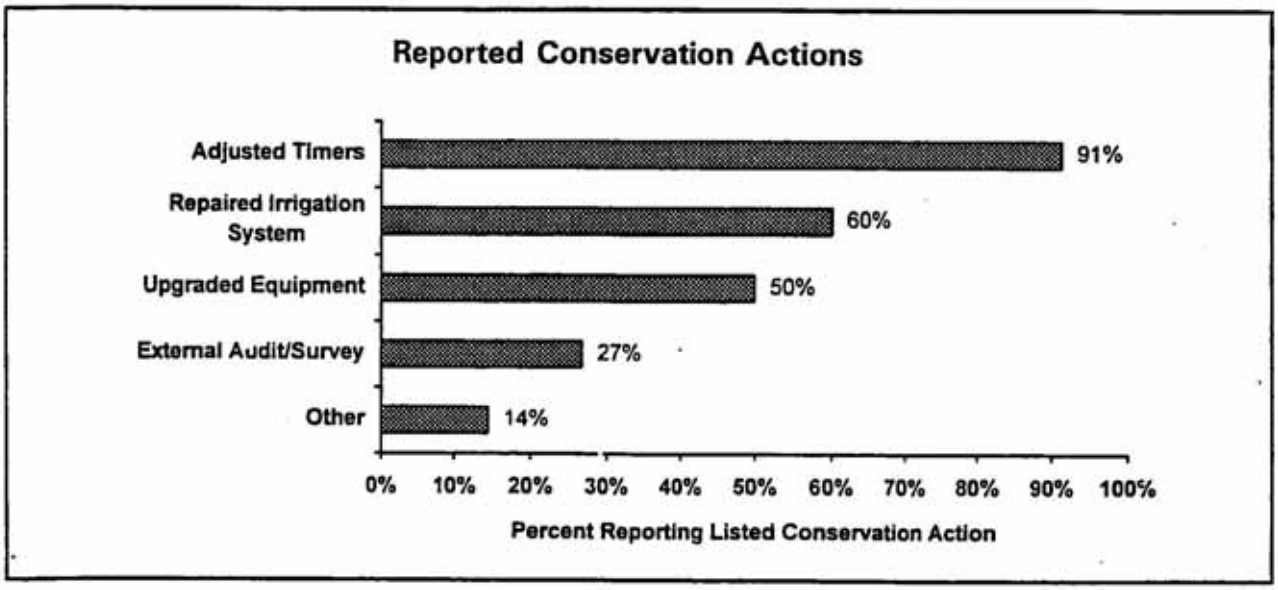


Table 3.4 shows the costs of these conservation actions reported by customers, calculated per customer and per acre. The cost per customer is the mean cost reported among customers who responded to this question. Cost per acre is the mean of the cost per customer divided by the reported acreage. We consider these high estimates because some of the customers who did not respond to any part of this question may not have responded because they faced zero costs.

Figure 3.4 shows that the water budget/allocation, multi-tier rate structure, and outreach/education programs all influenced conservation practices, according to customers. Fifty-six percent of customers that responded to this question reported that the water budget influenced their conservation practices.

3.5 Customer Satisfaction

Two sets of questions were fielded to elicit customer views on landscape program satisfaction. The first set of questions asked customers to rate their water agency's landscape conservation program based on four performance criteria. The second set of questions asked the customer to answer how satisfied they were with specific programs.

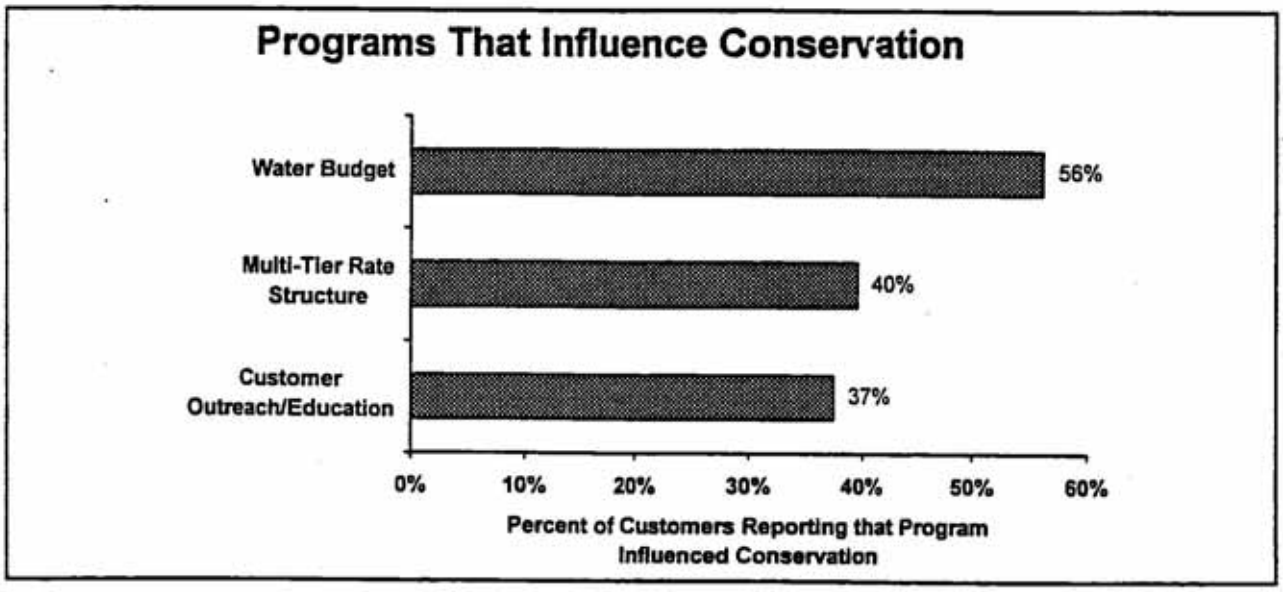
Figures 3.5-3.8 show the results of the customer ratings of landscape conservation program performance criteria. Overall the customer ratings are favorable; that is, clear and understandable, responsive to customer, effectively promotes conservation and efficient at administration/paperwork. For example, 37 percent of those who responded to the question reported that the conservation programs were very good to excellent in terms of their ability to be clear and understandable; another 33 percent rated their agency good. Another noticeable pattern among these four questions is that about one quarter of those who responded rated the programs fair to poor.

Table 3.4

Mean Reported Annual Costs of Conservation Actions

Action	Per Customer		Per Acre	
	Initial	Ongoing	Initial	Ongoing
Adjusted Timers	$482	$247	$137	$77
Upgrade Equipment	$2,571	$1,540	$953	$54
Repaired Irrigation System	$793	$2,571	$560	$399
External Audit	$45	$126	$43	$46
Other	$185	$77	$141	$80

Figure 3.4



Figures 3.9-3.11 show the results of customer satisfaction with the multi-tier rate structure, outreach/education, and water budget programs. Regarding outreach and education programs, all things considered, 39 percent of customers reported that they are either satisfied or very satisfied; 24 percent of customers reported that they are either dissatisfied or very dissatisfied. Regarding their water budget, 24 percent of customers reported that they are either satisfied or very satisfied; 28 percent reported that they are either dissatisfied or very dissatisfied. Regarding the multi-tier rate structure, 23 percent of customers reported that they are either satisfied or very satisfied; 39 percent reported that they are either dissatisfied or very dissatisfied.[2]

It is interesting to note that the net dissatisfied percentage for the multi-tier rate structure (39%) is larger than the net dissatisfied reported for either the water budget (28%) or the outreach/education (24%) programs. This supports the hypothesis that tiered rate structures alone are not popular among customers and that complementary programs, such as outreach and education, are important to reduce financial impact on customers and to assist customers in meeting clear water conservation goals. The "stick" needs to be accompanied by the "carrot" to result in satisfied customers.

These results point to important future research that could enhance understanding of the effects of water budget based rate structures. For example, linking site characteristics and customer satisfaction with water use data could determine whether those less satisfied are those customers in the penalty rate tiers.

[2] The standard errors of binomial variables reported in Appendix A indicate that the satisfaction difference for "outreach/education" and "multi-tiered rate structures" cannot be attributed solely to sampling error (e.g., 4%). Other explanations include non-sampling error, such as the question of non response bias mentioned above, or measured difference in customer satisfaction. The satisfaction difference for "water budget" is smaller; at 4 percent it is within the sampling error.

Figure 3.5

Clear and Understandable?

Figure 3.6

Responsive to Customer?

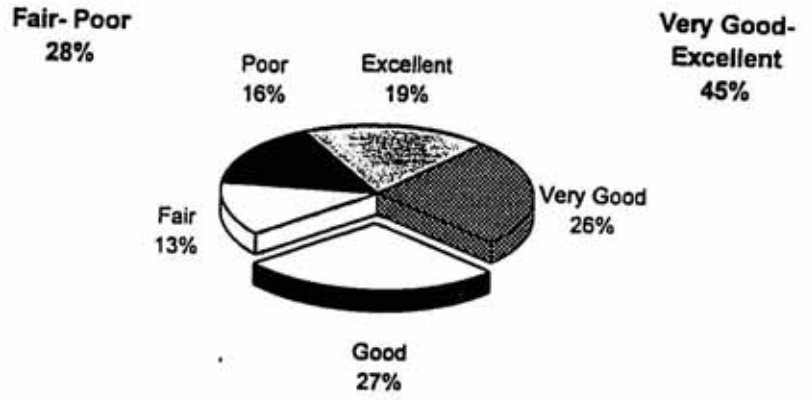


Figure 3.7

Promotes Conservation?

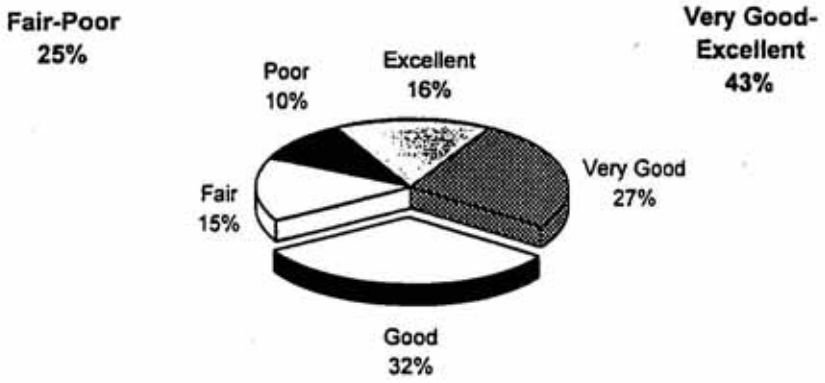


Figure 3.8

Administration/Paperwork?

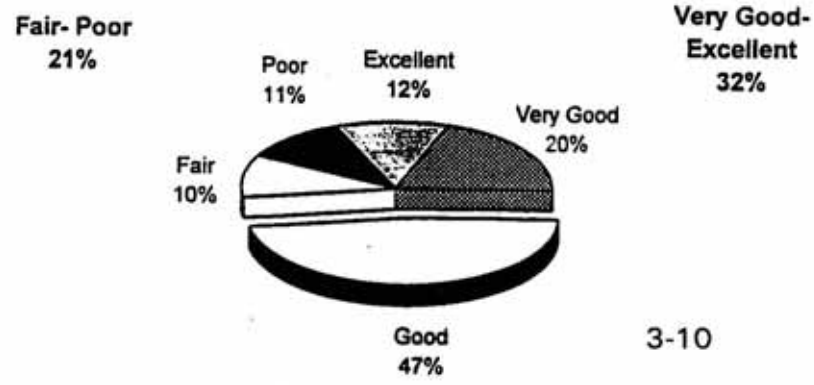


Figure 3.9

Satisfaction with Outreach/Education

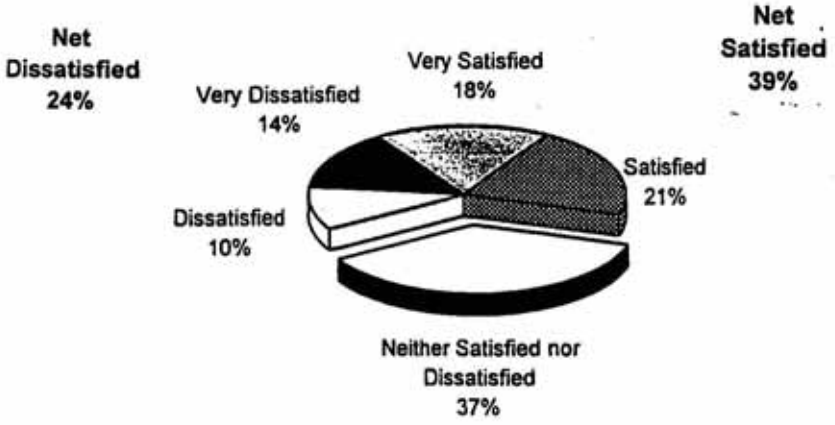


Figure 3.10

Satisfaction with Water Budget

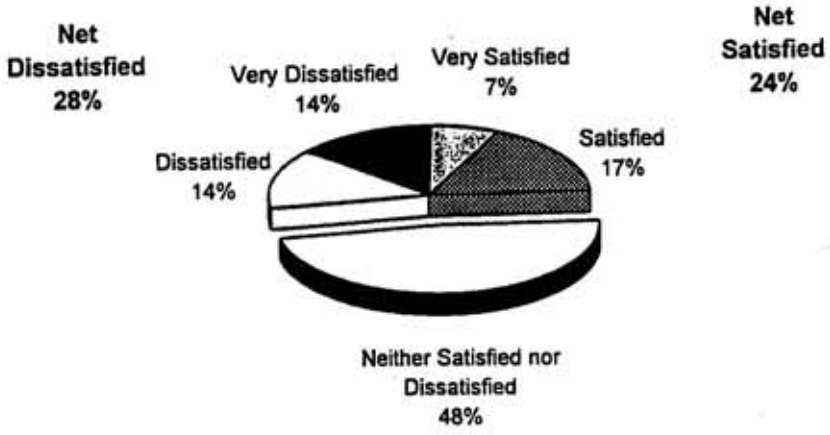
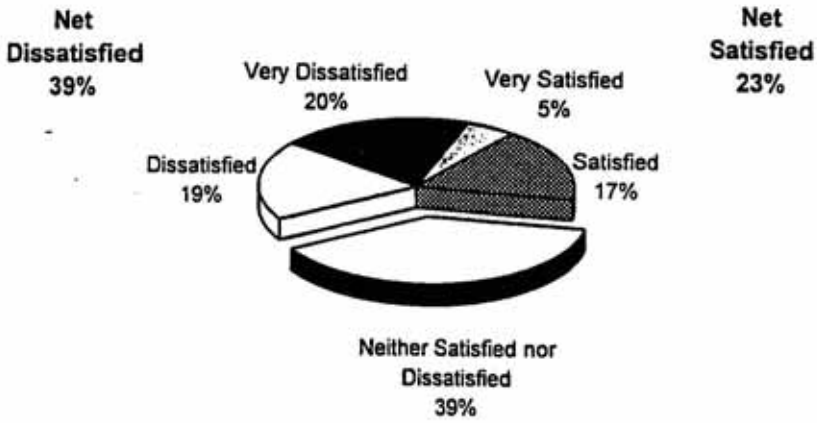


Figure 3.11

Satisfaction with Multi-Tier Rate Structure



CHAPTER 4. WATER USE ANALYSIS

Note to the reader:

This chapter contains necessarily technical material explaining how statistical methods can be used to obtain better estimates of water savings. Readers whose primary interest is not in technical issues can skip this chapter with little loss of continuity. The water savings results are presented in the **Summary** at the front of this report.

4.1 Introduction

Though the water use patterns of participating customers certainly changed, the direct impacts of the rate structures can be difficult to discern due to the existence of other types of ongoing conservation efforts: customer outreach, landscape professional continuing-education seminars, and mid-drought and post-drought naturally occurring conservation. Water-budget-based rate structures were not created in a vacuum; by design, these rate structures integrated a horticulturally based water budget and required customer-specific follow-up for customers requesting assistance in improving their water efficiency. It would be putting the horse before the cart to complain how a complicated program complicates an empirical impact analysis. Instead, we organize our analysis as a sequence of steps to sort through the factors we can, in fact, control statistically. The water savings analysis is presented in three steps.

1. **Pre-post water use comparisons** - comparisons of water use histories, before and after the adoption of a new rate structure with no statistical controls.
2. **Simple Statistical Models** - statistical models that estimate the average change in water use while controlling for weather and customer characteristics.
3. **Intervention models for structural change** - more involved statistical models that estimate changes in:

(1) the average level of water consumption,
(2) the shape of seasonal (normal weather) water demand, and
(3) the response of demand to climatic variation.

