BMP 5 Handbook:

A Guide to Implementing Large Landscape Conservation Programs as Specified in Best Management Practice 5

Prepared for

The California Urban Water Conservation Council

455 Capitol Mall, Suite 703
Sacramento, CA 95814
(916) 552-5885

by

John B. Whitcomb, PhD
Stratus Consulting Inc.

Gary F. Kah
AquaMetrics LLC

Warren C. Willig
Environmental Water Management

April 1, 1999

Contents

Overview

This handbook is intended to assist California water agencies with understanding and successfully administering landscape conservation programs in accordance with BMP 5. BMP 5 is one of the Best Management Practices (BMP) identified in the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU) as governed by the California Urban Water Conservation Council (CUWCC).

The intended audience for this handbook is the “water conservation coordinator” responsible for implementing BMPs. This handbook provides:

- A full explanation and discussion of BMP 5 definitions, implementation schedules, coverage requirements, and reporting requirements.
- Guidance and illustrative case studies regarding alternative ways to design, budget, promote, implement, administer, and monitor BMP 5 landscape water efficiency programs.
- References that interested readers can consult to obtain additional information on specific topics.

Chapter 1 addresses BMP 5 definitions and requirements. Chapters 2, 3, and 4 offer guidance and present case studies associated with the three primary program components addressed within BMP 5. Chapter 5 describes the exemption process associated with BMP 5 requirements. Official BMP 5 text from the MOU is reproduced in Appendix A. Appendix B provides background on collecting weather data. Appendix C provides background on options regarding the water budget equation. The glossary provides readers with technical terms associated with landscape management. These terms are highlighted in bold italics upon first use in a chapter.

Acknowledgements

The California Urban Water Conservation Council funded the creation of this handbook. We give thanks and credit to the Project Advisory Committee (PAC) that provided invaluable guidance and review of the handbook. The PAC members include:

Alice Webb	PAC Chairperson, Metropolitan Water District of Southern California
Chris Dundon	Contra Costa Water District
Steve Hedges	Municipal Water District of Orange County
David Mitchell	CUWCC Technical Support, M. Cubed
Dennis Pittenger	Department of Botany & Plant Sciences, UC Riverside and U.C. Cooperative Extension
Marsha Prillwitz	Bureau of Reclamation
Larry Rohlfes	California Landscape Contractors Association
David Shaw	University of California Cooperative Extension
Scott Silva	Metropolitan Water District of Southern California
John Swindell	East Bay Municipal Utility District
Sarah West	The Council for a Green Environment

Glossary of Terms

CII denotes commercial, industrial, and institutional customers, and for BMP 5 includes multifamily residential sites (e.g., homeowners' associations) with dedicated irrigation meters.

CIMIS is the California Irrigation Management Information System, which contains historical electronic records of daily observations of ETo and rainfall at about 100 locations in California.

Dedicated irrigation meters are used to measure water used exclusively for irrigation.

ETo denotes reference evapotranspiration and equals the depth of water evaporated and transpired from a reference crop (tall fescue) if water supply is not limiting.

Heads-up digitizing is a process in which a computer operator traces image shapes on a computer screen and uses software to calculate the resulting areas in real world units (e.g., square feet or acres).

Image processing software automates the calculation of hardscape and landscape areas within a parcel using information from either an aerial photo or a multispectral image.

Irrigation schedule specifies the start time, duration, and frequency of irrigation for each irrigated subregion (station) at a site. Irrigation schedules should change throughout the year to reflect changes in weather.

Mixed-use meters are utility water meters that measure the combined water consumption associated with irrigation and other end uses.

Planimeters operate on a printed hardcopy of an image and calculate the area of a shape as it traces the shape's perimeter. This method can be used on areas of any shape.

Submeters are water meters owned and read by customers to measure specific end uses (e.g., irrigation).

Turfgrass is divided into two general groups: cool season, which is green all year, and warm season, which is dormant in cold weather. Cool season turfgrass uses more water in hot weather than warm season species. In addition, athletic turf for playing fields and golf course tees and greens requires more water than low-traffic ornamental turf.

Water use budgets for BMP 5 consist of an upper bound estimate of water use for a landscape area over a billing period. Budgets are based on landscape area and local weather, among other possible factors (e.g., type of plant material, assumed irrigation system efficiencies).

Water use surveys are performed by trained staff at landscape sites to assess and recommend ways to improve both the technical performance and management of irrigation systems.

1 BMP 5 Description and Requirements

The mission of the California Urban Water Conservation Council (CUWCC) is to increase efficient water use statewide through partnerships among urban water agencies, public interest organizations, and private entities, and to integrate urban water conservation Best Management Practices (BMPs) into the planning and management of California's water resources. Signatory water suppliers agree to develop and implement comprehensive conservation BMPs using sound economic criteria.

CUWCC is the governing entity responsible for:

- monitoring implementation of the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU) signed into effect December 11, 1991
- defining urban water conservation BMPs
- reporting progress toward BMP implementation to the State Water Resources Control Board and other government entities.

In September 1997, CUWCC significantly modified and consolidated the BMPs related to landscape irrigation into what is now called BMP 5. This chapter describes the programs, schedules, minimum coverage, and reporting requirements of BMP 5. Appendix A reproduces the official BMP 5 text included in the MOU.

1.1 BMP 5 Objective

BMP 5 is one of 14 BMPs listed in the MOU as amended April 8, 1998. BMP 5 addresses outdoor irrigation at commercial, industrial, and institutional (***CII***) landscape sites. This handbook's definition of CII landscape sites also includes irrigation water use at multifamily residential sites with dedicated irrigation meters (e.g., homeowners' associations). Outdoor irrigation at single family sites and multifamily sites with combined indoor/outdoor water use meters (denoted as ***mixed-use meters***) is covered by the BMP 1 water use surveys (MOU, Exhibit 1, page 14).

The purpose of BMP 5 is to improve irrigation efficiency at CII landscape sites.[1] It does not address decisions related to landscaping size or plant selection. BMP 5 programs specifically target improving irrigation performance on existing landscapes. They do so by having water agencies provide their CII

1. The Water Conservation in Landscaping Act (Assembly Bill 325) mandated the creation of a Model Water Efficient Landscape Ordinance and required California's cities and counties to adopt a water-efficient landscape ordinance by January 1, 1993. The Model Ordinance and BMP 5 are similar in many ways. BMP 5, however, specifically applies and is relevant to retail water agencies.

landscape sites with ***water use budgets***, ***water use surveys***, financial incentives, and other supporting assistance.

1.2 BMP 5 Program Descriptions

The BMP 5 landscape programs can be split into three main components:

Water Use Budgets. This component requires water suppliers to develop water use budgets for CII landscape sites served by ***dedicated irrigation meters*** and provide customers with a comparison of actual water use relative to budget each billing period. Water use budgets, which cannot exceed 100% of ETo per square foot of landscape area, can increase customers' awareness of irrigation efficiency by providing pertinent, timely, site-specific information. Water use budgets can be provided to CII landscape customers solely for informational purposes or can be linked to water pricing strategies. Chapter 2 addresses water budgets.

Water Use Surveys. This component requires water agencies to conduct landscape water use surveys at CII landscape sites with mixed-use water meters or nonmetered sites. Trained staff (surveyors) are sent to landscape sites to diagnose and recommend ways to improve both the technical performance and the management of irrigation systems. Chapter 3 addresses water surveys.

Supplemental Landscape Programs. BMP 5 also includes several programs to support the water budget and water survey programs. These programs include providing financial incentives, providing training and educational opportunities, and encouraging the installation of dedicated irrigation meters. Chapter 4 addresses these programs.

1.3 BMP 5 Schedule and Minimum Coverage Requirements

Table 1-1 describes the schedule and minimum coverage requirements associated with each of the three BMP 5 components.

1.4 BMP 5 Reporting Requirements

Each reporting period (two year intervals), water agencies must provide the information contained in Table 1-2 showing progress toward BMP 5 goals. In addition, agencies must preserve water use records and water budgets for customers with dedicated landscape meters for at least two reporting periods (four years). This information may be used by the CUWCC to verify the agency's reporting on this BMP.

Table 1-1. BMP 5 Schedule and Minimum Requirements

Implementation Date[a]	Water Use Budgets	Water Use Surveys	Supplemental Programs[f]
Start date July 1, 1999	Program under way	Program under way	
First reporting period July 1, 2001		Surveys offered to at least 20% of CII mixed-use accounts[c] Cumulative completed surveys equal at least 1.5% of CII mixed-use accounts[d,e]	Financial incentives program under way
Second reporting period July 1, 2003	Budgets developed for 90% of CII landscape accounts with dedicated irrigation meters[b]	Surveys offered to at least 20% of CII mixed-use accounts[c] Cumulative completed surveys equal at least 3.6% of CII mixed-use accounts[d,e]	

a. Agencies signing the MOU or becoming subject to the MOU after December 31, 1997, must have a start date no later than July 1 of the second year following the year the agency signed or became subject to the MOU. Reporting periods will be every two years following start date.

b. Water use budgets do not have to be distributed to customers if actual use is less than budgeted use.

c. To meet the 20% requirement in each reporting period, agencies can include CII mixed-use accounts provided ETo based water budgets and those retrofitted with dedicated irrigation meters (see BMP 5 E.b).

d. To meet the completed survey percentage requirement, agencies can include a) all surveys completed after July 1, 1996; b) all surveys completed before July 1, 1996, that received a follow-up inspection; c) 50% of surveys completed before July 1, 1996, that have not received a follow-up inspection; d) CII mixed-use accounts provided ETo based water budgets; e) CII mixed-use accounts retrofitted with dedicated irrigation meters; and f) CII accounts receiving indoor/outdoor surveys as part of BMP 9 (see BMP 5 E.c and E.d).

e. The minimum percentage of completed surveys (cumulative) increases in each reporting period from 1.5, 3.6, 6.3, 9.6, and 13.6 over the first five reporting periods, respectively.

f. The only requirement is to have a start date for the financial incentives program (no specific coverage goals).

Table 1-2. BMP 5 Reporting Requirements

Water Use Budgets	
Number of dedicated irrigation meters served by agency at end of reporting period	X
Number of dedicated irrigation meters with water budgets at end of reporting period	X
Aggregate water use over all dedicated irrigation meters over reporting period (two years)	X
Aggregate budgeted water use over all dedicated irrigation meters over reporting period (two years)	X
Water Use Surveys	
Number of CII mixed-use accounts at end of reporting period	X
Number of water surveys offered to CII mixed-use accounts during reporting period	X
Number of CII mixed-use accounts provided water surveys during reporting period	X
Cumulative number of CII mixed-use accounts surveyed at end of reporting period	X
Financial Incentives	
Type of financial incentives offered to CII landscape customers during reporting period (e.g., rebates, loans)	X
Number of customers receiving financial incentives by type of incentive during reporting period	X
Dollar value of incentive by type of incentive	X

1.5 BMP 5 Exemption Criteria

As specified in the MOU, signatory water agencies will be exempt from the implementation of BMP 5 if its programs

- can be shown to be not cost-effective given prevailing local conditions,
- cannot be adequately funded, or
- are not within the legal authority of the water supplier.

Chapter 5 describes these conditions in more detail.

1.6 Nonmetered Service Areas

BMP 5 is focused on water agencies with metered customers; water use budgets are meaningless if water use is not measured.[2] In addition, water agencies have no direct way of identifying mixed-use water users from their billing systems. As a consequence, nonmetered service areas are excluded from the minimal coverage requirements listed in Table 1-1.

BMP 5 does, however, explicitly stipulate that "unmetered service areas will actively market landscape surveys to existing accounts with large landscapes, or accounts with landscapes which have been determined by the purveyor not to be water efficient." Nonmetered service areas are also subject to the stipulation requiring a landscape financial incentives program.

2. Of course irrigation scheduling is still an important issue.

2 Water Use Budgets

BMP 5 requires water agencies to provide ***water use budgets*** to their customers with ***dedicated irrigation meters***. A water use budget is an upper bound estimate of water use at a site given its landscape area and local weather conditions, among possible other factors (e.g., types of plants). Each billing period, customers are to receive notices comparing their water budgets with actual water consumption. Customers that are over budget should be able to lower their water consumption via improved irrigation system performance and management.

The water use budget component of BMP 5 is relatively new, first adopted as part of the BMP in September 1997. Hence, unlike ***water use surveys***, which have been widely employed in the water industry for many years, water budget programs offer new challenges to the water conservation coordinator. This chapter addresses these challenges and offers a step-by-step approach to assist with its implementation as shown in Figure 2-1.

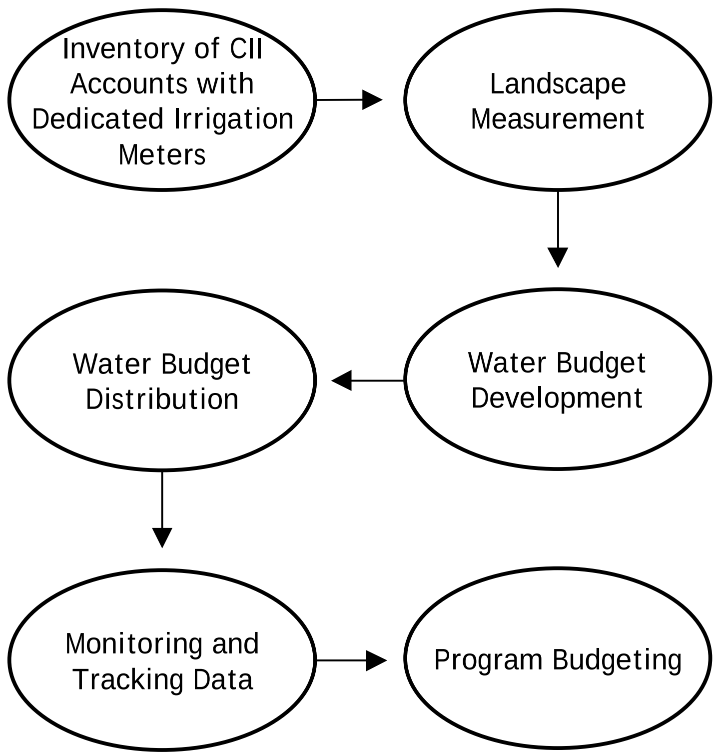

Figure 2-1. Steps in Developing a Water Budget Program

Each step is discussed in this chapter. We also present four case studies of California agencies regarding different aspects of water budget programs. Chapter 4 discusses how water budgets can be integrated with other landscape irrigation programs to offer a comprehensive set of services to landscape customers.