Format: Since some readers may only be interested in certain results developed in this chapter, each of the three sections uses a common format designed to facilitate access to the key issues and results. In particular, the first part of each section, *Issues*, outlines the issues addressed by the section. The second part, *General Findings*, briefly summarizes key findings. The third part, *Detailed Analysis*, discusses in much greater depth the analytic issues and methods used in developing these findings. At the conclusion of the chapter, **Section 4.5 Summary** provides necessary qualifications and pulls together the major findings from all the analytic sections.

4.2 Pre-post water use comparison

4.2.1 Issues

A good place to begin a water savings analysis is the examination of billed water consumption records. Though appealing, simple comparisons involving changes in average water use (before and after the adoption of water budget-based rates) are not likely to provide sound estimates of the change in consumption directly attributable to the revised rate structure. Other factors that differed in the pre-/post- period—weather, customer characteristics, other conservation programs, and customer outreach services specifically designed to inform customers how to best adapt to the revised rate structure—may also influence consumption. In such cases, it would be both incorrect and misleading to attribute all changes in water use solely to changes in the price of water.

The more involved—and necessarily more complex—analyses discussed in Sections 4.3 and 4.4 attempt to statistically isolate these extraneous influences. To illustrate how failure to properly account for these influences can lead to misleading inferences, a single

site was selected for a more focused statistical analysis. Capistrano Valley Water District agreed to provide the additional data needed to serve as a study site for in-depth statistical modeling[1]. Through statistical control of potentially confounding factors, the more sophisticated analysis provides improved estimates of the change in water consumption attributable to the revised rate structures than simple before and after comparisons.

4.2.2 General Findings

Despite the inherent limitations associated with simple before and after comparisons, they do provide a useful starting point for charting changes in water use. Table 4.1 below summarizes average use in the years before and after adoption of water budget-based rates by the Otay, Irvine Ranch, and Capistrano Valley Water Districts.

Table 4.1 — Pre-/Post- Water Consumption Comparison

Period	Average Annual Service Area Irrigation Rate* (In inches per acre)		
	Otay	Irvine Ranch	Capistrano Valley
pre '88 -'90 Average	28.71	52.16	28.35
post '90 Average	23.05	32.78	18.45
Difference	-5.66	-19.38	-9.90
Percent Change	-20%	-37%	-35%

$$\text{*service area irrigation rate (inches/acre)} = \frac{[\text{annual water demand (acre-feet)} \cdot 12\ (\text{inches/foot})]}{\text{irrigable area (acres)}}$$

[1]The narrowing of analytic effort for these additional questions was required due to constraints of the project budget and time. Readers should note that the analytical results derived for Capistrano Valley could easily differ if the same methods were applied to the remaining study sites.

4.2.3 Detailed Analysis

A more detailed inspection of annual water consumption and service area characteristics provides a basis for understanding how factors other than water rates can influence changes in water demand. Each water agency will be examined in turn using (1) averages of service area consumption, customers, and irrigable acreage and (2) graphs of customer level data before and after the introduction of water budget-based rate structures.

Otay Water District: Table 4.2 provides descriptive statistics on billed water consumption among irrigation-only customers in the Otay Water District. Though the number of accounts (column [2]) has increased 47 percent since the 1986-1990 period, total water demand (column [4]) has only increased 23 percent, based on pre-post averages. Water demand per customer (column [5]) has decreased by about 16 percent since the earlier period. Accounting for the slight increase in the average irrigable area per account (column [3]), the annual application rate for irrigation water (column [6]) has decreased about 20 percent on average—from 28.7 inches to 23 inches per acre. The last column [7] provides the annual change in service-area-wide irrigation rate. Ignoring the drought-emergency year of 1991, the water-budget affected period (1992-present) shows a very similar annual application rate of between 23 and 24 inches per acre.

Table 4.2 — Otay Water District: Billed Water Use

Year	Acres [1]	Accounts [2]	Acres per Account [3]	Total Demand (Acre-feet) [4]	Customer Demand (gl./day) [5]	Irrigation Demand (In./acre) [6]	Change from '86-'90 Average [7]
86	729	311	2.34	1647.8	4730	27.1	
87	824	370	2.23	1679.5	4052	24.5	
88	957	442	2.17	2299.0	4643	28.8	
89	1142	530	2.15	3187.1	5368	33.5	
90	1232	578	2.13	3045.8	4704	29.7	
91	1457	621	2.35	2554.1	3672	21.0	-26.7%
92	1513	656	2.31	3021.7	4112	24.0	-16.5%
93	1512	656	2.30	2947.6	4011	23.4	-18.5%
94	1544	665	2.32	3055.8	4102	23.7	-17.3%
95	1557	679	2.29	2998.4	3942	23.1	-19.5%
'88-'90 Average	977	446	2.20	2,371.9	4699.8	28.71	
post90 Average	1517	655	2.31	2,915.5	3968.0	23.05	-20%
Difference	540	209	0.11	543.7	-731.8	-5.66	
Percent difference	55%	47%	5%	23%	-16%	-20%	

Notes:
[1] Applicable acreage is defined differently among the three participating agencies.
[3] = [1] ÷ [2]
[4] and [5] derived from water consumption histories.
[6] = 12*[4] ÷ [1]

As cautioned previously, it cannot be concluded from these simple comparisons alone that the observed reduction in post 1990 water use is due entirely or even largely to

the introduction of a new rate structure. The largest potentially confounding factor is probably the different effect of weather in the pre- and post- time periods. The period before 1992 saw several years of hot and dry weather The period after 1991 experienced several wetter than average years.[2] Even if all the biasing effects of weather are controlled for, one may still not validly conclude that all the remaining reduction in water use is due entirely to the new rate structure. Because customer outreach efforts and other conservation programs were implemented at the same time, a difficult attributional problem will remain: how much did rates cause customers to reduce water use and how much did the conservation efforts of the water agency?

Several additional observations about the general trend in water use among Otay's irrigation-only customers can be developed based on the graph shown in Figure 4.1. Not only has total water demand "leveled" off, the seasonal shape of demand has also changed. Some observers may note changes in the peak summer water use that have not followed the steep trend of peak summer water use in the pre-1991 period. It would be difficult to discern from this figure, however, if demand has changed in other ways. Is demand more responsive to changes in climate, or less? Last, the growth in irrigated area has dramatically slowed down (due to reduced customer growth), no doubt contributing to the "leveling off" in total demand for irrigation water.

[2]The issue of how the influence of nonnormal weather patterns can be controlled for is addressed in *Section 4.3: Simple Water Impact Analysis*.

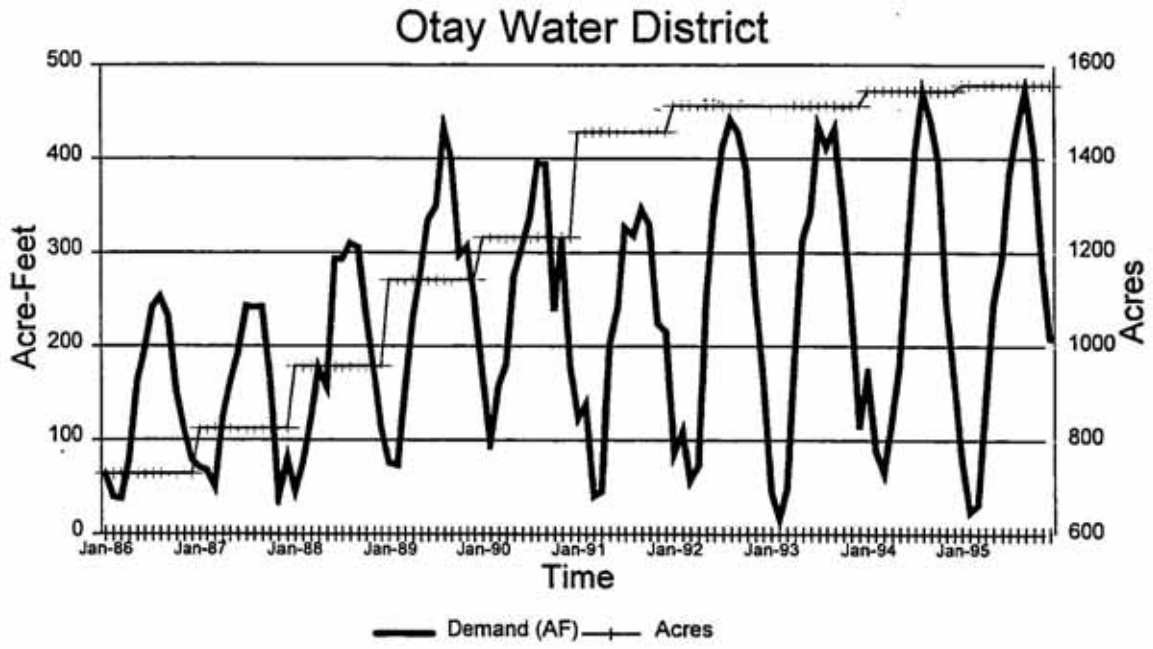


Figure 4.1 - Irrigation Water Demand and Acreage in Otay Water District: 1986 to 1995

Irvine Ranch Water District: Table 4.3 provides descriptive statistics on billed water use among irrigation-only customers in the Irvine Ranch Water District. Growth in the number of accounts (column [2]) has been strong, a 28 percent increase from the 1988-1990 period, while total demand for irrigation water (column [4]) has scarcely increased at all (less than 2 percent). Water demand per customer (column [5]) has decreased by about 21 percent since the earlier period. Since the average irrigable area per customer (column [3]) increased significantly (largely due to the types of new accounts added during the post-period), the annual application rate for irrigation water (column [6]) decreased about 37 percent on average—from 52 inches to 33 inches per acre.[3] The last column [7] provides

[3]Due to different definitions of landscape area (irrigable versus irrigated, slope adjustments, etc.) the measured "acreage" varies across the three service areas. This makes it difficult to compare demand in inches per "acre," across service areas. The reader is urged not to draw conclusions about differences between agencies that, instead, may be largely a matter of differences in definition and measurement. It is also likely that other

the annual change in service-area-wide irrigation rate that reveals even lower application rates (32 to 31 inches per acre) after the inception of the IRWD Operation Outreach in November of 1992 and other targeted conservation efforts[4].

Table 4.3 — Irvine Ranch Water District: Billed Water Use

Year	Acres [1]	Accounts [2]	Acres per Account [3]	Total Demand (Acre-feet) [4]	Customer Demand (gl./day) [5]	Irrigation Demand (In./acre) [6]	Change from 88-'90 [7]
88	2694	1515	1.78	11,901	7013	53.0	
89	3209	1803	1.78	13,892	6879	51.9	
90	3434	1941	1.77	14,741	6780	51.5	
91	4159	2034	2.04	12,040	5285	34.7	-33.4%
92	4454	2120	2.10	12,780	5382	34.4	-34.0%
93	5010	2208	2.27	13,413	5423	32.1	-38.4%
94	5677	2294	2.47	14,940	5814	31.6	-39.5%
95	5968	2532	2.36	15,421	5437	31.0	-40.6%
'88-'90 Average	3112.3	1753.0	1.78	13,511.5	6891	52.16	
post90 Average	5053.6	2237.6	2.25	13,718.9	5468	32.78	-37.2%
Difference	1941.3	484.6	0.474	207.5	-1422	-19.38	
Percent Δ	62%	28%	27%	2%	-21%	-37%	

Notes:
[1] Applicable acreage is defined differently among the three participating agencies.
[3]=[1] ÷ [2]
[4] and [5] derived from water consumption histories.
[6] = 12*[4] ÷ [1]

inter-site differences—in historical plant palate, irrigation equipment, and irrigation practices—would make interpretation of cross-sectional water use differences difficult.

[4]The same qualifications made about Otay billed water use comparisons apply to IRWD; *caveat lecteur*.

The graphs that follow provide another kind of interesting pre/post comparison: the irrigation demand (in inches per acre) is plotted against the irrigated area of the customer. (The straight line depicts the average application rate across customers; the slightly declining curved line represents a general trend, as captured by polynomial spline.) There are two qualitative conclusions that can be drawn from the BEFORE PICTURE (1988-1990 IRWD Irrigation Application Rate). Smaller irrigation customers not only tend to apply more water per acre on average, there is also more variation in irrigation practices. The AFTER PICTURE reveals a reduction in both the mean and the variance of application rates across customers.

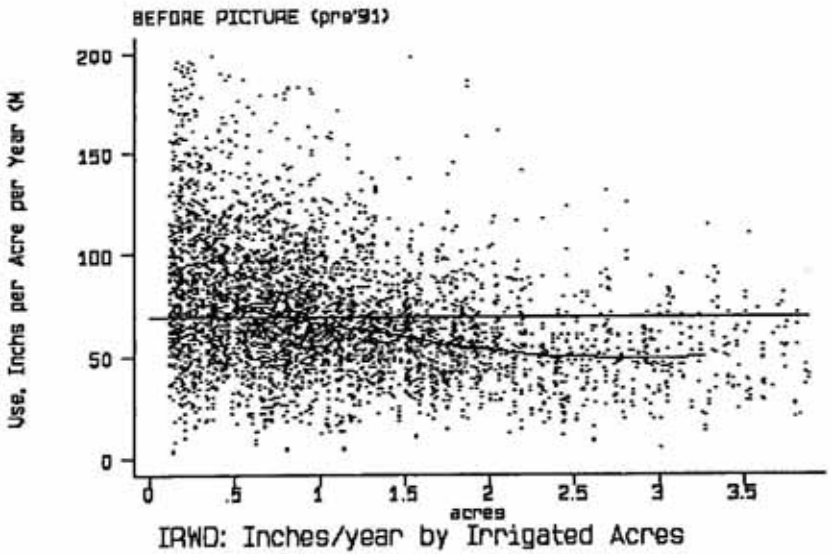


Figure 4.2 IRWD Application Rate (inches/year) by Irrigated Acres 1988-1990

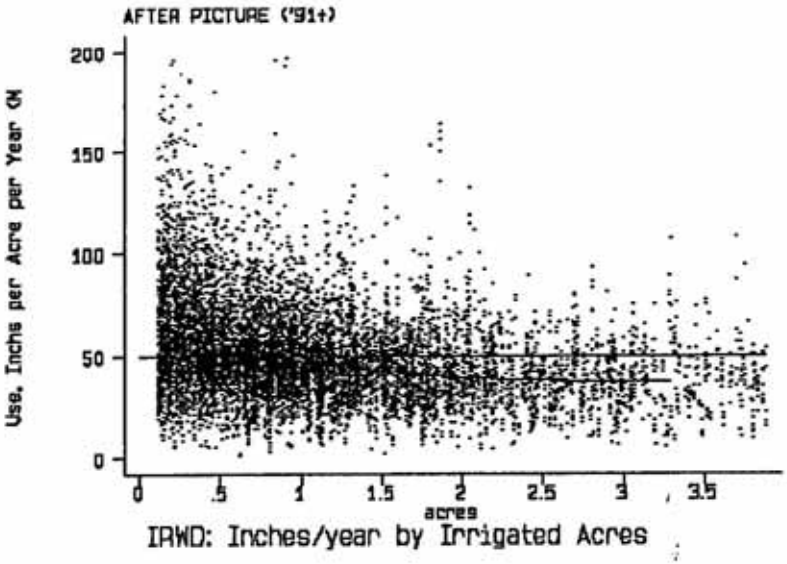


Figure 4.3 IRWD Application Rate (Inches/year) by Irrigated Acres 1991-1995

Capistrano Valley Water District: Table 4.4 provides descriptive statistics on billed water use among irrigation-only customers in the Capistrano Valley Water District. The number of accounts (column [2]) has increased 12 percent since the 1988-1990 period while total demand for irrigation water (column [4]) decrease by about 7 percent. Water demand per customer (column [5]) has decreased by about 17 percent since the earlier period. The average irrigable area per customer (column [3]) increased, again due largely due to the types of new accounts added during the post-period. As a result, the billed change in annual application of irrigation water (column [6]) was a decrease of about 35 percent—from 28 inches to 18 inches per acre. The annual change in service-area-wide irrigation rate (column [7]) reveals weather-driven annual fluctuations.