Developing a water budget for a site requires two basic inputs: landscape area and weather data as illustrated in Figure 2-2. The remainder of this section describes each of these inputs and how they can be used to create a water budget.

Landscape Area

Landscape area can be defined in different ways and with varying degrees of differentiation. The exact definition used will be a key decision for each water agency in developing their water budget program.

Ideally, landscape area equals the area of plant material that regularly receives water through an irrigation system. Plant materials typically include turfgrass, groundcovers, shrubs, trees, and annuals.

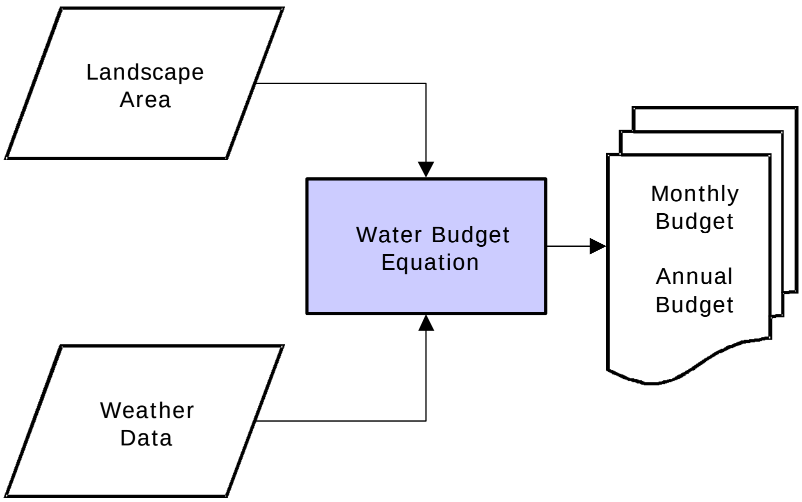

Figure 2-2. Water Use Budget Process

This is the ideal definition in the sense that it allows for the creation of water budgets that best represent the specific landscape water requirements at the site.

Some water agencies have, however, used a more expansive definition of landscape area (e.g., Irvine Ranch Water District and Otay Water District) to include all non-hardscape area. The difference in landscape area associated with these two definitions may not be large. Where sites have substantial undeveloped or nonirrigated landscape areas, however, the differences can be large—the impact being that water budgets will be in excess of what is actually required to irrigate efficiently.[3]

The decision of how to define landscape area will largely depend on a water agency's options and costs related to landscape measurement, as described in Section 2.2. Using the tax assessor records or self-reporting options tends to favor using the all non-hardscape definition. Using aerial photography or multispectral digital images favors the irrigated landscape definition. Hence, the conservation coordinator needs to explore and consider the landscape measurement task in conjunction with defining landscape area.

Another important issue regarding landscape area concerns differentiating among plant materials. BMP 5 does **not** require that plant materials be differentiated in the water budget process. An agency may choose to differentiate plant materials into two or more groupings to develop water budgets that more closely match the actual water requirements at a site. This is practiced mainly to separate out and quantify turfgrass areas, which are more water intensive. However, the added complexity of groupings must be weighed against the increased difficulties in landscape measurement.

---

3. The landscape area difference between the two definitions generally decreases with level of urbanization.

Weather Data

The other main input affecting water budgets is weather. Reference evapotranspiration (***ETo***) is a measure of the effect of weather on the need for water by landscape plant materials. Specifically, ETo is an estimate of the depth of water evaporated and transpired from a reference crop[4] if water is not a limiting factor. BMP 5 states that water budgets cannot exceed 100% of ETo per square foot of landscape area.

Historical and current ETo data for areas throughout California are available in electronic format from the California Irrigation Management Information System (***CIMIS***). At present it is necessary to select a weather station that is as representative as possible of your location. However, the Department of Water Resources is updating the CIMIS data system so that it will soon be possible to obtain weather data by entering the ZIP code for a specific area. Currently there are about 100 CIMIS stations throughout California. Appendix B presents more information on CIMIS.

When calculating water budgets, a water agency can use either some historical average of ETo or actual ETo observations. We recommend that actual ETo observations be used wherever possible so that water budgets reflect real-time irrigation demands. Significant fluctuations in weather from normal, such as events like El Niño, illustrate the importance of using real-time ETo and will minimize criticisms that water budgets do not reflect actual site conditions. For water agencies constrained in the short run to use historical averages of ETo (e.g., limited ability to generate water budgets based on real-time data), we suggest that a long-run conversion plan be considered.

It is possible to use non-CIMIS weather stations (e.g., National Oceanic and Atmospheric Administration, NOAA) to estimate ETo. In some cases a NOAA station may be in a more representative location than the closest CIMIS station. However, NOAA stations rarely collect all of the data needed to calculate ETo (i.e., net radiation, air temperature, windspeed, and humidity). NOAA stations usually are limited to temperature and precipitation, and sometimes pan evaporation. Although it is possible to use formulas that estimate ETo solely from temperature or pan evaporation, these formulas provide less accurate results. In our judgment, any gain derived from closer proximity to a NOAA stations will be negated by inaccuracies in ETo estimation. Hence, we recommend agencies use CIMIS ETo data in almost all cases.

BMP 5 states that agencies need to create ETo-based water budgets. It is also possible to include rainfall in the water budgeting process. Rainfall naturally supplies a portion of the ETo-based water needs of plants. Not all rain offsets ETo, however, as some is lost as runoff or percolates past relatively shallow rootzones (e.g., turfgrass). Moreover, California receives most of its rain in the

---

4. The reference crop is tall fescue grass that is actively growing, completely shading the soil, and cut 4 to 6 inches high.

winter when ETo is low. In general, only about 20 to 50% of annual rainfall is effective at offsetting ETo in California.

Although including rainfall can increase the precision of water budgets to reflect real water needs, most agencies may find integrating rainfall to be more trouble than it's worth. We conclude this for the following reasons:

- In California, most rain occurs in the winter when ETo is low. Including rainfall will have minimal impact on water budgets during the high-irrigation summer months.
- Rainfall can be highly variable spatially, unlike ETo. Rainfall at a CIMIS weather station may be quite different from that at a nearby landscape site.
- Effective rainfall depends on a number of site factors, such as soil type, which can be difficult to identify.
- Effective rainfall varies with the frequency, duration, and intensity of rainfall events, and is not easy to measure.

Hence, for most water agencies starting a water budget program, we suggest that effective precipitation not be included as part of the water budget calculation. If deemed worthy, it could be added later as an embellishment.

2.1 Inventory of CII Accounts with Dedicated Irrigation Meters

The first task is to identify the number of CII accounts with dedicated irrigation meters served by the agency. This is one of the data elements included in the BMP 5 reporting requirements shown in Table 1-2. Most water agencies have billing systems that contain a customer code field identifying these accounts. In some cases, a combination of data fields will be needed to isolate them. For example, one field may identify CII accounts and another field may identify that they do not pay a wastewater charge (a common motivation for establishing a dedicated irrigation account). Remember that multifamily residential accounts can have dedicated irrigation meters, and these are to be included in this program.

The next task is to identify sites with multiple dedicated irrigation meters. Many CII landscape sites, especially those over three acres or where nighttime water main delivery pressures are low, will have more than one irrigation meter. Water budgets are typically calculated at the site level, since landscape area associated with individual meters can be difficult to determine. If landscape areas associated with specific meters can be easily determined, however, individual budgets can be developed for each meter.

In addition, many customers such as banks, restaurants, park districts, school districts, and government agencies may have multiple sites spread throughout a service area. Agencies have the option of identifying these customers and creating comprehensive multiple-site water use budgets. This aggregation may be useful to site managers who are likely to make multiple-site changes related to irrigation performance, or those needing to prioritize efforts. In any event, knowing the relationships between accounts, sites, and customers can often expand water budgeting options and capabilities.

2.2 Landscape Area Measurement

The most challenging and expensive task associated with BMP 5 is likely to be generating estimates of landscape area. BMP 5 requires that water budgets be developed for at least 90% of dedicated irrigation accounts by the end of the second reporting period (see Table 1-2). Because water budgets require landscape area as an input, agencies must obtain landscape measurements associated with at least 90% of its dedicated irrigation meters.

There are a variety of ways to measure landscape area. The methods vary in cost, accuracy, timeliness, and resource requirements. Table 2-1 summarizes the primary advantages and disadvantages of six common methods. Each method is described in a subsequent section. A combination of methods can be used; for example, sites failing to respond to mail surveys asking for customer reported measurements can be measured by water agency staff using field measurement or landscape plan methods.

The best method for a given agency will depend on a variety of factors. Because these factors are interrelated and depend greatly on local circumstances, we cannot definitively identify the best course. Further, because of the newness of some emerging technologies (e.g., multispectral images) and conservation coordinators' ability to come up with creative solutions, we cannot say that conclusions made today will necessarily hold in the future. In addition, the context from which policy decisions are made needs to be considered in all of this. For example, the decision of whether to make water budgets informational only or to link them with water rates may have an impact on the level of accuracy desired from the measurement technique.

Given these complexities, selecting a landscape measurement technique is not a simple process. It is the intent of this section to outline the options and provide guidance as to our current understanding of the advantages, disadvantages, and constraints associated with each.

Field Measurement

Traditionally, landscape area has been measured in the field, at a site. The most common field measuring technique has been the use of a measuring tape or odometer wheel to calculate distances between points. Water use surveys, as described in Chapter 3, typically use this technique.

Table 2-1. Landscape Measurement Technique Comparison

Method	Relative Comparison of Methods
Field measurement	Accuracy is high if operators trained. Larger agencies will require multiple operators to measure all sites on timely basis. Can provide irrigated landscape area and make plant material distinctions. Cost per site is relatively high, although it may be the least total cost option for agencies measuring a small number of sites.
Landscape plans	Accuracy varies with quality of plans. Can provide irrigated landscape area and make plant material distinctions. Plans will not be available for many sites. Landscape plans can supplement other methods, but are not likely to be a primary technique. Cost is medium.
Customer reported	Accuracy is low because of differences in applied measurement techniques, level of effort exerted, and potential biases of self-reporting customers. Measurements can be obtained in a few months (time of mail survey), although many customers may not comply with request. Per site cost is low.
Tax assessor parcel information	Accuracy will vary and is limited to non-hardscape area (i.e., lot size minus footprint of structures). It does not provide for distinctions in plant material. Timeliness is high, but availability of data for CII sites may be low. Per site cost is low.
Aerial photography with manual delineation	Accuracy is medium and can vary with delineation operator. All sites can be done quickly if aerial photos and parcel database exist. Can provide irrigated landscape area and make limited plant material distinctions. Per site cost is medium.
Multispectral digital images with image processing software	Accuracy is medium to high. All sites can be done quickly if a parcel polygon database exists. Can provide irrigated landscape area and make plant material distinctions. Per site cost is high for small agencies and low for large agencies.

The measuring wheel, however, is not the only option. A recent Bureau of Reclamation study (Walker, 1998) described nine different field methods for obtaining landscape area measurements, summarized in Table 2-2. Methods 4, 6, and 8 are familiar to most people and are commonly used by landscape and water district personnel. The other methods are more familiar to surveyors and usually require specialized training, special equipment, or both.

Field measurement is often viewed as the most accurate measurement technique and is often used as the standard to which other techniques are compared. It should be noted, however, that field measurements are themselves prone to inaccuracies from uneven surfaces or human errors. All field

Table 2-2. Field Measuring Techniques

Field Method	Principle Used
1. Compass	Angle
2. Electronic distance measurement (EDM)	Length
3. Global positioning system (GPS)	Position
4. Odometer wheel	**Length**
5. Optical rangefinder	Length
6. Pacing	**Length**
7. Stadia	Length, horizontal angle
8. Measuring tape	**Length**
9. Total station	Length, angle

Note: Methods in bold are those most commonly used by landscape and water district personnel.

measurement techniques can benefit from a customer-supplied site map[5] and careful note-taking to ensure that small or remote areas are not omitted or double counted.

Landscape Plans

A detailed planting or irrigation plan can delineate landscaping areas with a high degree of accuracy. Areas can be measured from the plans with a ***planimeter*** or by digitizing.

A planimeter operates on a printed hardcopy of an image and calculates the area of a shape as it traces the shape's perimeter. It can be used on areas of any shape, and most agencies with engineering departments have planimeters. If the plans are digitized, GIS, CAD, or drawing software can be used to delineate the edges of the irrigated areas and provide measurements of internal areas.

If plans are used to obtain measurements of landscape area, users should beware that plans may not represent reality. Landscape areas may not have been built to specifications, or they may have changed over time. Sometimes a set of "as built" plans exist with markings denoting all changes made in the field at the time of construction.

---

5. A field sketch can be created to help keep track of which areas have been measured and to log measured distances.

Conservation coordinators using this technique will have to develop a process to obtain, copy, catalog, and store planting and irrigation plans. This will require direct customer contact and interaction. Many customers may not have plans available. Hence, conservation coordinators should not expect to exclusively rely on this technique as a means of obtaining landscape areas. This technique can be useful in supplementing other techniques (e.g., field measurement) when landscape plans are easily accessible.

Customer Reported

Several pioneering water budget programs have relied on self-reporting by customers of their irrigated area. In these cases, the water retailer sent a mail survey asking the customer to make a landscape area estimate. Customers make the estimates by using field measurement techniques, consulting landscape plans, relying on their commercial landscapers to create estimates, or using some other means such as making a subjective guess.

The advantage of the self-reporting technique is its low cost (cost of conducting the survey and entering results in a database). The disadvantage is that the accuracy and consistency of measurements across sites can vary significantly. In situations where water budgets are to be integrated with water rates, customers will have incentives to overestimate landscape areas to receive a lower water bill. The extent of this type of self-reporting bias is currently unknown, but should be considered. In addition, this method will fail to get responses from some landscape customers, perhaps 50% or more (Ash, 1996; Psomas, 1998). Hence, this method usually needs to be combined with other methods to obtain a complete landscape area census.

Tax Assessor Parcel Information

An estimate of landscape area can be obtained by taking total lot size and subtracting out the footprint area of buildings and other hardscape features (e.g., parking lots). The California county tax assessor offices often store this type of data by parcel.

The advantages of this approach are that landscape area estimates can be made on a timely, consistent basis, for a relatively low cost.

A disadvantage is that parcel data for commercial properties may be incomplete or not helpful in calculating a hardscape footprint. Unfortunately, each California county tax assessor has different data fields, percentage of data fields populated, and access restrictions. Hence, each conservation coordinator will have to check with their local county tax assessor office.