Table 4.4 — Capistrano Valley Water District: Billed Water Use							
Year	Acres [1]	Accounts [2]	Acres per Account [3]	Total Demand (Acre-feet) [4]	Customer Demand (gl./day) [5]	Irrigation Demand (In./acre) [6]	Change from 88-'90 [7]
88	495	294	1.68	1195.4	3630	29.0	
89	523	316	1.65	1272.3	3594	29.2	
90	539	322	1.67	1205.3	3342	26.9	
91	595	336	1.77	1049.3	2788	21.2	-25%
92	875	340	2.57	1134.0	2978	15.6	-45%
93	745	348	2.14	1217.8	3124	19.6	-31%
94	752	355	2.12	1267.6	3188	20.2	-29%
95	781	362	2.16	1020.1	2516	15.7	-45%
'88-'90 Average	519	311	1.67	1,224.3	3522.0	28.35	
post90 Average	750	348	2.15	1,137.8	2918.7	18.45	-35%
Difference	231	38	0.48	-86.6	-603.4	-9.90	
Percent Δ	44%	12%	29%	-7%	-17%	-35%	

Notes:
[1] Applicable acreage is defined differently among the three participating agencies.
[3]=[1] ÷ [2]
[4] and [5] derived from water consumption histories.
[6] = 12*[4] ÷ [1]

Similar qualitative conclusions can be drawn about the Figures 4.4 and 4.5 for Capistrano Valley. The amount of water applied to landscape changes with the size of landscaped area. Smaller sites tend to (1) use more water and (2) have a wider variation in watering practices. More formal statistical controls for climatic differences will be needed to quantify any structural changes related to water-budget based rate structures.

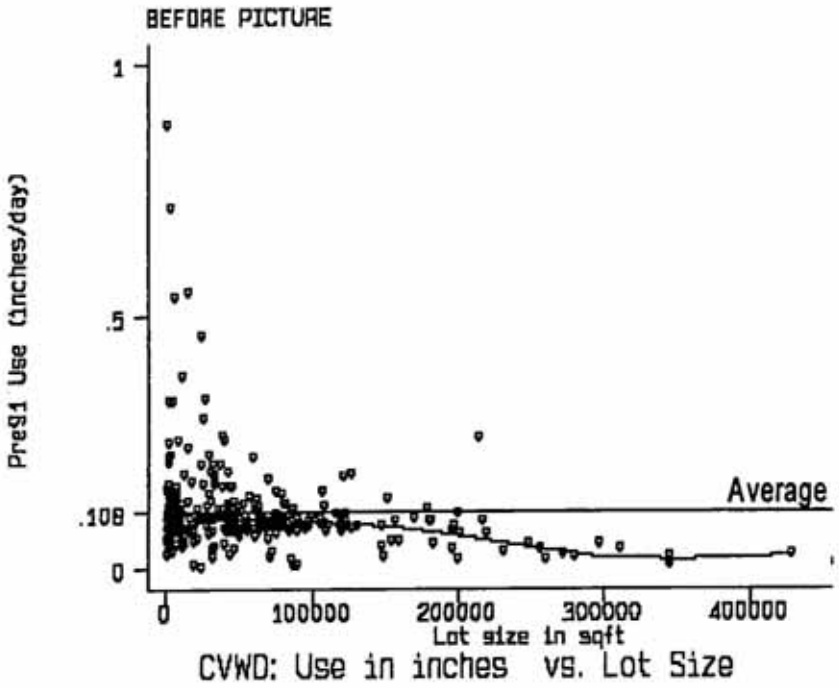


Figure 4.4 CVWD Application Rate (inches/day) by Lot Size (sq.ft.): 1988-1990

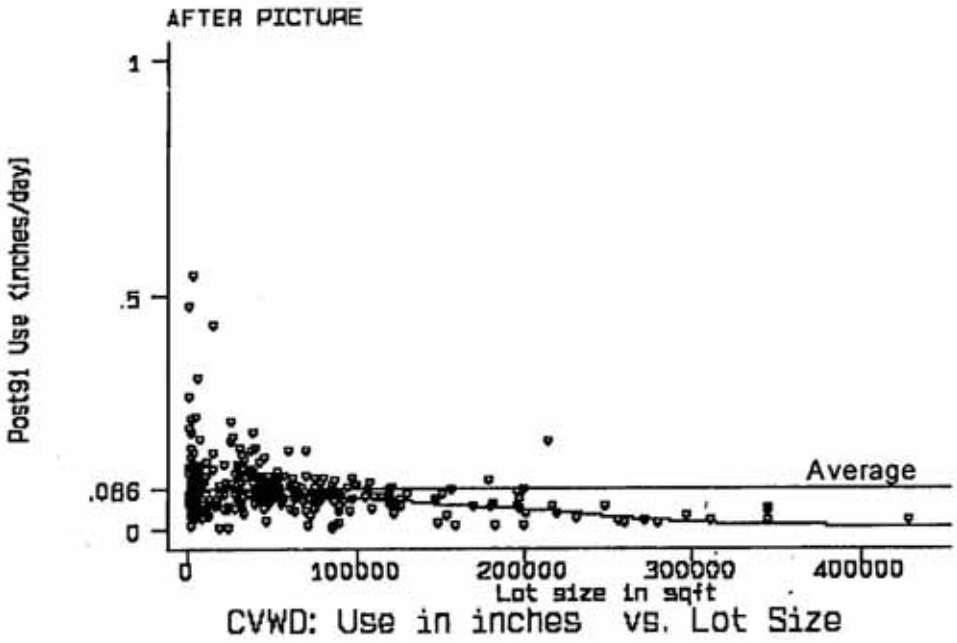


Figure 4.5 CVWD Application Rate (inches/day) by Lot Size (sq.ft.): 1991-1995

4.3 Simple Statistical Models

4.3.1 Issues

This section focuses on the example of Capistrano Valley Water District to illustrate how the confounding effects of changing customer characteristics and weather can be controlled using statistical methods. The detailed analysis first addresses how new customers can systematically differ from the existing customer base. A modeling framework is then provided to formalize the descriptive statistics derived from annual water consumption. This modeling framework can also be generalized to allow for statistical "control" for additional biasing factors such as climate.

Because weather can strongly affect water consumption, especially among irrigation-only accounts, landscape professionals often attempt to "normalize" billed consumption records for any nonnormal weather[5]. The modeling framework will be used to formally examine the effect of alternative climate correction methods on estimates of pre-/post- changes in water consumption using a statistical model. Special attention will be paid to characteristics and limitations of available weather measures of evapotranspiration, precipitation, and air temperature. The final section, **Section 4.4 Intervention Models for Structural Change**, extends the modeling framework to allow additional effects of these interventions, beyond a change in mean water use.

[5]If a pre-/post- comparison of water use includes hot and dry weather in the pre-period and wet and cool weather in the post-period, then the observed change in billed water use would reflect these weather differences in addition to any water rate-induced change.

4.3.2 General Findings

- **All is not what it seems.** The total change in water use will contain customer growth. The total change in water use per account will mix-up old customers with new customers. A more coherent picture emerges when a pre-intervention customer base is separated from post-intervention new customers.

- **ET° is not sufficient to "Normalize" for Climate.** Climate corrections using only observed evapotranspiration did not sufficiently capture the effect of climate on irrigation demand. One striking example is CVWD's decline in 1995 irrigation demand; this could not be explained at all by observed ET without considering the effect of 28 inches of rainfall in the San Juan Capistrano Valley.

4.3.3 Detailed Analysis

Customer Characteristics: As water agencies grow, new customers receive service connections and begin using water. There are several ways that changes in a customer base could bias an estimate of a change in water use. New customers may have larger or smaller irrigated areas. Even if the amount of irrigated area were controlled for, the new irrigation equipment installed by new customers is likely to reflect the higher water efficiencies of newer irrigation technology and may be designed and installed to reflect the most current horticultural knowledge and improved irrigation practices. To illustrate these effects in CVWD, the table of billed water use histories will be recalculated for the subset of customers having nearly continuous water use histories between 1988 and 1995. These results will then be replicated with slightly greater precision using a formal model.

Table 4.5 shows that the subset of customers with continuous histories now show no trend in the amount of irrigated area per customer. Thus, differences between the pre-/post- comparisons in customer water use and application rates are greatly reduced. More interestingly, the long-term customers showed a smaller decline in mean water use—from 29 inches to 23 inches. Newer customers tended to come on line with lower application rates for irrigation water.

Table 4.5 — CVWD: Billed Water Use of Long-Term Customers							
Year	Acres [1]	Accounts [2]	Acres per Account [3]	Total Demand (Acre-feet) [4]	Customer Demand (gl./day) [5]	Irrigation Demand (In./acre) [6]	Change from 88-'90 [7]
88	437	273	1.60	1098	3591	30.2	
89	464	295	1.57	1134	3432	29.4	
90	461	295	1.56	1108	3353	28.9	
91	462	295	1.56	863	2613	22.4	-24%
92	461	295	1.56	930	2815	24.2	-18%
93	460	295	1.56	930	2814	24.2	-18%
94	460	295	1.56	993	3006	25.9	-12%
95	469	295	1.59	754	2281	19.3	-35%
'88-'90	454	288	1.58	1,113.4	3458.7	29.5	
post90	462	295	1.57	894.1	2705.7	23.2	-21%
Diff.	9	7	-0.01	-219.3	-752.9	-6.2	
Percent	2%	3%	-1%	-20%	-22%	-21%	

Notes:
[1] Applicable acreage is defined differently among the three participating agencies.
[3]=[1] ÷ [2]
[4] and [5] derived from water consumption histories.
[6] = 12*[4] ÷ [1]

Modeling Framework: The results in Table 4.5 can also be expressed formally. The change in customer water use, for example, can be expressed as:

$$Use = \mu_{pre} + \Delta \cdot i_{post} \qquad (1)$$

where

Use is the water use per irrigation account in gallons per day,
μ_{pre} is a constant term (the estimated mean water use in the pre-intervention period),
i is a zero-one indicator variable for all post-intervention periods, and
Δ is the estimated change in mean water use.

A least squares regression estimate of the model given in (1) using the customer-level data summarized in Table 4.6 is:

Table 4.6 Simple Water Use Model
CVWD Long Term Customers

Dependent Variable: use (gpd)

Variable	Coefficient.	Std. Err.
Constant Term	μ_{pre} = 3445.2	62.4
0-1 Indicator for reads after 12/90	Δ = - 778.0	74.5
Observations = 19382	Adj R^2 0.0063	√MSE = 4448.7

Thus the estimated model is:

$$Use = 3445\ gpd - 778\ gpd \cdot i_{post} \qquad (2)$$

The model suggests that customer water use was reduced by about 22.5 percent (= 778gpd / 3445gpd). What is the advantage of using regression to estimate a mean and a change in mean? Expressing the problem in the framework of a model explaining irrigation customer water use allows for:

(1) probabilistic statements about changes in water use[6],
(2) statistical control of biasing factors, and
(3) a richer characterization of customers response to the intervention.

Note that the model of Table 4.6 is not the only form in which a model could be expressed; it is merely the form that directly matches column (5) of Table 4.5.[7] Another choice for the dependent variable would be the application rate of irrigation water (column 6 of Table 4.5)—the amount of water per some unit of landscape area. Models of this dependent variable are not presented for several reasons. Dividing metered water use by an additional measurement of landscape area should be understood as a standardization that constitutes a form of weighting. Descriptive statistics or models constructed using customer applications of irrigation water will weight by the number of customers. Thus, while the CVWD service area used 28.35 inches of water per square foot of irrigable area before 1991, the average application rate per customer was almost 40 inches of water in the same period. This difference is entirely due to the skew in application rates depicted in Figures 4.4 and 4.5. Practically speaking, the use of application rate as a dependent variable accentuates rather that reduces heterogeneity in the equation.[8]

The following section will explicitly account for the confounding effect of climate by

---

[6]As an example of a probabilistic statement, the model above could be used to conclude that the observed change in water use would be extremely unlikely if there were truly no change in water use. Put in terms of hypothesis testing, one would reject the null hypothesis (a zero change) at very high levels of statistical confidence. In terms of effect size, the estimated change ($\Delta \approx 778$ gpd) is more than ten times as large as its standard error ($\sigma_{\Delta} \approx 75$ gpd).

[7]The change estimates in Tables 4.5 and 4.6 differ slightly. Table 4.5 uses simple averages of annual averages while the model in Table 4.6 constitutes a more appropriate weighted average that properly accounts for the number of observations in each period.

[8]In addition, when ratios are used as dependent variables, measurement error in either the denominator or numerator can be amplified. Additional complications would also come about if one wanted to make predictive inferences about mean water use. The expected change in water use in a post-intervention period could not be derived by multiplying the expected change in application rate by the mean area. This is due to the theoretically well-known property that the product of two expectations does not, in general, equal the expectation of the product.

extending the water use model to include climate.

Accounting for climate: Why bother controlling for changes in climate? Table 4.7 presents measures of annual climate from two weather stations in Orange County—the Irvine CIMIS Station #75 and a recently constructed weather station within San Juan Capistrano. The pre-intervention period (1988-1990) is characterized by higher than average evapotranspiration and air temperatures and lower than average precipitation. This type of climatic pattern would tend to increase irrigation water demand. The post-intervention period (1991-1995) is characterized by higher than average evapotranspiration and precipitation in several years. The effect of the weather on irrigation water demand in these years is less readily discerned. The large amount of 1995 rainfall recorded in the first year of San Juan Capistrano's weather station corresponds to a large drop in water demand.

Table 4.7 — Historical Climate in Orange County

IRVINE CIMIS Station Number 75						
Year	Evapotranspiration		Precipitation		Max. Temperature	
	(in./year)	Deviation	(in./year)	Deviation	(degrees F)	Deviation
1988	48.8	2.5%	12.4	-6%	74.3	1.3%
1989	48.8	2.4%	4.5	-66%	74.6	1.6%
1990	50.9	6.8%	8.2	-38%	74.8	1.9%
1991	48.5	1.9%	21.1	60%	72.7	-0.9%
1992	48.7	2.1%	Corrupted data		74.5	1.6%
1993	49.7	4.3%	20.8	57%	73.2	-0.2%
1994	47.6	-0.1%	7.5	-43%	73.2	-0.2%
1995	48.5	1.8%	14.5	10%	73.9	0.7%
Mean	47.6		13.2		73.4	
San Juan Capistrano Station						
Year	Evapotranspiration		Precipitation		Max. Temperature	
	(in./year)	Deviation	(in./year)	Deviation	(degrees F)	Deviation
1995	44.0	n.a.	28.0	n.a.	70.3	n.a.

The following section will extend the modeling framework to (1) estimate the effect of the weather on water demand and (2) control for the influence of weather in estimating a long term shift in water demand.

Models to Correct for Climate: Is ET° Enough? The model described by equation (1) will now be extended in several ways. The model of a change in mean water use (as in equation (1)), though simple in form, did not do a very good job of explaining water use. Less than one percent of the total variation in water use was explained by the mean-change-in-mean model. This simple model will be modified in several ways.

- The dependent variable will be the natural logarithm of daily use.[9]
- A measure of irrigable area will be added as an explanatory variable.[10]
- Variables representing a constant seasonal pattern of water use will be added.
- Different weather measures—evapotranspiration, precipitation, and maximum air temperature—will be tested for their contribution to explaining water use.[11]
- The zero-one indicator will be broken into two parts—a zero-one indicator for 1991 and a zero-one indicator for points in time thereafter.[12]

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[9]A logarithmic transformation was chosen for the dependent variable for several reasons: equation fit, reduction of skew, and variance stabilization. A small scaling factor is added to use prior to taking logarithms due to the problem of "inliers." In this example, inliers are values of billed water consumption between zero and one that, when logarithmically transformed, are converted into large negative values. Scaling factors in the 400-500 gpd range lessened an undue influence by these logarithmically-transformed near-zero consumption reads.

[10]This is a direct adjustment for size that is less restrictive than dividing water use by irrigable area.

[11]The climatic measures use logarithmic transformations and a departure-from-mean form as described in Equation (3). Subtracting the seasonal mean from each climate measure does not change the equation prediction because seasonal harmonics are also included.

[12]The rate structure was not in place for all of calendar year 1991. Additional observations from the first half of calendar year 1996 will also be included. These observations were initially excluded to ensure comparability between the billed water consumption table and the simple regression model.