Other disadvantages of this approach are that only non-hardscape area is measured (not irrigated area) and that plant material distinctions cannot be made.

In a study conducted for customers in the Moulton Niguel Water District, the use of tax assessor information for this purpose proved unworkable. This was, in part, because the building area for multistory buildings included total floor area, not its footprint.[6] In addition, only a small fraction (15.3%) of sites in the database actually contained parcel size values (Psomas, 1998).

In a study supported by the Metropolitan Water District, Volt VIEWtech (1996) performed a Tax Assessor Database Targeting pilot study for a test area in the Helix Water District. Although the degree of accuracy of landscape area varied, the technique did prove useful for improving the targeting of residential water audit services. However, VIEWtech concluded that the tax assessor's database did not have sufficient details to permit usage on commercial properties.

Aerial Photography

This image-based method is based on taking aerial photos of an agency's service area and overlaying them with a parcel map. Then estimating techniques can be used to measure landscaping areas for specific parcels or sites. Estimating techniques include analyzing hardcopy photos (e.g., manual delineation or use of a planimeter) or images on a computer monitor (***"heads up" digitizing***). Significant advantages result when the image is "orthographic," so that the dimensions of objects in the image are to scale across the entire image.

Photos can be in black and white, color, or infrared and can reflect different scales. Certain image types such as grayscale aerial photos may not permit distinction between different plant material types, especially at smaller map scales. Figure 2-3 shows an example of an aerial photo where manual delineation has been used.

Multispectral Digital Images

This image-based method is similar to aerial photography, except that the image records information ranging from infrared radiation through the visible spectrum all the way to ultraviolet light. "Hyperspectral" imaging has been used for forestry and agricultural purposes (with over 200 distinct recording bands) and would work well in urban settings, but four-band digital cameras (red, blue, green, infrared) have been shown to provide sufficient detail for landscape measurement purposes.

Area estimating techniques for multispectral images can include the methods described with aerial photos, but the trend has been to employ ***image processing software*** to determine the relative distribution of hardscape and landscape areas within the site boundaries. When image processing

6. Tax assessor databases also vary in if and how they record non-building hardscape areas such as parking lots.

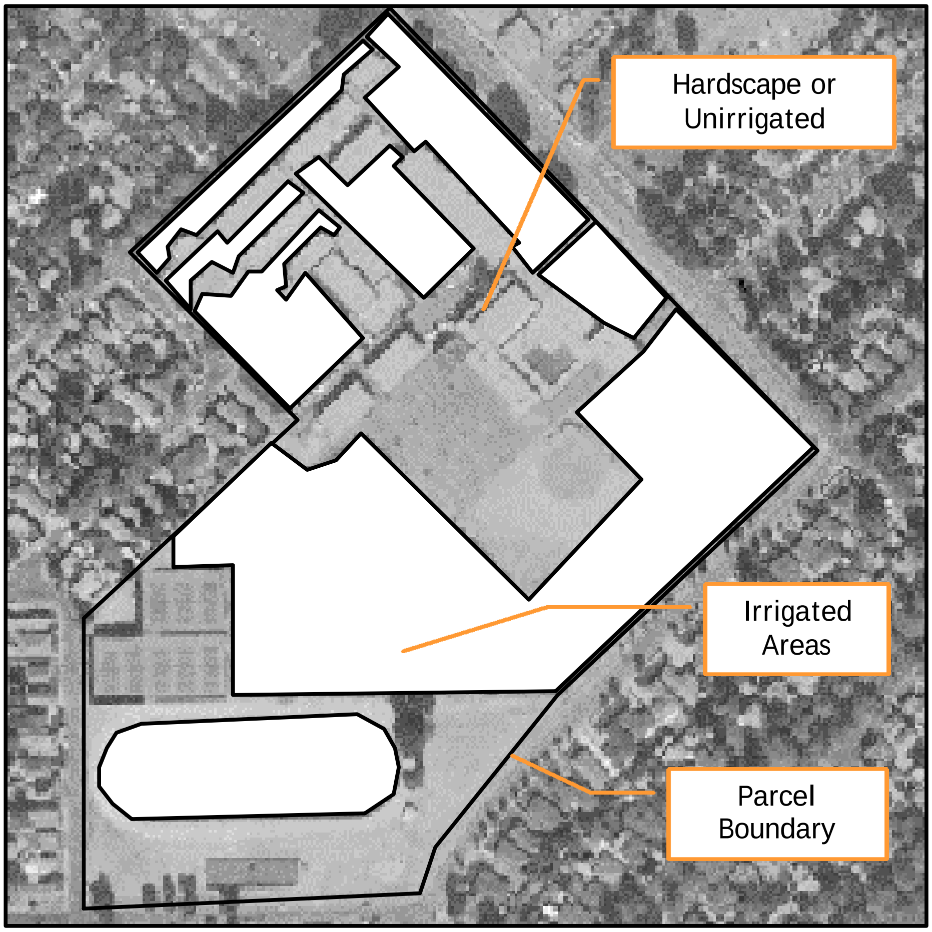

Figure 2-3. Aerial Photography Using Manual Delineation

software is used, a parcel polygon database is required to define site boundaries. The advantage of this method is that it can be automated, leading to consistent and relatively accurate assessments of landscape types on any particular site.

Case Study: Contra Costa Water District

The Bureau of Reclamation funded a study (AquaMetrics LLC, in press) to compare the cost and accuracy of four alternative landscape measuring methods as implemented at the Contra Costa Water District (CCWD). The methods include field measurement, planimetric analysis of scanned landscape plans, heads up digitizing of color aerial photography, and multispectral imaging.

CCWD staff selected 20 landscape sites to measure using each technique. Sites included a range of conditions and included commercial (11), institutional (4), and multifamily residential (5) customers.

Unfortunately, this handbook was completed before the CCWD report was available. It is expected that the CCWD report will be available June 1999.

Those interested in a copy of the report can contact:

U.S. Bureau of Reclamation
2800 Cottage Way, MP 410
Sacramento, CA 95825
Attention: Marsha Prillwitz
Phone: (916) 978-5213
Fax: (916) 978-5290
e-mail: mprillwitz@mp.usbr.gov

Those interested in learning more details concerning the study can contact either:

Contra Costa Water District
P.O. Box H20
Concord, CA 94524
Attention: Chris Dundon
Phone: (925) 688-8321

or

AquaMetrics LLC
Attention: Gary Kah
Phone: (650)366-8076
e-mail: Gary_Kah@AquaMetrics.com

Case Study: Municipal Water District of Orange County

A study of alternative landscape area measurement techniques by Psomas and Associates (Psomas, 1998) was funded in 1997 by the Municipal Water District of Orange County, Metropolitan Water District of Southern California, U.S. Bureau of Reclamation, and the Moulton Niguel Water District. This study was designed to investigate data resources and four different methods to determine irrigable areas at both residential and commercial sites.

Three irregularly shaped areas within the City of Laguna Niguel (totaling approximately one square mile) were selected for the study; the areas included single family residential, condominium, apartment, commercial, park, street medians and greenbelt sites.

The four area measurement techniques evaluated include photo-interpretation of aerial photography (organized into four submethods), mail-out survey, parcel and building information database, and field measurements. The photo-interpretation of aerial photography techniques included four submethods: manual tracing of areas from hardcopy air photos at 1" = 100' map scale, tracing at 1" = 200', heads-up digitizing, and visual estimation of percent irrigable area.

A parcel database consisting of Assessor's Parcel Numbers (APN), property addresses, and parcel polygons was used; the parcel addresses were used to match water meter data from the Moulton Niguel Water District to each property. GIS software was used to apply parcel polygons to aerial imagery and to provide the context for the heads up digitizing and visual estimation methods.

Photo-interpretation results from 25 sites (including 4 commercial sites, 8 multifamily residential sites, 1 institutional site, and 12 residential sites) were analyzed for accuracy by comparing them to field measurements and to each other. Advantages and disadvantages of the various methods studied are provided in the next box.

Review of MWDOC Landscape Measurement Techniques

Area Measurement Method	Advantages	Disadvantages
Manual tracing from aerial photos~~g~~eneral comments	Not limited by the number of available computers Can be used to create hardcopy presentations of classification results	Shadows, tree canopies, and building overhangs may obscure the boundaries of irrigated and nonirrigated areas
Manual tracing at 1" = 100'	Most objects of interest are visible at this scale	Scale is so small that work areas become very large
Manual tracing at 1" = 200'	Time expended per unit of area measured is less tracing than for 100'scale	Some objects of interest (sidewalks, drainage ditches) are not visible at this scale
Heads-up digitizing using GIS software	Image resolution on-screen can be better than hardcopy; can zoom in to small areas Most objects of interest are visible	Lots of zooming becomes time-consuming Quality control was done on-screen to avoid cost of printing hardcopies Limited by the number of available computers and disk storage space
Visual estimation of irrigable percentage	Quick and comparatively low cost Digital parcel polygon database not required	Very subjective; results by one analyst may vary over time, or results for the same parcel by different analysts may differ Complex parcels such as apartment, condominiums, or shopping centers are very difficult
Customer self-reporting via mail out surveys	Allows customer participation	Response rate was low (4%) Completeness varies greatly No easy way to evaluate accuracy
Parcel and building information database	None	Dataset had parcel size data for only 15% of pilot sites Judged to be not practical
Field measurements	Thought to be accurate; used as the reference for other methods Permits additional observations such as type of plant material by area	Requires more time per site than any other method Site boundaries are often difficult to determine in the field Requires cooperation of site owner/manager, especially for residential or security minded commercial properties

2.3 Water Budget Calculation

The basic water budget equation prescribed by BMP 5 and illustrated below is

water budget = landscape area × (ETo × adjustment factor),

where

water budget	=	volume of water budgeted for billing period
landscape area	=	total amount of landscape area at site
ETo	=	depth of ETo estimated for site during billing period
adjustment factor	=	scaler ranging between 0% and 100% (i.e., 0.0 to 1.0 in decimal form) that indicates the percentage of ETo to be used in water budget

Example Water Budget Calculation

Landscape area = 40,000 ft^2

ETo = 6 inches or 0.5 ft

Intensity factor = 1

Water budget = 40,000 ft^2 × (0.5 ft × 1) = 20,000 ft^3 = 200 Ccf = 149,600 gallons

Useful Conversion Factors:

1 acre = 43,560 ft^2

1 Ccf = 748 gallons = 0.748 thousand gallons

The adjustment factor lowers the percentage of ETo used to calculate the water budget. BMP 5 states that the adjustment factor must be equal or less than 100% of ETo. If an adjustment factor of 80% is selected, for example, then water budgets would be based on 80% of ETo.[7] The specific adjustment level selected by water agencies to calculate water budgets will depend on various factors. For example, agencies facing water shortages may be inclined to use a lower adjustment factor.

In addition, some agencies may choose to develop more complex budgets to more accurately match budgeted water use with actual water need at a site; this will typically reduce a water use budget. Budgets can be enhanced by:

---

7. Water budgets calculated under the Water Conservation in Landscaping Act (AB 325) Model Ordinance are based on an adjustment factor of 0.80.

- adjusting ETo to account for specific plant types (e.g., turf versus other landscaping)
- reducing water budgets for impacts of rainfall.

Agencies interested in incorporating these additional factors can consult Appendix C.

Water Budget Calculation for Mixed Use Sites

If an agency wants to offer irrigation water use budgets to ***mixed-use meter*** sites, all of the above principles of meter assignment, area measurement, and budget calculation still apply. The one important distinction comes with tracking actual use: a reasonable estimate of the split between indoor and outdoor use must be made.

A common way of making this distinction is to assume that indoor water use throughout the year equals winter water use (e.g., December, January, February). In the winter, outdoor landscape irrigation in California is minimal in most areas. This approach, however, is predicated on indoor water use being stable throughout the year. For customers with seasonal indoor water demands (e.g., caused by seasonal patterns in tourism or other business activities), assuming indoor water use equals winter water use may not be valid. In these cases, especially where outdoor irrigation is significant, installing dedicated irrigation meters may be a preferable option.

Revolving Meter Read Dates

A complication in creating water budgets is that most agencies use some type of revolving meter reading program. Hence, billing periods vary with individual accounts. In this case, if water budgets are to reflect actual weather conditions over a billing period, agencies will need to make individual customer calculations of ETo (and potentially rainfall) based on daily observations over the actual days contained in a billing cycle. Fortunately, CIMIS ETo values are provided on a daily basis.

2.4 Distributing Water Budgets

Once water budgets are developed, they need to be distributed to customers. Sending notices to customers requires some interaction or integration with the agency's customer billing system. This can be complicated by revolving meter reading dates and by the fact that individuals receiving water bills are not necessarily landscape managers. It is also possible to have water budgets tied to water rate structures. These topics are discussed in this section.

Billing System Integration

BMP5 states that agencies are to provide notices each billing cycle showing the relationship between the water budget and actual consumption.

An obvious way to meet this requirement is to add water budget information to the water bill itself. The advantage of this approach is that it automates the process. The disadvantage of this approach is that it could require significant changes to the billing process. Factors to consider are:

- adding or linking water budget data inputs to the billing database
- changing billing software to calculate water budgets
- changing bill design and layout to show water budget information
- dealing with site budgets corresponding to multiple irrigation meters
- dealing with customers with multiple landscape accounts
- sending copies of the bill to multiple parties (e.g., landscape managers).
- including and explaining water rates associated with different levels of water consumption

In some cases, it may be more effective for agencies to create a separate water budget document that can be distributed as an attachment to the water bill or as a separate mailing. This approach will allow for more flexibility in addressing some of the factors listed above. Not constrained by water bill layout, agencies will have greater ability to add graphical exhibits and supply information relevant specifically to landscape accounts. Such information could promote other landscape programs such as water surveys and financial incentives, and could provide advice such as reminding customers to decrease irrigation run times in the fall.

Water Budget Presentation

Water use budgets need to be presented to customers in a format that is readily understood. Budgets can be shown in both tables and graphs. They can cover the current billing period as well as historical observations. Water use budgets are to be presented in volumetric units of water (e.g., thousands of gallons), but can also be shown in lost dollars. Figure 2-4 shows an example water budget over a 12 month period.