The exact form of the model is:

$$\ln(Use+\delta) = \mu + \ln(Area)\cdot\beta_{Area} + S\cdot\beta_S + C\cdot\beta_C + \Delta_{91}\cdot i_{91only} + \Delta_{92+}\cdot i_{92+} \qquad (3)$$

where

$\delta \equiv$ a scaling factor

$$S\,\beta_S = \sum_{j=1}^{4}\left\{\beta_{1,j}\sin\left(\frac{2\pi jT}{365}\right) + \beta_{2,j}\cos\left(\frac{2\pi jT}{365}\right)\right\}; \text{ where } T = (1,\ldots,365).$$

$C \equiv DLE, DLR, DLT$; i.e., climatic measures, where

$$DLE \equiv \ln(ET^{\circ}+1) - \overline{\ln(ET^{\circ}+1)},$$

$$DLR \equiv \ln(Rain+1) - \overline{\ln(Rain+1)}, \text{ and}$$

$$DLT \equiv \ln(Temp.) - \overline{\ln(Temp.)}.$$

Table 4.8 displays four models that control for climate to varying degrees. The estimation method is least squares. The measure of interest is the percentage change in water use from January 1992 to June 1996. The first model that does not control for climate, Model 0, estimates that water demand decreased about 25.2 percent ($\approx 1-e^{(.29)}$). Model 1 includes a measure of evapotranspiration that helps explain variations in water demand. The estimated coefficient on evapotranspiration can be interpreted as an elasticity—a one percent increase in monthly evapotranspiration increases consumption by 6 percent. Controlling for the variations in water use explained by evapotranspiration reduces the estimated post-intervention change in mean water use to about 24.4 percent. In addition to evapotranspiration, Model 2 adds a measure for monthly precipitation. The estimated coefficient is both statistically significant ($t=-1.517\div 0.134\approx -11.3$) and practically meaningful. Controlling for the variations in water use explained by variations in evapotranspiration and precipitation reduces the estimated post-intervention change in mean water use to about 22.3 percent. Model 3, adding temperature, does not produce qualitatively significant differences (the percent reduction is less than one-half of a percent less while equation prediction and root mean squared error are about the same.) Since temperature is one of the major forces that drive evapotranspiration, this result is not

surprising[13].

Controlling for climate reduces the estimated change in water use—from about 25 percent to 22 percent. For the sake of parsimony, Model 2 will be selected for further development of the intervention effect.

It is entirely possible that the intervention of water-budget-based rate structures and customer outreach programs did more than merely reduce average annual water demand. These interventions may have also changed

- the seasonal shape of demand and
- how customers respond to changes in climate.

The following section specifies a formal model to empirically test for these types of changes in the structure of irrigation water demand. All the models presented in Table 4.8 assume that the relationship between irrigation demand and climate, β_c, is the same in the post-period as the pre-period. If this assumption is not true, the estimated coefficient measuring the change in water demand can be biased.[14]

[13]In exploratory modeling, we also estimated models that combined evapotranspiration and precipitation into a single index. The key issues in creating this type of index, is how much rainfall effectively reduces evapotranspiration requirements. The estimate of the proportion of effective rainfall derived from these models was about 40 percent. This result is comparable to recent work by Bamezai (1996).

[14]In our previous work (Chesnutt, et al. 1995, 1994) concern over the validity of this restriction led to a more laborious process of estimating a structural model in the pre-intervention period, forecasting into the post-intervention period, and generating a formal definition of conservation as the difference between expected use (the model prediction) and actual use. A second set of models would then be developed to explain (or map) this definition of conservation. The analysis in this chapter has focused on the mean change model to explain its shortcomings, and present a one-step structural model that comes closer to the answers produced by the multiple-step method described above.

Table — 4.8 Models Controlling for Climate
CVWD Long Term Customers
Dependent Variable ln use (gpd) per account

	Model 0 w/o Climate		Model 1 with ET°		Model 2 with ET° & Rain		Model 3 w/ET°, Rain, & Temp.	
Variable	**Coef.**	**Std. Error**	**Coef.**	**Std. Error**	**Coef.**	**Std. Error**	**Coef.**	**Std. Error**
Intercept	3.098	0.037	3.084	0.037	3.068	0.037	3.065	0.037
ln Irrigable Area (sq.ft.)	0.446	0.003	0.446	0.003	0.446	0.003	0.445	0.003
First sine harmonic	-0.399	0.007	-0.413	0.007	-0.392	0.008	-0.401	0.008
First cosine harmonic	-0.514	0.007	-0.504	0.007	-0.505	0.007	-0.508	0.007
Second sine harmonic	-0.161	0.008	-0.155	0.008	-0.132	0.008	-0.134	0.008
Second cosine harmonic	-0.055	0.008	-0.030	0.008	-0.035	0.008	-0.035	0.008
Third sine harmonic	-0.032	0.009	0.006	0.010	0.015	0.010	0.008	0.010
Third cosine harmonic	0.057	0.009	0.035	0.009	0.023	0.009	0.021	0.009
Fourth sine harmonic	0.018	0.011	0.025	0.011	0.018	0.011	0.020	0.011
Fourth cosine harmonic	0.005	0.011	-0.004	0.011	-0.011	0.011	-0.004	0.011
ln ETo + 1 Deviation			6.108	0.378	5.413	0.382	4.231	0.485
ln Rain + 1 Deviation					-1.517	0.134	-1.471	0.134
ln Max Temp. Deviation							0.855	0.216
Change in 1991 consumption	-0.173	0.019	-0.159	0.019	-0.135	0.019	-0.117	0.019
Change in use beginning Jan. 1992	-0.290	0.012	-0.279	0.011	-0.252	0.012	-0.245	0.012
percent Δ92 ($=1-e^{(\beta-\sigma^2/2)}$)	**-25.2%**		**-24.4%**		**-22.3%**		**-21.7%**	
	Adj R^2 = 0.582 √MSE = 0.689		Adj R^2 = 0.588 √MSE = 0.684		Adj R^2 = 0.591 √MSE = 0.682		Adj R^2 = 0.591 √MSE = 0.682	

Notes: Estimation method is least squares.

4.4 Intervention Models for Structural Change

4.4.1 Issues

The last step will present a more involved statistical "intervention" model to formally test a simple set of hypotheses. The term "intervention" is used here to refer to the combined effect of water-budget based rate structures **and** the accompanying customer outreach programs on water consumption. Statistically speaking, if both the rate structure and the outreach programs occur together, an empirical analysis will not be able to identify the separate effect of each, only their joint effect.

Formal statistical models can be extended to test for more than an average reduction of water consumption. The combination of water-budget based rate structures and outreach programs can change **how** customers respond to changes in weather. This section specifies a formal model to estimate: the change in the level and shape of water consumption and how customers changed their response to weather. Special attention will be paid to methodological issues surrounding how this type of model should be estimated. Specifically, this section addresses how the issues of customer heterogeneity and model heteroskedasticity should be handled statistically.

4.4.2 General Findings

- mean water use among CVWD pre-intervention customers declined approximately 18.6 percent.
- the reduction in summer peak water demand was slightly less.
- customers became more responsive to changes in evapotranspiration.

4.4.3 Detailed Analysis

The formal model expressed in equation (3) is expanded by allowing several model

coefficients to change in the post intervention period. Specifically, the model will be specified to permit a structural change in:

- mean water use,
- the seasonal pattern of water use,
- the response of customer demand to changes in evapotranspiration, and
- the response of customer demand to changes in rainfall.

The model is formulated using interactions of the intervention term with other structural influences:

$$\ln(Use+\delta) = \mu + \ln(Area)\cdot\beta_{Area} + S\cdot\beta_S + DLE\cdot\beta_{DLE} + DLR\cdot\beta_{DLR} + i_{92*}\cdot\left\{\Delta_{92*} + \Delta_{1,1}\sin\left(\frac{2\pi T}{365}\right) + \Delta_{DLE}\cdot DLE + \Delta_{DLR}\cdot DLR\right\} \quad (4)$$

The estimation method is random coefficients[15], so as to control for both customer heterogeneity and heteroskedasticity in the equation error.[16] The drought emergency year of 1991 is omitted since demand response in this year was supply-constrained and not representative of either a typical pre- or post- intervention period.

[15]The random coefficient method can be thought of as a random effect estimator of the mean function that allows for correlation of the coefficients with the equation error, i.e., a variance function.The exact form of the variance, or link, function is a linear relationship between the absolute white noise error and the regressors. The implementation is Generalized Least Squares, based on the theory and methods of Carroll and Ruppert (1988).

[16]Table 4.9 provides a formal test for customer-specific heterogeneity in the form of an F-Test on the hypothesis that the intercept is common for all customers; This hypothesis can be rejected at a very high level of statistical confidence ($Prob[F_{(294,16787)} > 39.8] \ll 0.00001$.)

Table — 4.9 Structural Intervention Model 4
CVWD Long Term Customers
Dependent Variable ln use (gpd) per account

Variable	Coef. β	Std. Err. σ	"t" statistic β/σ
Intercept	0.1863	0.0239	7.78
ln Irrigable Area (sq.ft.)	0.6329	0.0144	43.84
First sine harmonic	-0.2973	0.0107	-27.83
First cosine harmonic	-0.4941	0.0065	-76.24
Second sine harmonic	-0.1561	0.0068	-22.81
Second cosine harmonic	-0.0369	0.0064	-5.73
Third sine harmonic	-0.0082	0.0075	-1.10
Third cosine harmonic	0.0479	0.0075	6.38
Fourth sine harmonic	0.0164	0.0085	1.93
Fourth cosine harmonic	0.0148	0.0085	1.73
ln (ETO + 1) Deviation	2.1348	0.5728	3.73
ln (Rain + 1) Deviation	-5.1469	0.4235	-12.15
i91: Indicator for Periods Jan. 92 +	-0.2058	0.0096	-21.51
i92 * First sine harmonic	-0.1060	0.0125	-8.47
i92 * ln (ETo + 1) Deviation	1.9374	0.6869	2.82
i92 * ln (Rain + 1) Deviation	4.5236	0.4556	9.93

Total R-squared (Weighted Space) .793
Total R-squared (Unweighted Space) .703

Standard Error of white noise error is: 0.5310
Standard Error of Individual constants is: 0.4244
Intraclass Correlation: 0.8378

Test on Hypothesis that all intercepts are equal (i.e., OLS is correct)
F (294 , 16787) = 39.836

Number of obs 17096 Number of Groups: 295 Mean Number of Periods: 58

The estimates in Table 4.9 suggest that the combined intervention of water-budget-based rate structures and customer outreach programs in CVWD had the following effects on the structure of water demand:

- Average water demand was reduced.
- The seasonal peak demand was also reduced, though to a lesser degree than average daily demand.
- Customer demand became more responsive to evapotranspiration.
- Customer demand became less responsive to rainfall.

Specifically, average water demand, controlling for climate and customer heterogeneity, was reduced about 18.6 percent ($\approx 1 - e^{-.2058+\sigma^2/2}$). The normal weather seasonal pattern of water demand before and after 1991 can be derived and compared using the above coefficient estimates. Figure 4.6 plots this "normal weather" irrigation demand. Horizontal lines are placed through the mean of the pre- and post- 1991 seasonal patterns. The pre-1991 seasonal pattern is given by the linear combination:

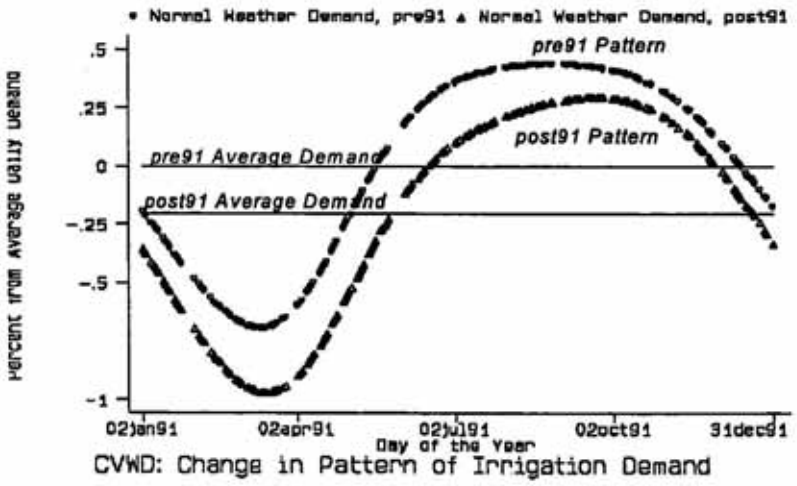

Figure 4.6 Normal Weather Irrigation Demand.

sin1*-.2973 + cos1*-.4941 + sin2*-.1561 + cos2*-.0369 + sin3*-.0082 + cos3*.0479 + sin4*.0164 + cos4*.0148. After 1991, the seasonal pattern can be found by adding and additional sin1*-.1060 to the pre-1991 pattern. Readers may note that the reduction in peak demand in Figure 4.6 is less than the reduction in mean demand.

The change in customer response to climate, with customer demand being more responsive to changes in evapotranspiration in the post-period, would certainly accord with prior expectations[17].

4.5 Summary

4.5.1 Qualifications

The estimated changes in water demand have controlled for climate, estimated the mean reduction, documented the change in shape of demand, and documented a change in how demand responds to climate. The estimated model can not attribute how much of this total change is due to water-budget-based rate structures and how much is due to customer outreach or education programs. Doing so would require knowledge about the exact nature of customer outreach and education programs occurring during the analysis period. Though this is possible, it was not attempted here due to time and budget constraints.

Models were estimated that have a richer specification for the response to climate—allowing the climate elasticities to vary through the year, for example. The models using these specifications produced similar mean change estimates to the less complex structural intervention model presented above. Given the relatively short snippet of climatic history represented in these eight and a half years of calendar time, we chose the simpler models.

[17]The change in the rainfall elasticity may be more difficult to evaluate due to the noncomparability of climatic variation in the pre- and post- periods.

4.5.2 Findings

- **All is not what it seems.** The total change in water use will reflect customer growth. The total change in water use per account will mix old customers with new customers.

- **ET° is not sufficient to "Normalize" for Climate.** Climate corrections using only observed evapotranspiration did not sufficiently capture the effect of climate on irrigation demand. One striking example is CVWD's decline in 1995 irrigation demand. This could not be explained at all by observed ET without considering the effect of 28 inches of rainfall in the San Juan Capistrano Valley.

- **Assuming an invariant climate-response is risky.** Many impact evaluations use a single-step regression model with a zero-one indicator to estimate the average participation/intervention effect. When the climate-coefficients are assumed equal in the post-intervention periods, a biased participation/intervention effect can result.

- **Nothing is something.** Analysts should not discard zero consumption readings, especially from irrigation-only meters where zero reads are both meaningful and likely. Omission of zero reads can greatly effect the estimated coefficients on indicator variables in regression models. Appropriate scaling can lessen the leverage of zero realizations of the dependent variable. Two-part conditional models could yield an analytically more appropriate portrayal of the distribution of irrigation water demand.

- **Estimation methods should account for customer differences and nonconstant variance.** Formal tests strongly suggested the presence of customer heterogeneity and heteroskedasticity of the equation error. Appropriate panel data estimation methods should be used.

- **Structural models can estimate more than an "average" program effect.** The structural intervention model of CVWD irrigation demand revealed changes in:
  (1) the average level of water consumption,
  (2) the shape of seasonal (normal weather) water demand, and
  (3) the response of demand to climatic variation.

- **Empirical impact evaluation should go beyond estimation of an "average" effect.**

CHAPTER 5. GUIDELINES AND RECOMMENDATIONS

In this concluding chapter, we first summarize recommendations for successful programs, based on our in-person interviews and other data collection. Then we summarize recommendations for successful evaluations.

5.1 Guidelines and Recommendations for Successful Programs

Based on interviews conducted at the four agencies, the research team put together a list of factors that influence the success of the landscape water conservation programs. This list of factors is expressed in the form of recommendations for agencies developing similar programs in other service areas. Our expectation is that the recommendations will also be helpful to agencies that already have landscape conservation programs by providing a base of comparison and ideas for further program development. The focus of these findings, as with the study as a whole, is on water-budget-based programs with tiered rate structures. The central finding of this study is the importance of combining a water-budget-based program with other complementary efforts, such as customer outreach, education, audits, and rebates.

Caveats: These recommendations can assist new program design and focus discussion of how to improve existing programs. However, implementing *all* recommendations listed below may not be necessary for a successful program. Nor does implementation of recommendations guarantee success.

When planning and designing water-budget-based conservation programs, the following recommendations provide guidance based on "hard knocks" experience.

- **Coordinate Internally First.**
- **Develop Sustained Commitment to the Program by Board and Staff.**
- **Focus on Information Systems Requirements in the Beginning.**
- **Water-Budgets are seen as "Fair."**
- **Target Any Additional Revenue to Conservation Programs.**

- **Design Appropriate Tiers for the Rate Structure.**
- **Motivate the Program with Ethical *and* Economic Arguments.**
- **Create a Win-Win Program for the Agency and its Customers.**
- **Utilize Horticultural Science.**

And when implementing these programs . . .

- **Be Responsive to Customer Concerns.**
- **Be Strategic about Timing of the Program.**
- **Show the Customer How to Save Money with Conservation.**
- **Educate, Educate, Educate!**
- **Prioritize Conservation.**
- **Communicate Well and Often.**

We address each of these in turn:

- **Coordinate Internally First.** Designing and implementing a water-budget or tiered-rate landscape conservation program involves all levels of the water agency: board members, general manager, conservation staff, accounting and finance staff, computer and information systems, and public affairs. To maximize the chances and extent of success it is important to coordinate, communicate, and educate all of those who have a significant role in the program. A thorough understanding of the motivation and operation of the program by all levels of the organization will enhance the ability to create a more effective program and improve it over time.

- **Develop Sustained Commitment to the Program by Board and Staff.** For the board and staff to stand behind the program, they must be firmly convinced it is a good idea. The idea needs to be developed and adjusted until it is well understood by the staff and board and until there is a critical mass of consensus that it is a strongly positive program. Moving to a tiered rate structure, or redesigning an existing system is likely to encounter resistance, at least from some segment of the customer base. With sustained commitment to the program, the leadership of the

agency can support and defend the program, and also be ready and motivated to fix problems when they are identified.

Commitment will help put the up-front program development costs in perspective. Although water-budget-based conservation programs and tiered rate structures involve effort and start-up costs, they are likely to pay off in the long run.

- **Water-Budgets are seen as "Fair."** One of the major payoffs of water-budget based rate structures, identified in each of the implementing water agencies, was their greater perceived "fairness." While there can be an "inverse relationship between fairness and complexity," most of the agency staff involved felt the additional complexity of customer-specific water budgets were more than outweighed by the increased customer acceptance of their customized rate structure. Customers prefer that their water-budget-based rates be based on the characteristics of their site, not an average. One staffer described that using an analogy to buying a quart of milk at the super market–"You want to pay based on what you buy, not based on the average milk consumption in your customer class." There are two ways to increase the accuracy, and hence the perceived fairness, of a water budget:

  - Adjust water budget and rates based on observed ETo, rather than average.
  - Adjust water budget and rates based on actual days of service, not an average billing period (e.g. 30 days)

  Variance programs have also been used to increase "fairness" when applying landscape-budgets to customers having significant non-landscape water use.

- **Focus on Information Systems Requirements in the Beginning.** It is important to get the billing automation right from the beginning. Water budget-based rate structures are more complicated and require regular monitoring and follow-up; the customer billing system requirements are thus greater. Building a more capable and adaptable

billing information system does have other collateral benefits.

Collect data on square footage of landscape sites by direct measurement or from a consistent real estate data service. GIS systems are developing and can serve as an appropriate repository for customer landscape information. Monitor water use and follow-up with top water users.

A fair water-budget-based program with a tiered rate structure is complex and it relies greatly on information system professionals within the water agency and their willingness to modify the system. The critical ingredient is usually not hardware or software; it is the liveware.

- **Be Strategic about Timing of the Program.** Many water agencies have implemented rate adjustments in the summer to be coincident with the fiscal accounting year. Though convenient for accounting purposes, an increase in rates in mid-summer gives customers little time to adapt; "sticker shock" is greatest during the peak season.

- **Target Any Additional Revenue to Conservation Programs.** Several of the agency staff involved in the implementation of water budget based rate structures felt that the linkage of any additional revenues to the conservation programs was a strong selling point. "The customers pay, the customers benefit." The revenue can go to subsidize the low tier rate, provide rebates for conservation equipment for those over the water-budget, and pay for staff to provide customer assistance. Don't make "conservers" pay for "wasters'" conservation; this linkage helps to explain where the money for conservation comes from and how that contributes to conservation.

Some agencies have found that establishing a separate account for the water-

budget based rates has helped sustain internal agency support. Any revenue lost from saved water is offset by the upper tiers, undermining arguments that conservation erodes agency financial stability. This accounting structure creates the incentives for the agency to be at least indifferent to, if not supportive of, conservation. The agency may further benefit by obtaining regional incentives for conservation. These accounting constructs contain incentives for both the agency and customers to act in concert.

- **Design Appropriate Tiers for the Rate Structure.** This is a "Goldilocks" message—not too hot and not too cold. If the upper tiers of the rate structure are set too low, they may be ignored. If the rate structure does not have a reward in its lower tiers, then it is also likely to be ignored. If the upper tiers of the rate structure are set to levels that are many times higher that the marginal cost of water, customers will have incentives to over-invest in landscape conservation.[1] To properly influence the irrigation practices, there must be appropriate incentives.

- **Motivate the Program with Ethical *and* Economic Arguments.** The program should make sense from an ethical perspective as well as from an economic point of view. Two obvious ethical values for program development are "environmental conservation" and "fairness to the customer." This type of value-driven program will appeal to a broader range of customers, as well as develop stronger commitment from staff and the board. Another source of motivation for signatory agencies is fulfillment of the goals of the Memorandum of Understanding Regarding Water Urban Conservation in California. Conservation programs appeal to forward thinking water agencies who believe in responsible stewardship of an important natural resource. The combination of economic cost-effectiveness and ethical appeal can be

[1]While the notion of over-investing in water conservation may seem unlikely or alien to some, the possibility should be recognized. For example, if a customer were to pave their front yard in the name of "water conservation," we would be hard put to call this a wise and worthy stewardship of Mother Nature's scarce resources.

convincing and motivating.

- **Create a Win-Win Program for the Agency and its Customers.** For a rate structure/water-budget-based program to be Win-Win, it must give both the agency and the customer the incentive to conserve water. Under what conditions does an agency have the economic incentive to conserve? Take, for example, an agency with mixed supply sources–say lower-cost local supply and higher-cost imported water. To create a "Win" for the customer, the agency can use conservation to reduce the purchase of high-cost imported water, allowing for a lower melded rate for all customers.

  These programs may also create a "Win" for green industry landscape professionals who can deliver effective design, installation, and maintenance of conserving landscapes. Environmental supporters realize a "Win" for such programs when they are effective at conservation, which reduces reliance on sources such as the Bay Delta and also reduces urban runoff into local ecosystems. One board member put it this way: "I have presented our program to both the Chamber of Commerce and to environmental groups and both support it."

- **Be Responsive to Customer Concerns.** No program is perfect, and the agency and board should be ready to take up good suggestions not only at the outset of program development but also through implementation in the years to come. Adapt! Allow variances for good reason, and make the variance process convenient for the customer. Deal with customers one by one when problems arise. Be ready with staff and information to respond to customers right from the outset of the program.

- **Show the Customer How to Save Money with Conservation.** Be prepared with information and assistance to show customers how to save money with conservation by moving into lower tiers. Pose this question to customers, "How much green (cash) are you willing to pay for your green (turf)?" Help high-water use

customers "get out of the penalty box." Be prepared to do some customer "hand-holding" and to provide customer service to support the program. Showing the customer how to save money, and helping them do it when needed, is an effective way to turn "complainers" into "supporters."

- **Educate, Educate, Educate!** Educate landscape maintenance and installation crews and give them the incentive to save water. All the tiered rate structures and water budgets in the world will not save water or money if the person with their hand on the irrigation controller does not know how or does not have the motivation to conserve water. Educate the controller of the controller. Make access to education easy by providing training in Spanish and English. Offer training to landscape contractors and provide outreach. Contact landscape sites with high water use and offer training sessions–be proactive. When possible, hold training classes in the winter because contractors will have more time. Educating installation contractors is also important.

- **Prioritize Conservation.** Seek autonomy to focus on conservation and water management goals. City agencies may face competing objectives that compete with conservation.

- **Utilize Horticultural Science.** Base the allocation on horticultural science as much as possible. This makes the water budget formula more objective. More science means less discretion by the agency, which will win over some of the skeptics. Be explicit where subjective judgments enter the formula and explain how these judgments were made; be up front about where agency discretion enters the allocation formula. Science can build trust in the agency. Manage the allocation by the numbers.

- **Communicate Well and Often.** Bring the public into the decision process. Do public outreach to explain conservation programs, conduct tours of landscape sites, hold

advisory meetings. Bring the message about the program out to the public. Do a good job communicating how the program works. Show the impacts dramatically with before and after photos, before and after budgets, and tools such as soil probes. Design bills with good labels indicating the tiers.

Communicate ancillary benefits of conservation; sometimes they are more important than primary benefits! For example: less street damage and fewer potholes from excess water runoff (really catches attention); less peeling paint, less root rot (healthier plants without over watering), less non-point pollution in the area, reduced costs of mowing, hauling, and disposing of green waste.

Use labels to send a message about the tiers in the rate structure. "Abusive" is a controversial term that elicits strong reactions from water customers.

Regular feedback to the customer helps. For example, monthly bills give the customer a message about their water consumption soon after it is used.

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APPENDIX A
SURVEY METHOD SUMMARY

This appendix describes the methodology used to design and implement the customer satisfaction survey. The survey was designed to collect information from the customer's perspective to complement the other analyses: the in-person interviews, water use analysis, and cost-effectiveness analysis. Specifically, the survey was designed to collect data on site characteristics, customer awareness, conservation actions, and customer satisfaction.

The target population of the study includes separately metered landscape sites in the four participating agencies. The population of separately metered sites serves as a good focus for landscape water use analysis compared to sites with meters that measure indoor and outdoor water use. Target sites were active at the time of the study, and were not in the proposed or construction phase.

Data were collected by mailing surveys to all customers with separately metered landscape accounts in each of the four agencies. The surveys included a cover letter with the purpose of the study, instructions, and a statement of confidentiality. The research team, in collaboration with the project advisory committee, drafted the survey and a sample cover letter and follow-up post card. Each agency tailored the cover letter to their circumstances and mailed them with the surveys, signed by agency conservation coordinators. The follow up postcard was mailed two weeks after the survey. Surveys were returned to the agencies and then forwarded to the research team, with the exception of one agency, for which surveys were mailed directly to the research team. Examples of a cover letter and follow up post card are included at the end of this appendix.

The survey instrument was designed to be short and easily read to facilitate respondent completion of the survey. A set of draft questions were submitted to review by a variety of conservation professionals and revised prior to pretesting. The surveys were sent to a small group of customers before the bulk mailing to pretest the instrument.

Since the target population was not large, surveys were sent to all qualifying customers to improve the chances of collecting enough surveys for agency level analysis. Surveys mailed, received, and response rates are reported in Table A.1. Each of the agencies mailed out one survey per customer. Eastern sent out one survey per account. For EMWD, a total of 23 customers are represented by the 43 returned surveys. Of the two Eastern customers who returned more than survey, one returned 8 surveys and the other returned 14 surveys. These two were aggregated into two customer level surveys by taking the sum or the mean as appropriate for the survey question.

Table A.1
Customer Response Rates

Agency	Mailed	Returned	Response Rate*
Capistrano Valley	119	25	21.0%
Otay	340	41	12.1%
Eastern	154	23	14.9%
Irvine Ranch	500	81	16.2%
Total	1,113	170	15.3%

*Response rate is the number of customers who returned surveys divided by the number of customers mailed surveys.

Although the survey project was designed without telephone follow up, some of the agencies undertook additional efforts to improve response rates. For example, EMWD made a number of follow up phone calls, IRWD faxed out a second reminder to their list of contractors, and Otay conducted a fax follow up to all surveyed customers. Although mail surveys are cost effective, they may have response bias. The research team identified the possible response bias during project design, but decided on the mail survey because of the limited resources and the agencies willingness to cover the costs of reproducing and mailing the survey. Respondents who may respond with higher probability may be those with strong sentiments toward the program (either positive or negative) or customers with a larger staff.

All survey responses were double key punched and compared to assure accuracy. Descriptive statistics were performed to examine data integrity. Questionable observations were verified by checking with the original hard copy survey and in some cases checking with agency staff. A complete set of survey results is included at the end of this appendix.

A number of the survey questions are structured as non-mutually exclusive categorical choices, with more than one answer possible (Questions 1, 5, 6, 15, 16, and 17). Binary indicator variables were coded zero if missing for those surveys that had at least one response to such questions.

Table A.2 contains standard errors surrounding mean responses taken across all returned surveys. These estimates of uncertainty only reflect the sampling error. The small sample size for each agency will limit the precision of agency-specific inference due to sampling error alone. A potentially larger source of error lies in the unique characteristics of the customers that chose to complete and return the surveys–the issues of response bias mentioned above. Because the standard errors below omit other know sources of error, they should only be used as a lower bound on an estimate of total uncertainty. Comparisons between agencies, in particular, should be treated with skepticism.

Table A.2

Question 1

Variable	Obs	Mean	Std. Err.	-- Binomial Exact -- [95% Conf.	Interval]
median	170	.1176471	.0247108	.0732996	.17581
park	170	.0705882	.0196447	.0370175	.120054
school	170	.0647059	.0188678	.0327321	.1128863
hoa	170	.3941176	.0374785	.3202206	.4719238
golfcrse	170	.0058824	.005865	.0001494	.0323371
commsite	170	.4294118	.0379642	.3539292	.5074219
agricult	170	.0117647	.0082698	.0014246	.0418026
Q1other	170	.0705882	.0196447	.0370175	.120054

Questions 2 and 3

Variable	Obs	Mean	Std. Err.	[95% Conf.	Interval]
acres	148	24.396	5.729	13.076	35.717
meters	147	7.040816	1.709874	3.661515	10.42012

Question 5

Variable	Obs	Mean	Std. Err.	-- Binomial Exact -- [95% Conf.	Interval]
contract	168	.8452381	.027904	.7814738	.8963216
staff	168	.202381	.0309976	.1444731	.2711211

Question 6

Variable	Obs	Mean	Std. Err.	[95% Conf.	Interval]
timers	168	.9047619	.0226474	.8499814	.9445685
computer	168	.1904762	.0302957	.1341146	.2580683
rainsoff	168	.0833333	.0213236	.0463053	.1359253
soilmois	168	.0892857	.0220002	.0508336	.1429814
soilprob	168	.1785714	.0295486	.1238142	.2449515
Q6other	168	.0357143	.0143176	.0132185	.076089

Question 15

Variable	Obs	Mean	Std. Err.	-- Binomial Exact -- [95% Conf.	Interval]
adjtimer	138	.9130435	.023986	.8530804	.9542289
upgrade	138	.5	.0425628	.4138184	.5861816
repair	138	.6014493	.0416775	.5148147	.6837671
audit	138	.2681159	.0377088	.196374	.3501313
Q15other	138	.1449275	.0299666	.0908628	.2148614

Question 17

Variable	Obs	Mean	Std. Err.	-- Binomial Exact -- [95% Conf.	Interval]
prograte	139	.3956835	.0414762	.3137646	.4821408
progoutr	139	.3741007	.041043	.2935449	.4602841
progbudg	139	.5611511	.0420911	.4745672	.6451495
Q17other	139	.1079137	.0263169	.0616499	.1717275

Question 18

Variable	Obs	Mean	Std. Err.	[95% Conf.	Interval]
clear	139	3.04	0.10	2.83	3.24
response	141	3.20	0.11	2.98	3.42
promotes	138	3.23	0.10	3.03	3.43
admin	136	3.11	0.09	2.92	3.30

Question 19

Variable	Obs	Mean	Std. Err.	[95% Conf.	Interval]
satrates	114	2.68	0.11	2.47	2.89
satoutre	125	3.19	0.11	2.97	3.42
satbudg	116	2.90	0.10	2.70	3.09
Q19other	26	2.42	0.22	1.96	2.88

Complete Survey Results

Frequency of Customer Response by Agency

Agency	Freq.	Percent	Cum.
Capistrano Valley	25	14.71	14.71
Otay	41	24.12	38.82
Eastern	23	13.53	52.35
Irvine Ranch	81	47.65	100.00
Total	170	100.00	

QUESTION 1

Frequency of Site Type

Customer Type	Freq.	Percent
Median Strip	20	11.76
Park	12	7.06
School	11	6.47
HOA	67	39.41
Golf Course	1	0.59
Commercial	73	42.94
Agriculture	2	1.18
Q1 Other	12	7.06

Question 1 Other

GREEN BELT
MODELS/HOMES
MUNICIPAL
SLOPES
CHURCH
SLOPE AREA
HWY FUNCTIONAL
FWY FUNCTIONAL
CHURCH
CHURCH
RETAIL
CHURCH

QUESTION 2

Summary of Acres

Variable	Obs	Mean	Std. Dev.	Min	Max
Acres	148	24.396	69.691	0.002	521.000

Summary of Acres by Agency

Agency	Obs	Mean	Std. Dev.	Min	Max
Capistrano Valley	21	11.678	24.022	0.011	107.956
Otay	37	34.352	84.735	0.172	400.000
Eastern	23	32.041	68.997	0.057	260.000
Irvine Ranch	67	20.261	70.672	0.002	521.000