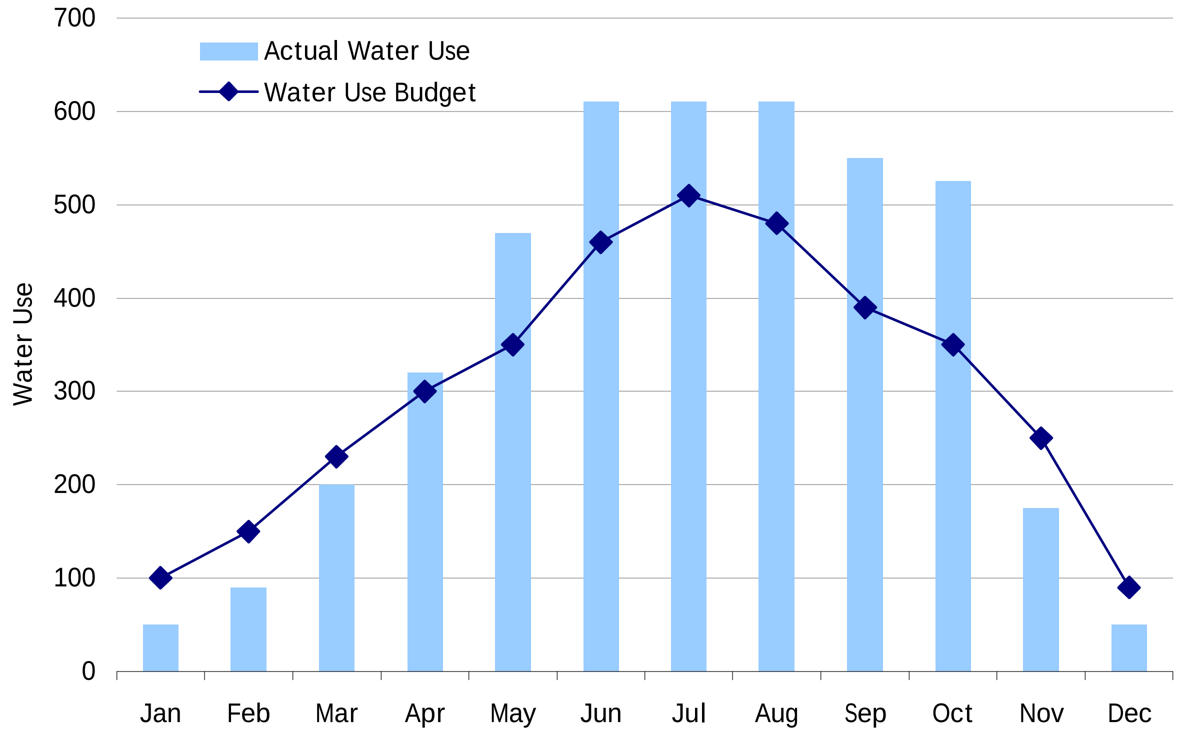

Figure 2-4. Example Water Use Budget

Targeting Decision Makers

It may prove useful for agencies to contact customers to identify the name and contact information of the key decision maker regarding landscape management at a site. Although it is an additional data burden, it means that the landscape conservation information and messages are getting to the right person. This could greatly increase the efficacy of the water budget program, especially when water bills are sent to accounting departments far removed from the actual site.

Integrating Water Budgets with Water Pricing

Water budgets can be tied to water pricing strategies. The basic concept is to have a higher water price for water consumption over a water budget allocation. This creates an additional financial incentive for over-budget customers to improve irrigation efficiency. Several California water agencies have implemented such pricing approaches, including the Capistrano Valley Water District, Irvine Ranch Water District, and Otay Water District. Analysis of the Capistrano Valley Water District case showed water budgets tied with pricing lead to a 22% drop in landscape water use after controlling for customer growth and weather (A&N, 1997b).[8]

Agencies planning to tie water budgets to water pricing should carefully account for the fact that some sites may have multiple irrigation meters. Some agencies may be restricted by billing system constraints to conduct pricing at the individual meter level. In this case, efforts should be made to measure landscape areas associated with each meter. This can be problematic (see Section 2.2). In particular, delineating individual meter landscape areas at multiple meter sites is not possible using tax assessor, aerial photography, or multispectral images. Use of these techniques needs to be supplemented with site inspections to make area associations with individual meters.

Integrating pricing into the process also complicates obtaining self-reported assessments of landscape area. Careful policy considerations are required to maximize consistency and fairness if this route is taken. Self-reporting is less of a concern if water budgets are being developed solely as information sources to help sites better understand their water use.

Finally, the conservation coordinator should fully recognize that pricing policies tend to be political and will affect multiple stakeholders.

2.5 Monitoring and Tracking Data

BMP 5 requires submission of basic summary data regarding the water budget program each reporting period as summarized in Table 1-2. The summary data include number of ***dedicated irrigation meters***, number of dedicated irrigation meters with water budgets, aggregate water use over all dedicated irrigation meters, and aggregate budgeted water use over all dedicated irrigation meters.

In addition, agencies may find it prudent to conduct other evaluation and tracking tasks to fine-tune the water budget program over time:

- Denoting sites by CII and/or SIC code classifications (e.g., commercial building, park, street meridian, homeowners' association).
- Denoting sites by landscape measurement technique if multiple methods are employed.

---

8. A&N Technical Services reported the simple pre- and post-program water use drop for Capistrano, IRWD, Otay, and to be 35%, 37%, and 20% respectively. However, these savings can be misleading when customer growth and weather are not considered. When growth and weather were controlled for in Capistrano (only case), the water savings were reduced to 22%.

- Validating accuracy of landscape measurements at a random sample of sites using field measurement techniques.
- Conducting market research on a sample of sites (e.g., focus groups, mail surveys, telephone interviews) to find ways to improve the water budget program and its complementary programs.

2.6 Project Costs

The costs of developing water budgets can vary greatly, depending on the specifics of the water budget program and existing circumstances. In this section we present information to assist conservation coordinators in constructing financial budgets for the water budget program.

We estimate the approximate cost of a typical water budget program is about $150 per site when all direct and indirect factors are considered. Table 2-3 shows an example budget by task. The labor rates include all overhead and indirect costs (e.g., equipment and transportation). In this example, the cost of running a water budget program includes a fixed cost of $3,000 plus $142 per site.

Table 2-3. Example Water Budget Program

Task	Fixed Costs	Cost per Site	Notes
Inventory of dedicated irrigation meters	$1,800		30 hours x $60/hour = $1,800
Landscape measurement		$100	Assumes field measurement method used
Budget calculation	$1,200		20 hours x $60/hour
Budget distribution		$12	$1 per site per monthly billing period
Monitoring and tracking		$30	0.5 hours x $60/hour
Total	$3,000	$142	

This estimate, however, could easily vary between $50 and $300 per site. The largest and most variable cost factor concerns landscape measurement.

For small agencies or for agencies with few dedicated irrigation meter accounts (e.g., less than 100 to 200), field measurement, landscape plans, customer reported, or some combination of these measurement methods will most likely be the most prudent course. However, if adequate aerial photos with associated parcel databases exist and can be accessed for minimal cost, this method may prove attractive.

For larger agencies, the possibility of using multispectral images becomes more promising as the fixed cost associated with obtaining an image can be spread over more accounts. Multispectral images can also be valuable to agencies for other purposes. This can include creating water budgets for mixed-use metered accounts and/or residential accounts. Multispectral images can also be valuable in other utility functions such as serving stormwater programs. Identifying other potential benefits and beneficiaries of multispectral images may lead to cost share arrangements.