Summary of Acres by Site Type

Variable	Obs	Mean	Std. Dev.	Min	Max
Median	19	52.872	99.271	0.126	400.000
Park	12	94.330	135.762	2.000	400.000
School	11	126.273	153.525	4.000	521.000
HOA	55	20.710	40.832	0.344	200.000
Golf Course	1	180.000	.	180.000	180.000
Commercial	64	13.503	54.901	0.002	400.000
Agriculture	2	55.478	74.215	3.000	107.956
Q1 Other	12	36.790	114.449	0.344	400.000

QUESTION 3

Summary of Water Meters

Variable	Obs	Mean	Std. Dev.	Min	Max
meters	147	7.040816	20.73112	1	200

Frequency of Water Meters

Water Meters	Freq.	Percent	Cum.
1	63	42.86	42.86
2	22	14.97	57.82
3	13	8.84	66.67
4	8	5.44	72.11
5	7	4.76	76.87
6	5	3.40	80.27
7	2	1.36	81.63
8	5	3.40	85.03
9	2	1.36	86.39
10	1	0.68	87.07
11	4	2.72	89.80
13	1	0.68	90.48
14	1	0.68	91.16
15	2	1.36	92.52
16	1	0.68	93.20
17	1	0.68	93.88
18	1	0.68	94.56
23	1	0.68	95.24
25	1	0.68	95.92
33	1	0.68	96.60
34	1	0.68	97.28
44	1	0.68	97.96
74	1	0.68	98.64
125	1	0.68	99.32
200	1	0.68	100.00
Total	147	100.00	

QUESTION 4

Summary of Percent Vegetation Type

Vegetation Type	Obs	Mean	Std. Dev.	Min	Max
Irrigated Turf	159	43.08	29.02	0.00	100.00
Bushes/Shrubs	159	42.43	27.10	0.00	100.00
Annual Color	159	3.16	7.21	0.00	50.00
Xeriscape	159	2.27	8.72	0.00	70.00
Non-Irrigated Landscape	159	2.79	10.18	0.00	85.00
Q4 Other	159	5.21	17.03	0.00	99.00

Percent of Percent Vegetation Type Weighted by Acres

Vegetation Type	Obs	Weight	Mean	Std. Dev.	Min	Max
Irrigated Turf	142	3453.0924	58.21	26.12	0.00	100.00
Bushes/Shrubs	142	3453.0924	26.69	23.22	0.00	100.00
Annual Color	142	3453.0924	1.33	2.93	0.00	50.00
Xeriscape	142	3453.0924	4.33	8.16	0.00	70.00
Non-Irrigated Landscape	142	3453.0924	5.44	11.14	0.00	85.00
Q4 Other	142	3453.0924	1.42	6.38	0.00	99.00

Question 4 Other

FOUNTAINS
GROUND COVER
TREES
SLOPE COVER
STREET/SIDWALK
MYAPOSIUM
DRIP
ROCK
SLOPES
BANKS
GROUND COVER
TREES
SLOPES
GROUND COVER
TREES
TREES
IVY
GROUNDCOVER
BLDG
GROUND COVER

QUESTION 5

Frequency of Landscape Maintenance Work

Staff/Contractor	Freq.	Percent
Staff (Private Owner)	18	10.71
Contractor (Private Owner)	132	78.57
Staff (Publicly Owned)	16	9.52
Contractor (Publicly Owned)	12	7.14
Q5 Other	1	0.60

Question 5 Other

IN HOUSE CREW

Frequency of Contractor and Staff

Who Landscapes	Freq.	Percent
Contractor	142	84.52
Staff	34	20.24

QUESTION 6

Frequency of Irrigation Equipment

Equipment	Freq.	Percent
Sprinkler Timers	152	90.48
Computer Controls	32	19.05
Rain Shut-off Sensor	14	8.33
Soil Moisture Sensors	15	8.93
Soil Probe	30	17.86
Q6 Other	6	3.57

Question 6 Other

SPRINKLERS MAN
MANUAL
MANUAL CONTROL
ALL TYPES
E T DATA
E T DATA MASTER
MASTER VALVE
IRWD SOFTWARE

QUESTION 7

Summary of Typical Water Use (in billing units)

Variable	Obs	Mean	Std. Dev.	Min	Max
Summer	78	1817.04	4867.52	13.00	40000.00
Winter	69	582.23	1223.11	5.00	7900.00

QUESTION 8

Frequency of Adjust Timers (Yes or No)

Adjust Timers?	Freq.	Percent	Cum.
No	6	3.57	3.57
Yes	162	96.43	100.00
Total	168	100.00	

QUESTION 9

Summary of Timer Adjustments

Variable	Obs	Mean	Std. Dev.	Min	Max
Adjustments	147	22.58163	58.88074	1	365

Frequency of Timer Adjustments

Frequency	Freq.	Percent	Cum.
Annually	2	1.36	1.36
Biannual	27	18.37	19.73
Quarterly	39	26.53	46.26
Bimonthly	19	12.93	59.18
Monthly	20	13.61	72.79
Biweekly	18	12.24	85.03
Weekly	18	12.24	97.28
Daily	4	2.72	100.00
Total	147	100.00	

QUESTION 10

Frequency of Multi-Tier Rate Structure

Agency	No	Yes	Don't Know	Total
Capistrano Valley	4	7	14	25
	16.00	28.00	56.00	100.00
Otay	13	5	21	39
	33.33	12.82	53.85	100.00
Eastern	6	3	14	23
	26.09	13.04	60.87	100.00
Irvine Ranch	3	57	19	79
	3.80	72.15	24.05	100.00
Total	26	72	68	166
	15.66	43.37	40.96	100.00

QUESTION 11

Summary of Highest Rate ($ per billing unit)

Variable	Obs	Mean	Std. Dev.	Min	Max
Highest Rate	76	2.74	2.31	0.08	12.08

QUESTION 12

Frequency of Subject to Water Budget

Agency	Have Water Budget? No	Yes	Total
Capistrano Valley	4	9	13
	30.77	69.23	100.00
Otay	10	28	38
	26.32	73.68	100.00
Eastern	13	5	18
	72.22	27.78	100.00
Irvine Ranch	1	73	74
	1.35	98.65	100.00
Total	28	115	143
	19.58	80.42	100.00

QUESTION 13

Summary of Water Budget

Variable	Obs	Mean	Std. Dev.	Min	Max
Budget	28	22762.82	74860.77	64	377000

Frequency of Know Your Water Budget

Know Budget?	Freq.	Percent	Cum.
Know	28	16.47	16.47
No Response	142	83.53	100.00
Total	170	100.00	

QUESTION 14

Frequency of Encouraged to Conserve Water

Agency	No	Yes	Total
Capistrano Valley	4	15	19
	21.05	78.95	100.00
Otay	2	38	40
	5.00	95.00	100.00
Eastern	6	7	13
	46.15	53.85	100.00
Irvine Ranch	9	65	74
	12.16	87.84	100.00
Total	21	125	146
	14.38	85.62	100.00

QUESTION 15

Frequency of Actions

Action	Freq.	Percent
Adjusted Timers	126	91.30
Upgraded Equipment	69	50.00
Repaired Irrigation System	83	60.14
External Audit/Survey	37	26.81
Q15 Other	20	14.49

Q15 Other

MONTHLY TRACKIN
SKIMP
DROUGHT TORLERA
LANDSCAPE RESPO
CONV TO DRIP
EDUCATION
MATCH BUDGET
REVISED CONTRCT
SHUT OFF
CHANGE PLANT MA
AUDITED SYSTEM
MOISTURE SENSOR
MOISTURE SENSOR
CONV TO RECLAIM
EDUC OF STAFF
WATER CONSERV
EMPLOYEE EDUCAT
INTERNAL AUDIT
ALL OF THE ABOV
FRLY NW SYS CON

QUESTION 16

Summary of Initial and Ongoing Costs of Actions

Variable	Obs	Mean	Std. Dev.	Min	Max
Per Customer:					
Adjusted Timers Initial Costs	76	482.04	2576.45	0.00	16000.00
Adjusted Timers Ongoing Costs	76	246.74	817.44	0.00	5000.00
Upgrade Equipment Initial Costs	76	2571.20	5695.81	0.00	32000.00
Upgrade Equipment Ongoing Costs	76	1539.62	7284.76	0.00	62000.00
Repaired Irrigation System Initial	76	792.53	2700.49	0.00	18000.00
Repaired Irrigation System Ongoing	76	2571.18	6083.27	0.00	40000.00
External Audit Initial Costs	76	44.75	154.39	0.00	900.00
External Audit Ongoing Costs	76	126.18	532.09	0.00	3000.00
Other Initial Costs	76	185.22	977.73	0.00	6000.00
Other Ongoing Costs	76	76.97	577.49	0.00	5000.00
Per Acre:					
Adjusted Timers Initial Costs	72	137.01	474.47	0.00	3146.00
Adjusted Timers Ongoing Costs	72	77.41	259.05	0.00	1742.40
Upgrade Equipment Initial Costs	72	952.73	2113.73	0.00	13068.00
Upgrade Equipment Ongoing Costs	72	54.10	198.47	0.00	1633.50
Repaired Irrigation System Initial	72	559.51	1993.89	0.00	15342.80
Repaired Irrigation System Ongoing	72	398.61	909.00	0.00	4752.00
External Audit Initial Costs	72	42.75	210.16	0.00	1633.50
External Audit Ongoing Costs	72	45.56	253.91	0.00	2052.63
Other Initial Costs	72	140.64	801.41	0.00	6000.00
Other Ongoing Costs	72	79.50	593.56	0.00	5000.00

Question 16 Other

LANDSCAPE
PLANT MATERIAL
INCORPERATED
INCLUDED IN MON
NEW LANDSCAPE
MAIN LINE REPR
SOFTWARE SETUP

QUESTION 17

Frequency of Program that Influences Conservation

Program	Freq.	Percent
Multi-Tier Rate Structure	55	39.57
Customer Outreach/Education	52	37.41
Water Budget	78	56.12

Frequency of Program that Influences Conservation by Agency

Agency	Multi-Tier Rate Structure	Customer Outreach/ Education	Water Budget	
Capistrano Valley	5	5	14	Freq.
	25.00	25.00	70.00	Percent
Otay	5	10	27	Freq.
	13.89	27.78	75.00	Percent
Eastern	1	7	6	Freq.
	6.67	46.67	40.00	Percent
Irvine Ranch	44	30	31	Freq.
	64.71	44.12	45.59	Percent
Total	55	52	78	Freq.
	39.57	37.41	56.12	Percent

Frequency of Program that Influences Conservation by Agency

Program	Capo_Val	Otay	Eastern	IRWD	Total
Multi-Tier Rate Structure	5	5	1	44	55
	25.00	13.89	6.67	64.71	39.57
Customer Outreach/Education	5	10	7	30	52
	25.00	27.78	46.67	44.12	37.41
Water Budget	14	27	6	31	78
	70.00	75.00	40.00	45.59	56.12

Question 17 Other

COMMON SENSE
PERSONNEL DRIVE
COST OF WATER
CONTRACTOR
PURCHASE WELL
STAGE 5 WATER
HEALTHY TURF
COST
COST
COST
CALTRANS POLICY
CALTRANS MANDAT
SAME NATURAL
DONT KNOW
EXCESSIVE PENAL
DROUGHT IN CALI
TO THE GARDENER
ALL ABOVE
ET HOT LINE

QUESTION 18

Summary of Conservation Program Ratings

Variable	Obs	Mean	Std. Dev.	Min	Max
Clear and understandable	139	3.04	1.22	1.00	5.00
Responsive to customer	141	3.20	1.32	1.00	5.00
Effectively promotes cons.	138	3.23	1.19	1.00	5.00
Administration/paperwork	136	3.11	1.10	1.00	5.00

Summary of Clear and Understandable by Agency

Agency	Mean	Std. Dev.	Freq.
Capistrano Valley	3.23	1.36	13
Otay	3.08	1.16	37
Eastern	2.76	0.56	17
Irvine Ranch	3.04	1.35	72
Total	3.04	1.22	139

Summary of Responsive to Customer by Agency

Agency	Mean	Std. Dev.	Freq.
Capistrano Valley	3.50	1.34	14
Otay	3.16	1.38	37
Eastern	3.18	0.95	17
Irvine Ranch	3.16	1.37	73
Total	3.20	1.32	141

Summary of Effectively Promotes Conservation by Agency

Agency	Mean	Std. Dev.	Freq.
Capistrano Valley	3.62	1.12	13
Otay	3.27	1.17	37
Eastern	2.94	0.77	16
Irvine Ranch	3.21	1.29	72
Total	3.23	1.19	138

Summary of Administration/Paperwork by Agency

Agency	Mean	Std. Dev.	Freq.
Capistrano Valley	3.08	1.32	13
Otay	3.17	1.08	36
Eastern	3.00	0.37	16
Irvine Ranch	3.11	1.19	71
Total	3.11	1.10	136

Frequency of Clear and Understandable Ratings by Agency

Agency	1.00	2.00	3.00	4.00	5.00	Total
Capistrano Valley	1	4	2	3	3	13
	7.69	30.77	15.38	23.08	23.08	100.00
Otay	5	5	12	12	3	37
	13.51	13.51	32.43	32.43	8.11	100.00
Eastern	1	2	14	0	0	17
	5.88	11.76	82.35	0.00	0.00	100.00
Irvine Ranch	14	10	18	19	11	72
	19.44	13.89	25.00	26.39	15.28	100.00
Total	21	21	46	34	17	139
	15.11	15.11	33.09	24.46	12.23	100.00

Frequency of Responsive to Customer Ratings by Agency

Agency	1.00	2.00	3.00	4.00	5.00	Total
Capistrano Valley	0	5	2	2	5	14
	0.00	35.71	14.29	14.29	35.71	100.00
Otay	8	2	9	12	6	37
	21.62	5.41	24.32	32.43	16.22	100.00
Eastern	2	0	8	7	0	17
	11.76	0.00	47.06	41.18	0.00	100.00
Irvine Ranch	12	11	19	15	16	73
	16.44	15.07	26.03	20.55	21.92	100.00
Total	22	18	38	36	27	141
	15.60	12.77	26.95	25.53	19.15	100.00

Frequency of Effectively Promotes Conservation Ratings by Agency

Agency	1.00	2.00	3.00	4.00	5.00	Total
Capistrano Valley	0	3	2	5	3	13
	0.00	23.08	15.38	38.46	23.08	100.00
Otay	3	6	12	10	6	37
	8.11	16.22	32.43	27.03	16.22	100.00
Eastern	1	2	10	3	0	16
	6.25	12.50	62.50	18.75	0.00	100.00
Irvine Ranch	10	10	20	19	13	72
	13.89	13.89	27.78	26.39	18.06	100.00
Total	14	21	44	37	22	138
	10.14	15.22	31.88	26.81	15.94	100.00

Frequency of Administration/Paperwork Ratings by Agency

Agency	1.00	2.00	3.00	4.00	5.00	Total
Capistrano Valley	1	4	4	1	3	13
	7.69	30.77	30.77	7.69	23.08	100.00
Otay	3	5	15	9	4	36
	8.33	13.89	41.67	25.00	11.11	100.00
Eastern	0	1	14	1	0	16
	0.00	6.25	87.50	6.25	0.00	100.00
Irvine Ranch	11	4	31	16	9	71
	15.49	5.63	43.66	22.54	12.68	100.00
Total	15	14	64	27	16	136
	11.03	10.29	47.06	19.85	11.76	100.00

QUESTION 19

Summary of Satisfaction Questions

Variable	Obs	Mean	Std. Dev.	Min	Max
Multi-Tier Rate Structures	114	2.68	1.13	1.00	5.00
Customer Outreach/Education	125	3.19	1.26	1.00	5.00
Water Budget	116	2.90	1.07	1.00	5.00

Summary of Satisfaction with Multi-Tier Rate Structure by Agency

Agency	Mean	Std. Dev.	Freq.
Capistrano Valley	2.75	0.87	12
Otay	2.45	1.14	22
Eastern	2.91	0.83	11
Irvine Ranch	2.70	1.22	69
Total	2.68	1.13	114

Summary of Satisfaction with Customer Outreach/Education by Agency

Agency	Mean	Std. Dev.	Freq.
Capistrano Valley	3.00	1.35	13
Otay	3.46	1.00	28
Eastern	3.00	1.00	15
Irvine Ranch	3.16	1.39	69
Total	3.19	1.26	125

Summary of Satisfaction with Water Budget by Agency

Agency	Mean	Std. Dev.	Freq.
Capistrano Valley	2.55	0.82	11
Otay	2.84	1.05	32
Eastern	3.00	0.71	9
Irvine Ranch	2.97	1.15	64
Total	2.90	1.07	116

Frequency of Multi-Tier Rate Structure Satisfaction Ratings by Agency

Agency	1.00	2.00	3.00	4.00	5.00	Total
Capistrano Valley	1	3	6	2	0	12
	8.33	25.00	50.00	16.67	0.00	100.00
Otay	7	2	9	4	0	22
	31.82	9.09	40.91	18.18	0.00	100.00
Eastern	0	4	4	3	0	11
	0.00	36.36	36.36	27.27	0.00	100.00
Irvine Ranch	15	13	25	10	6	69
	21.74	18.84	36.23	14.49	8.70	100.00
Total	23	22	44	19	6	114
	20.18	19.30	38.60	16.67	5.26	100.00

Frequency of Customer Outreach/Education Satisfaction Ratings by Agency

Agency	1.00	2.00	3.00	4.00	5.00	Total
Capistrano Valley	2	2	6	0	3	13
	15.38	15.38	46.15	0.00	23.08	100.00
Otay	2	1	10	12	3	28
	7.14	3.57	35.71	42.86	10.71	100.00
Eastern	1	3	7	3	1	15
	6.67	20.00	46.67	20.00	6.67	100.00
Irvine Ranch	13	6	23	11	16	69
	18.84	8.70	33.33	15.94	23.19	100.00
Total	18	12	46	26	23	125
	14.40	9.60	36.80	20.80	18.40	100.00

Frequency of Water Budget Satisfaction Ratings by Agency

Agency	1.00	2.00	3.00	4.00	5.00	Total
Capistrano Valley	1	4	5	1	0	11
	9.09	36.36	45.45	9.09	0.00	100.00
Otay	4	6	15	5	2	32
	12.50	18.75	46.88	15.63	6.25	100.00
Eastern	0	2	5	2	0	9
	0.00	22.22	55.56	22.22	0.00	100.00
Irvine Ranch	11	4	31	12	6	64
	17.19	6.25	48.44	18.75	9.38	100.00
Total	16	16	56	20	8	116
	13.79	13.79	48.28	17.24	6.90	100.00

Question 19 Other

LOWER SURCHARGE RATES
SURCHARGES TOO
CALTRANS POLICY
ASSOC & ETRATES

Landscape Customer Survey

• *Individual survey results will be strictly confidential. Only aggregate statistics will be reported. Please circle your answer(s) (circle all that apply) or fill in the blanks.*

1. Which category(ies) best describes your site?

Median strip or parkway	1
Park	2
School	3
Home Owners Association	4
Golf course	5
Commercial site	6
Agriculture	7
Other _____	8

2. What is the approximate total area of the irrigated landscape at your site (all meters/accounts)? *In acres or sq. feet.*

_____ acres *or*
_____ sq. feet

3. How many separate irrigation water meters/accounts are at your site?

_____

4. Approximately what percent of the site is growing the following vegetation types?

Irrigated turf	___%
Bushes/shrubs	___%
Annual color	___%
Xeriscape	___%
Non-irrigated landscape	___%
Other _____	___%
Total Landscaped Area	100%

5. Who performs the irrigation and other landscape maintenance work?

Staff (Private Owner)	1
Contractor (Private Owner)	2
Staff (Publicly Owned)	3
Contractor (Publicly Owned)	4
Other_____	5

6. What type(s) of irrigation equipment do you use at the site?

Sprinkler timers	1
Computer controls	2
Rain shut-off sensor	3
Soil moisture sensors	4
Soil probe	5
Other _____	6

7. What is your typical water use per billing period?

_____ billing units (Summer)
_____ billing units (Winter)

8. Do you seasonally adjust your irrigation timer(s)?

Yes	1
No	2

9. If yes, how often do you adjust your irrigation timers?

_____ times a year

10. Do you have a Multi-Tier water rate structure?

Yes	1
No	2
Don't know	3

11. What is the highest rate per billing unit that you pay in a typical billing period?

_____$/unit (hundred cubic feet)

12. Is your site subject to a water allocation/budget level, above which a higher rate or penalties apply?

Yes	1
No	2

13. Do you know what your annual water allocation/budget is?

_____billing units per year

14. Has the water allocation/budget encouraged you to conserve water?

Yes	1
No	2

15. If yes, what action(s) have you taken as a result of the water allocation/ budget?

Adjusted timers	1
Upgraded equipment	2
Repaired irrigation system	3
External audit/survey	4
Other _____	5

16. What were your approximate *initial, one-time* costs of the conservation actions listed in Question 15? What are their *annual ongoing* (operation and maintenance) costs?

	Initial Costs	Ongoing Costs
Adjusted timers	$_____	$_____
Upgraded equipment	$_____	$_____
Repaired irrigation system	$_____	$_____
External audit/survey	$_____	$_____
Other _____	$_____	$_____

17. Which conservation program(s) influence your conservation practices?

Multi-Tier Rate Structure	1
Customer Outreach/Education	2
Water Budget	3
Other _____	4

18. How would you rate your water agency's landscape conservation programs? *Circle 1 (Poor), 2 (Fair), 3 (Good), 4 (Very Good), or 5 (Excellent)*

Clear and understandable	1 2 3 4 5
Responsive to customer	1 2 3 4 5
Effectively promotes conservation	1 2 3 4 5
Administration/paperwork	1 2 3 4 5

19. All things considered, how satisfied are you with the following? *Circle 1 (Very Dissatisfied), 2 (Somewhat Dissatisfied), 3 (Neither Satisfied nor Dissatisfied), 4 (Somewhat Satisfied), or 5 (Very Satisfied).*

Multi-Tier Rate Structure	1 2 3 4 5
Customer Outreach/Education	1 2 3 4 5
Water Budget	1 2 3 4 5
Other _____	1 2 3 4 5

• *Please answer the following two questions on the back of this survey form or on a separate sheet of paper.*

20. What changes do you plan to make in the near future to save water?

21. What additional services/programs would you like your water agency to provide?

• ***Thank you for your cooperation!***

20. What changes do you plan to make in the near future to save water?

21. What additional services/programs would you like your water agency to provide?

...Dedicated to Community Service
2554 SWEETWATER SPRINGS BOULEVARD, SPRING VALLEY, CALIFORNIA 91977-7299
TELEPHONE: 670-2222, AREA CODE 619

August 23, 1996

Dear Commercial Irrigation Customer,

We request your participation in a survey to assess the satisfaction with, and effectiveness of, our agency's landscape irrigation ordinances. The objective of the survey is to collect information that we can use to improve the quality and effectiveness of our landscape programs. [If you are not the person responsible for landscape irrigation, please pass this letter and survey along to the appropriate person.]

With this letter is a two page form titled, "Landscape Customer Survey." The survey should take about 15 minutes to complete. It is not our intent that you spend lots of time looking up many details; rather, we are looking for approximate values and your impression.

To maintain full confidentiality, only summarized aggregate results will be reported. No individual survey answers will be identified with a particular customer. the final report will be available by request.

Please use the enclosed envelope to send your completed survey by August

Landscape Survey
Jan Tubiolo, Water Conservation Coordinator
Otay Water District
2554 Sweetwater Springs Blvd.
Spring Valley, CA 91977-7299

If you have any other questions, please call me, your conservation coordinator, at (619) 670-2290.

Thank you for your cooperation!

Sincerely,

Jan Tubiolo
Water Conservation Coordinator

LANDSCAPE CUSTOMER SURVEY

Dear Valued Customer:

Last week we mailed you a survey questionnaire requesting information on your landscape water use and site characteristics. The objective of the survey is to collect information that we can use to improve the effectiveness of our landscape programs.

If you have already completed and mailed the survey back, please accept our thanks. If you have not, we would appreciate if you would take the time to complete the survey today. Your response will assure that the study results give the most accurate representation of landscape water use.

Your survey will be kept strictly confidential and will only be used for planning purposes. If you have any questions about the survey, please call me at 888/888-8888.

Thank you for your assistance and cooperation.

Jane C. Agency, Conservation Coordinator

APPENDIX B: DOCUMENTS REVIEWED

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Cassens, C., 1996, Water Budget Approach to Landscape Irrigation, presentation.

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Spectrum Economics (1991), "The Cost of Industrial Water Shortages", Prepared for the California Urban Water Agencies.

Stokey, E. and R. Zeckhauser (1978) *A Primer for Policy Analysis*, New York: Norton, Chapter 14.

APPENDIX C: INTERVIEW PROTOCOL AND SAMPLE

INTERVIEW PROTOCOL

Date of Interview: 8/20/96 Revision

Note to all Respondents: YOUR RESPONSES TO THE FOLLOWING QUESTIONS WILL BE TREATED IN COMPLETE CONFIDENCE AND USED ONLY TO EVALUATE CONSERVATION PROGRAMS IN YOUR SERVICE AREA. RESULTS OF THE SURVEY WILL ONLY BE PRESENTED IN A SUMMARY FORM, TO PROTECT THE IDENTITY OF RESPONDENTS.

Name of Organization:

Name of Respondent: Job Title:

(1) We are interested in your conservation program for irrigation customers. How familiar are you with this program?

(2) Were you personally involved in the creation of the program?

(3) Were you personally involved in the implementation of the program?

(4) Describe the previous rate structure.

(5) Describe the circumstances that lead up to the creation of the program.

(6) Describe any cross-pollination with other water agencies.

(7) What was the political impetus behind the creation of the program?

(8) Describe the program as originally designed.

(9) What changes were made to the program in the first year? After?

(10) On a 1 to 10 scale, how successful do you think the program was?

(11) What were the most important barriers to the program's success.

(12) What is your impression of your customers' response to this program? (1 = v. negative, 10 = v. positive)

(13) What is your impression of the program's effectiveness in achieving water savings?

(14) In percentage terms, what level of water use reduction would you expect among participating customers?

(15) How confident are you in this estimate? Could you give a range of expected savings.

(16) Besides water savings, what additional benefits would you attribute to the program?

(17) Did this program involve significant additional effort on your part?

(18) What advice would you give to other agencies contemplating a water-budget based rate structure?

(19) What would limit the applicability of your program to other areas?

SAMPLE INTERVIEW

CVWD - Sample interview

Impetus-1991 Drought emergency

Fairness-Equal percentage cutbacks (based on historical use) was not fair. Customers who had already conserved would be punished. What was fair?

Political-Change in rates structure was motivated by MWD curtailments

Success - Was perceived by staff to be v. successful.

Barriers - Getting customers to understand the program
- getting past check writers to the hand on the hose
- Collecting consistent square footage data (solvable)

Corrective Actions - Addition of conservation staff
Addition of landscape water efficiency classes

Customer Response - a 7 on a 1-10 scale. There is still more education to be done, an ongoing task.

Additional Benefits - Improved customer service provided by agency
More in-depth knowledge of landscaping (decreased maintenance costs)
Perceived as much fairer
More stable agency financing(due to improved political support)

Lessons - What would you do different? Do area measurement consistently and at the very beginning.

"Your customers are your neighbors" Emphasize nonadversarial approach.
Use real time ET at beginning. (Avoids a very hot month causing complaints)
Need to hold hands with the Board. Re-explain basis for program periodically.

Appendix D. Cost-Effectiveness Analysis

D.1 Cost-Benefit and Cost-Effectiveness Analysis

The cost-effectiveness of landscape conservation programs will vary depending on their design and the circumstances of the agency. In this section, we conduct cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA)[1] for an agency that is considering program designs similar to those of our four study sites. This prospective analysis is designed to show agencies considering water-budget based landscape conservation programs how to get an early picture of which factors most influence costs and benefits of the planned program.

The CBA and CEA presented in this appendix use information from the customer survey, the water use analysis, the in-person interviews, and other sources. The agency we consider, in characteristics and program design, is a "composite sketch" of the four study sites. The results of CBA or CEA naturally depend on the program design and other assumptions. The following are characteristics of the hypothetical agency and program design used in this example:

- 2000 acres of irrigated landscape in the program;
- 2 acres per customer;
- 1000 customers with separate landscape meters;
- Program consists of water-budget, tiered rate structure, education/outreach, and equipment upgrade rebates; and
- 40 percent of customers participate in equipment upgrade rebates.

[1] CBA and CEA differ in that CBA compares both costs and benefits measured in dollar terms, whereas CEA compares costs measured in dollar terms to benefits measured in physical units (a.k.a., measures of effectiveness), such as acre-feet of water.

The analysis presented below follows the four steps recommended in the *Guidelines to Conduct Cost-Effectiveness Analyses of Best Management Practices for Urban Water Conservation* by the California Urban Water Conservation Council:

- Step 1. Identify Costs and Benefits
- Step 2. Measure and Value Costs and Benefits
- Step 3. Discount Costs and Benefits
- Step 4. Analyze Uncertainty

D.2 Identify Costs and Benefits

Table D.1 identifies costs and benefits of the example water-budget based landscape conservation program. All of the separately metered sites in this service area participate one way or another in the program. Some sites are only subject to the tiered rate structure and others may accept outreach/education or rebates. For customers who perform equipment upgrades, the *participating customer program costs* may include the new equipment, as well as adjusting irrigation timers and repairing leaks. The *retail agency program costs* consist of the costs of designing and setting up the program initially, and then operating the program over its life time. Some of these costs are particular to the program design, such as computer programming. Landscape area measurement may take place by manual measurement or by acquiring data from real estate or satellite geographic data bases.

The *participating customer program benefits* include reduced water bills and the rebate for customers who participate in this part of the program. The *retail agency benefits* include the saved expense of purchasing imported water and conservation incentives, if

Table 5.1 - Identify Costs and Benefits

Water-Budget Based Landscape Conservation Program	
Category	**Costs**
Participating Customer Program Costs	• Landscape crew training and irrigation timer adjustments • Irrigation system leak repair • Irrigation equipment upgrades (e.g., sprinkler heads, controllers, and/or rain shut-off devices) • External Audits
Retail Agency Program Costs	• Computer programming • Program design and setup • Area measurement • Operation of program • Education/outreach, time and materials • Equipment rebates
Category	**Benefits**
Participating Customer Program Benefits	• Reduced water bills • Rebate • Reduced frequency and cost of major leaks • Improved landscape quality
Retail Agency Benefits	• Reduced water imports • Wholesaler conservation incentives
External Environmental Benefits	• Reduced environmental costs of water diversion, supply, and transportation

available from their regional water wholesaler.[2] *External environmental benefits* derive from reduced water diversion and supply.

[2] Lost or gained revenue from conservation programs is not included in *long run* analyses from the supplier perspective because revenues are assumed to adjust over time and such revenue effects are considered transfer payments between participating and nonparticipating customers. *Short run* analyses explicitly consider revenue and rate payer impacts.

D.3 Measure and Value Costs and Benefits

Costs. The costs of the conservation program can be divided between the initial costs to start the program and the ongoing costs of implementation (Table D.2).[3] The initial *retail agency costs* include computer programming to accommodate new features, such as a tiered rate structure, weekly water-budget CIMIS adjustments, and/or days of use billing. Based on agency interviews, we have estimated that six months of time is needed for a typical reprogramming job of this magnitude. We have valued each hour of programmer time including salary, benefits, and other overhead and support (office, telephone, supplies). Of the 1,000 customers in the example agency, we assume 400 are eligible for the equipment rebate program and are allocated a rebate of $1,000 per customer.

Some of the participating customers will elect to make equipment upgrades in response to the programs. The *participating customer costs (upgrade equipment)* in Table D.2 are typical of customers who make substantial upgrades in conservation equipment in response to the rebate incentive. Other customers may already have up-to-date equipment. For customers who need equipment upgrades, their costs include the new equipment, as well as adjusting irrigation timers and repairing leaks. The *participating customer costs (average participation)* in Table D.2 are the sum of customer costs averaged over all customers who are affected by at least some part of the program.[4] Participating customers costs have been valued based on the results of the customer survey for each of the

[3] In this illustration, all costs and benefits are denominated in constant (1996) dollars.

[4] In a more detailed analysis, we recommend separate cost and benefit accounting for those customers who upgrade equipment.

Table D.2

Costs								
		Initial			Ongoing Annual			
Perspective	Units	Number	Value/Unit	Value	Number	Value/Unit	Value	
Retail Agency Costs								
Computer Programming	Hours	700	$ 65.00	$ 45,500.00				
Design and Setup	Hours	1200	$ 80.00	$ 96,000.00				
Area Measurement				$ 10,000.00				
Operation	Hours				960	$ 88.00	$	84,480.00
Education/Outreach	Hours	300	$ 88.00	$ 26,400.00	200	$ 88.00	$	17,600.00
Education/Outreach	Materials						$	5,000.00
Equipment Rebate	Rebates	400	$ 1,000.00	$ 400,000.00				
Total				$ 577,900.00			$	107,080.00
Total/Acre				$ 288.95			$	53.54
Participating Customer Costs (Upgrades Equipment)								
Adjust Timers	Cost/Acre			$ 137.00			$	77.00
Upgrade Equipment	Cost/Acre			$ 953.00			$	54.00
Repair Irrigation System	Cost/Acre			$ 560.00			$	399.00
External Audit	Cost/Acre			$ 43.00			$	46.00
Other	Cost/Acre			$ 141.00			$	80.00
Total/Acre				$ 1,834.00			$	656.00
Participating Customer Costs (Average Participation)								
Total/Acre	Cost/Acre			$ 733.60			$	262.40
Total Society Costs								
Computer Programming	Hours	700	$ 65.00	$ 45,500.00				
Design and Setup	Hours	1200	$ 80.00	$ 96,000.00				
Area Measurement				$ 10,000.00				
Operation	Hours				960	$ 88.00	$	84,480.00
Education/Outreach	Hours	300	$ 88.00	$ 26,400.00	200	$ 88.00	$	17,600.00
Education/Outreach	Materials						$	5,000.00
Adjust Timers	Program Cost			$ 109,600.00			$	61,600.00
Upgrade Equipment	Program Cost			$ 762,400.00			$	43,200.00
Repair Irrigation System	Program Cost			$ 448,000.00			$	319,200.00
External Audit	Program Cost			$ 34,400.00			$	36,800.00
Other	Program Cost			$ 112,800.00			$	64,000.00
Total				$ 1,645,100.00			$	631,880.00
Total/Acre				$ 822.55			$	315.94
Regional Wholesaler Service Area Costs								
Computer Programming	Hours	700	$ 65.00	$ 45,500.00				
Design and Setup	Hours	1200	$ 80.00	$ 96,000.00				
Area Measurement				$ 10,000.00				
Operation	Hours				960	$ 88.00	$	84,480.00
Education/Outreach	Hours	300	$ 88.00	$ 26,400.00	200	$ 88.00	$	17,600.00
Education/Outreach	Materials						$	5,000.00
Equipment Rebate	Rebates	400	$ 1,000.00	$ 400,000.00				
Total				$ 577,900.00			$	107,080.00
Total/Acre				$ 288.95			$	53.54

following categories: adjusting timers, upgrading equipment, repairing irrigation system, external audit, and other.[5]

When adding up the *total society costs*, we add the participating customer costs (for the 400 rebate customers) to the agency program costs. From the total society perspective, the rebate is a transfer payment and therefore not included.[6] When adding up the *regional wholesaler service area costs*, we add up the costs to all relevant agencies, including wholesale, retail, and federal if federal funding is applied. Wholesaler service area

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[5] When assessing the costs and benefits to customers, rate changes are fundamental because of their determination of water bills. To the extent benefits of a conservation program are greater or less than its costs, revenue requirements may increase or decrease. Rate changes will affect both participating and nonparticipating customers in that rate changes may induce changes in water demanded; the degree to which quantity responds to price changes may be represented by price elasticity of demand. For participating customers, the price effect will be in addition to direct water savings from the conservation measure (e.g., conservation devices or incentives). For nonparticipating customers, the price effect works alone.

The difficulty of including price impacts in the analysis derives from the difficulty of projecting rate changes, which depend on policy decisions, political climate, the difference between rates and marginal costs, in addition to whether the conservation program's benefits exceed its costs. With limited resources, one needs a practical simplifying assumption to conduct prospective CBA, along with sensitivity testing. One such simplifying assumption is to assume that rates will be adjusted to recover supplier costs in the year they are incurred.

For this analysis we proceed as follows: For participating customers we assume that their water bill changes as a result only of conservation reduced demand, and not changed by induced rate changes. This assumption puts the focus of the CBA on water savings rather than the rate changes that may ensue from the conservation program. Rate changes *are* important, but projecting rate changes, again, depends on a host of factors that are difficult to predict and that are not all related to the conservation program. The down-side of this simplifying assumption about rates is that it ignores potentially important changes in quantity demanded that would result from rate increases or decreases.

An approach for nonparticipating customers is to assume that rates will change by the difference between conservation program benefits and costs faced by the supplier. Such changes in revenue requirements would result, according to this assumption, in commensurate rate changes. If benefits exceed costs, then rates are assumed to go down in the long run, and vice versa. These assumptions provide a practical first cut method without the need for more specialized economic skills--albeit a simplistic one.

[6] The total society perspective differs from the regional wholesaler service area perspective in that customer costs are included in the former.

costs do not include costs to the retail customer. We assume that the wholesaler's incentive is used by the retail agency to offset agency costs of initiating and operating the conservation program. Thus, to avoid double counting, we do not include the wholesaler incentive as a separate regional wholesaler service area cost category.

Benefits.

Total society benefits include the avoided costs of new supply sources and the external environmental benefits derived from reduced water diversion and supply.[7] The *participating customer benefits* include reduced water bills and the rebate for customers who participate in this part of the program.

The water use analysis in Chapter 4 of this report documents the method of estimating water savings for the agencies in this study. These estimates range from 6 inches per acre to over 16 inches per acre. As discussed in Chapter 4, differences in water savings depend on differences in program design, water use patterns, and other variables. For this example, we use the middle-of-the-road example of 11 inches per acre savings and test our results for sensitivity.

Table D.3 shows the *retail agency benefits* derived from water conservation include reduced water imports and a wholesaler conservation incentive. The current (1996-1997) rate for MWD treated non-interruptible water is $431/AF.[8] The current conservation incentive is $154/AF. The benefits assume that all of the conserved water is offset by reducing wholesale purchases rather than by reducing local supply.

[7] In this concise analysis, we do not explicitly value external environmental benefits. As we see below, we can determine that benefits of the conservation program exceed costs, even without explicit valuation of external environmental benefits.

[8] The Metropolitan Water District of Southern California Water Rates, Operations Division, Systems Operations Branch, Water Administration Section, Revised 3/10/95.

Table D.3

Benefits							
		Initial			Ongoing Annual		
Perspective	Units	Number	Value/Unit	Value	Number	Value/Unit	Value
Retail Agency Benefits							
Avoided Water Imports	AF Saved				1833	$ 431.00	$ 790,166.67
Wholesaler Incentive	AF Saved				1833	$ 154.00	$ 282,333.33
Total							$1,072,500.00
Total/Acre							$ 536.25
Participating Customer Benefits (Average Participation)							
Reduced Water Bills	CCF/Acre				399	$ 2.00	$ 798.60
Equipment Rebate	$/Acre			$ 400.00			
Total/Acre				$ 400.00			$ 798.60
Total Society Benefits							
Avoided New Supply	AF				1833	$ 602.00	$1,103,666.67
Total							$1,103,666.67
Total/Acre							$ 551.83
Regional Wholesaler Service Area Benefits							
Avoided New Supply	AF				1833	$ 602.00	$1,103,666.67
Total							$1,103,666.67
Total/Acre							$ 551.83

Participating customer benefits include reduced water bills as well as the equipment rebate. We average the rebate over all acres in the program because our savings estimates are across all participating customers--whether or not they upgraded equipment. *Total society benefits* and *regional wholesaler service area* benefits are valued by determining the avoided cost of new water supply for the regional wholesaler. MWD has recently estimated the regional costs of new supply to be $602/AF for supply, treatment, and distribution.[9] These costs are expected to increase by about 1.5 percent per year in terms of real growth.

[9] See "Southern California's Integrated Water Resources Plan," Report Number 1107, Metropolitan Water District of Southern California, March 1996. These costs are average costs within supply categories (transfers, storage, reclamation); however, the highest cost source for each category would be a better reflection of the avoided supply costs.

A number of benefits have not been included in this analysis due to limits in time and data. External environmental benefits can be expected from this program in the form of reduced regional water supply projects (benefits to fish populations, groundwater, and other ecosystem aspects) and reduced runoff to local rivers and bays. Benefits from reduction in over watering also can be expected in the form of reduced damage to painted surfaces, reduced damage to asphalt streets and parking lots, and reduced root rot.

D.4 Discount Costs and Benefits

Discounting from the Agency Perspective. Our example agency has a 7 percent per year (nominal) cost of capital for projects of 10 year duration. Ten years is our period of analysis, based on the life span of new irrigation equipment and based on the ongoing education and maintenance work included throughout the program. Based on the 7 percent nominal rate and a 3 percent inflation rate, the real (adjusted for inflation) discount rate is approximately 4 percent. Table D.4 shows the year-by-year costs and benefits from the retail agency's perspective. Undiscounted benefits are calculated by multiplying the water savings (Column [2]) times the value of conserved water. As described above, we expect the costs of new water supply to rise, so benefits per acre-foot saved are escalated over time (Column [3]). Column [5] contains the year-by-year costs. Columns [4] and [6] calculate the present value of benefits and costs, respectively. Finally, column [7] contains the present value of benefits minus the present value of costs (Net Present Value). Notice from the retail agency perspective that for the life of the program that NPV is $3587 for each acre in the program.

Discounting from the Customer's Perspective. Table D.5 displays the CBA calculations from a participating customer's perspective when calculated with a 7 percent discount rate. The benefits of the landscape conservation program in this illustration are greater than the costs from the perspective of the participating customer; NPV is $3667 for each acre in the program.

Discounting from a Total Society Perspective. Table D.6 shows the present value of costs and benefits from the total society perspective. We see that the benefits we have quantified thus far exceed the costs from the total society perspective. However, many

important benefits are not included, such as street damage, paint damage, esthetic value of improved landscape quality, reduced root damage, and a range of reduced environmental damages.

Discounting from the Regional Wholesaler Service Area Perspective. Table D.7 shows the present value of costs and benefits from the regional wholesaler service area perspective. The benefits exceed costs; net present value is $4,116.

Table D.4

Retail Agency Perspective ($/acre)						
Year	AF Saved	Benefits	PV Benefits	Costs	PV Costs	NPV
0	0.000	$ -	$ -	$ 288.95	$ 288.95	$ (288.95)
1	0.917	$ 498.94	$ 479.75	$ 53.54	$ 51.48	$ 428.27
2	0.917	$ 506.42	$ 468.21	$ 53.54	$ 49.50	$ 418.71
3	0.917	$ 514.02	$ 456.96	$ 53.54	$ 47.60	$ 409.36
4	0.917	$ 521.73	$ 445.97	$ 53.54	$ 45.77	$ 400.21
5	0.917	$ 529.55	$ 435.25	$ 53.54	$ 44.01	$ 391.25
6	0.917	$ 537.50	$ 424.79	$ 53.54	$ 42.31	$ 382.48
7	0.917	$ 545.56	$ 414.58	$ 53.54	$ 40.69	$ 373.89
8	0.917	$ 553.74	$ 404.61	$ 53.54	$ 39.12	$ 365.49
9	0.917	$ 562.05	$ 394.89	$ 53.54	$ 37.62	$ 357.27
10	0.917	$ 570.48	$ 385.39	$ 53.54	$ 36.17	$ 349.23
Total	9.167	$ 5,339.97	$ 4,310.41	$ 824.35	$ 723.21	$ 3,587.20
Real discount rate is 4%, real escalation rate is 1.5%, marginal supply cost is $431 per acre foot, and wholesaler incentive is $154 per acre foot.						

Table D.5

Participating Customer Perspective (Average Participation, $/acre)						
Year	AF Saved	Benefits	PV Benefits	Costs	PV Costs	NPV
0	0.000	$ 200.00	$200.00	$ 733.60	$733.60	($533.60)
1	0.917	$810.58	$757.55	$ 262.40	$245.23	$512.32
2	0.917	$822.74	$718.61	$ 262.40	$229.19	$489.42
3	0.917	$835.08	$681.67	$ 262.40	$214.20	$467.48
4	0.917	$847.60	$646.63	$ 262.40	$200.18	$446.45
5	0.917	$860.32	$613.40	$ 262.40	$187.09	$426.31
6	0.917	$873.22	$581.87	$ 262.40	$174.85	$407.02
7	0.917	$886.32	$551.96	$ 262.40	$163.41	$388.55
8	0.917	$899.62	$523.59	$ 262.40	$152.72	$370.87
9	0.917	$913.11	$496.67	$ 262.40	$142.73	$353.94
10	0.917	$926.81	$471.14	$ 262.40	$133.39	$337.75
Total	9.167	$8,875.40	$6,243.09	$3,357.60	$2,576.59	$3,666.50
Real discount rate is 7%, real escalation rate is 1.5%, and retail water rate is $871 per acre foot ($2.00/CCF).						

Table D.6

Total Society Perspective ($/acre)						
Year	AF Saved	Benefits	PV Benefits	Costs	PV Costs	NPV
0	-	$0.00	$0.00	$ 822.55	$822.55	($822.55)
1	0.917	$560.11	$538.57	$ 315.94	$303.79	$234.78
2	0.917	$568.51	$525.62	$ 315.94	$292.10	$233.52
3	0.917	$577.04	$512.99	$ 315.94	$280.87	$232.12
4	0.917	$585.70	$500.66	$ 315.94	$270.07	$230.59
5	0.917	$594.48	$488.62	$ 315.94	$259.68	$228.94
6	0.917	$603.40	$476.87	$ 315.94	$249.69	$227.18
7	0.917	$612.45	$465.41	$ 315.94	$240.09	$225.32
8	0.917	$621.64	$454.22	$ 315.94	$230.85	$223.37
9	0.917	$630.96	$443.30	$ 315.94	$221.98	$221.33
10	0.917	$640.43	$432.65	$ 315.94	$213.44	$219.21
Total	9.167	$5,994.71	$4,838.91	$3,981.95	$3,385.11	$1,453.81

Real discount rate is 4%, real escalation rate is 1.5%, and marginal supply costs $602 per acre foot.

Table D.7

Regional Wholesaler Service Area Perspective ($/acre)						
Year	AF Saved	Benefits	PV Benefits	Costs	PV Costs	NPV
0	0.000	$0.00	$0.00	$ 288.95	$288.95	($288.95)
1	0.917	$560.11	$538.57	$ 53.54	$51.48	$487.09
2	0.917	$568.51	$525.62	$ 53.54	$49.50	$476.12
3	0.917	$577.04	$512.99	$ 53.54	$47.60	$465.39
4	0.917	$585.70	$500.66	$ 53.54	$45.77	$454.89
5	0.917	$594.48	$488.62	$ 53.54	$44.01	$444.61
6	0.917	$603.40	$476.87	$ 53.54	$42.31	$434.56
7	0.917	$612.45	$465.41	$ 53.54	$40.69	$424.73
8	0.917	$621.64	$454.22	$ 53.54	$39.12	$415.10
9	0.917	$630.96	$443.30	$ 53.54	$37.62	$405.69
10	0.917	$640.43	$432.65	$ 53.54	$36.17	$396.48
Total	9.167	$5,994.71	$4,838.91	$824.35	$723.21	$4,115.71

Real discount rate is 4%, real escalation rate is 1.5%, and marginal supply costs $602 per acre foot.

D.5 Analyze Uncertainty

Table D.8 shows results of sensitivity tests focusing on savings per acre in the program. The CBA is conducted by calculating net present value for each of three savings levels which represent the range found in the water use analysis.

Table D.8 - Cost-Benefit Sensitivity to Water Savings

	Water Savings		
Savings	**High**	**Medium**	**Low**
Inches per Acre	16.0	11.0	6.0
	NPV*		
Perspective	**High**	**Medium**	**Low**
Retail Agency	$5,547	$3,587	$1,627
Customer	$6,413	$3,667	$919
Total Society	$3,653	$1,454	($745)
Reg. Wholesale Service Area	$6,315	$4,116	$1,916

Notes:

*NPV calculated with same discount rates, escalation rates, and value of conserved water as presented previously in this illustration, by perspective

Table D.9 - Cost-Effectiveness Sensitivity to Water Savings

	Water Savings		
Savings	**High**	**Medium**	**Low**
Inches per Acre	16.0	11.0	6.0
	Dollars per Acre Foot		
Perspective	**High**	**Medium**	**Low**
Retail Agency	$61.86	$89.97	$164.95
Customer	$255.37	$371.45	$681.00
Total Society	$289.53	$434.39	$772.08
Reg. Wholesale Service Area	$61.86	$89.97	$164.95

Notes:

*$/AF calculated with same discount and escalation rates as presented previously in this illustration, by perspective