Because of their significance, the conservation coordinator should investigate the landscape measurement options carefully, noting the tradeoffs between costs and other objectives such as accuracy, consistency, and timeliness. Table 2-4 shows an estimated range of costs associated with each method.

Table 2-4. Estimated Costs of Alternative Landscape Measurement Methods

Method	Cost	Notes
Field measurement	$75 to $150 per site	Assumes average time varies between 3 and 6 hours @ $25/hour. Time includes travel and administration tasks.
Landscape plans	$75	Walker (1998) and AquaMetrics LLC (in press).
Customer reported	$5 per site	Estimate considering cost of mailing plus database management.
Tax assessor	$2 per site	Assumes tax assessor information needs to be purchased for $1 per site. Assumes cost of data analysis and administration equals $1 per site.
Aerial photography	$40 to $80 per site	Assumes that aerial photos and parcel database do not need to be purchased (IRTC, 1998; Psomas, 1998).
Multispectral images	$30 to $60 per site	Assumes a fixed cost between $20,000 and $30,000 to obtain multispectral image and orthophoto/base map (Kah, 1999). Assumes parcel database does not need to be purchased, and assumes 500 dedicated irrigation meters. If agency needs measurements for all dedicated irrigation meters plus CII mixed-use meters, the per site cost will drop to approximately $10.

Case Study: Irvine Ranch Water District

This case study illustrates integrating water budgets with water prices.

The Irvine Ranch Water District (IRWD) Board of Directors adopted an ascending block rate structure in June 1991 in an effort to ensure customer equity during the drought and to provide revenue stability for the district. The IRWD also wanted to help build a conservation ethic for all of its customers (residential, landscape, agricultural, commercial, industrial, and institutional) by adopting a credible and flexible program.

For dedicated landscape accounts, IRWD developed both water budgets based on landscape areas and ETo and an ascending block rate structure, shown below, based on each customers'water budget.

IRWD Ascending Block Rate Structure

Tier	Usage as % of Water Budget	Cost of Irrigation Water
Low Volume	0-40%	3/4 of Base Rate
Conservation	41-100%	Base Rate
Penalty	101-110%	2 x Base Rate
Excessive	111-120%	4 x Base Rate
Abusive	> 120%	8 x Base Rate

IRWD's water budget is based on 100% of ETo and includes all non-hardscape area at a site (not irrigated landscape area). The landscape areas were estimated for approximately 3,000 dedicated irrigation meters in three ways:

- Customers reporting via mail questionnaire.
- For customers failing to respond to questionnaire, IRWD requested landscape plans, which were planimetered for landscape area.
- For customers not responding to questionnaire or providing plans, IRWD sent temporary staff (college students) to the site to measure the area with a measuring wheel.

For some sites, IRWD has found that working with commercial landscapers to obtain landscape area estimates can be productive.

Case Study: Otay Water District

This case study illustrates the use of water budgets developed in response to a water-efficient landscape irrigation ordinance.

In the fifth year of a five-year drought (1991), Otay Water District developed a water budget-based ordinance to assist commercial irrigation customers with dedicated irrigation meters to reduce consumption. Dedicated landscape accounts represented 3% of Otay's customers, but 17% of its water use, and these customers were faced with elimination of all landscape water use.

The ordinance was adopted in part to provide for the economic survival of commercial landscape firms and to avoid regulations that might restrict the type and amounts of specific landscape plant materials such as turfgrass. The industry said: "Tell us how much water we can have and let us make the decisions." The ordinance was enacted after a one-year study by a 24-member task force drawn from the landscape industry, the Otay Water District, and local government.

The ordinance that resulted from this process states that commercial irrigation accounts (dedicated meters) have water use allocations determined by their reported landscape square footage. The annual allocation is spread out over the year, and unused water is banked to avoid incurring overuse penalties during brief hot spells, establishment of new plantings, or irrigation system failures resulting in unanticipated usage. Specifically:

- Customer measures and reports square footage of irrigated **or** landscape (usually equal to all nonhardscape area).
- When a meter is activated, the billing computer automatically checks for the square footage data. Failure to report square footage causes a flat seven units to be allocated to the account until correct amount is reported.
- An annual irrigation allocation is assigned to accounts based on reported square footage and the applied water requirement for landscape as if planted completely with tall fescue. This requirement was estimated to be equal to 100% of local ETo.
- Customer is allowed to bank up to 12" to avoid incurring overuse penalties during scheduled or emergency pipeline shutdowns, plant establishment or rehabilitation, fertilization procedures or in exceptionally hot weather.
- Actual monthly irrigation water use is monitored by computer, which tracks water consumption over the last three years. Over-use penalties are automatically calculated and compliance is enforced through the billing system.

Using this approach, Otay's dedicated irrigation meter water demand was reduced by 23% in the first year. The ordinance has been in effect since June 1992 and has met with overwhelming support from the landscape industry, which now endorses the fairness and workability of the program. Otay Water District received the Theodore Roosevelt Environmental Award for excellence in natural resource management from the Association of California Water Agencies (ACWA). The next box compares some of the characteristics of this program to those of the program conducted by the IRWD.

Comparison of IRWD and Otay Landscape Budget Programs

Description	IRWD	Otay
Number of dedicated meters	1,095 potable 2,059 reclaimed	945 potable 53 reclaimed
Number of sites served by these meters	Not known	Not known
Irrigable area	1,547 acres potable 6,147 acres reclaimed	1,996 acres total
Method of area measurement (percent of sites by method)	50% customer/contractor 35% IRWD staff or consultants 15% planimetered	95% customer/contractor 5% Otay staff or consultants
Accuracy of area measurement	Not known but considered acceptable	Not known but considered acceptable
Cost of area measurement	Not known	Not known
Areas split by plant material type (e.g., turf vs. shrubs)	No	No
Budget intensity level	100% of ETo	100% of ETo
Percent of meters out of compliance	Normally <10% except in fall when rises to 30%	Normally <1% except in fall when rises to 2.5%
Applied water amount (most recent data)	3,094 AF potable 11,207 AF reclaimed (July 97 –June 98)	3,644 AF total
Applied water depth[a]	2.0 AF/A potable 1.8 AF/A reclaimed	1.9 AF/A average

a. Because the areas used in this calculation are total irrigable area, and thus include areas not irrigated (bare ground and natural landscapes), these rates of water application will appear low for climates that have between 44 and 55 inches of ETo.

3 Water Use Surveys

A landscape ***water use survey*** consists of sending trained staff to landscape sites to measure and recommend ways to improve both the technical performance and the management of irrigation systems. Water surveys are sometimes referred to as water audits, irrigation performance tests, and landscape water use analyses, among other terms.

According to BMP 5, a water survey includes the following five basic elements:

1. Landscape area measurements
2. Irrigation system check of technical performance
3. Distribution uniformity analysis of sprinkler system
4. Irrigation schedules
5. Survey report and information packet to customers

Each element is a part of the curriculum of basic landscape water auditor training administered by the Irrigation Training and Research Center, Cal Poly San Luis Obispo, and the Irrigation Association. Readers interested in the details of these survey tasks can consult the *Landscape Water Management Handbook* (Walker and Kah, 1993).

This chapter addresses seven steps that water conservation coordinators need to undertake in developing and administering a landscape water survey program as shown in Figure 3-1.

Each topic is discussed separately below. We also present two case

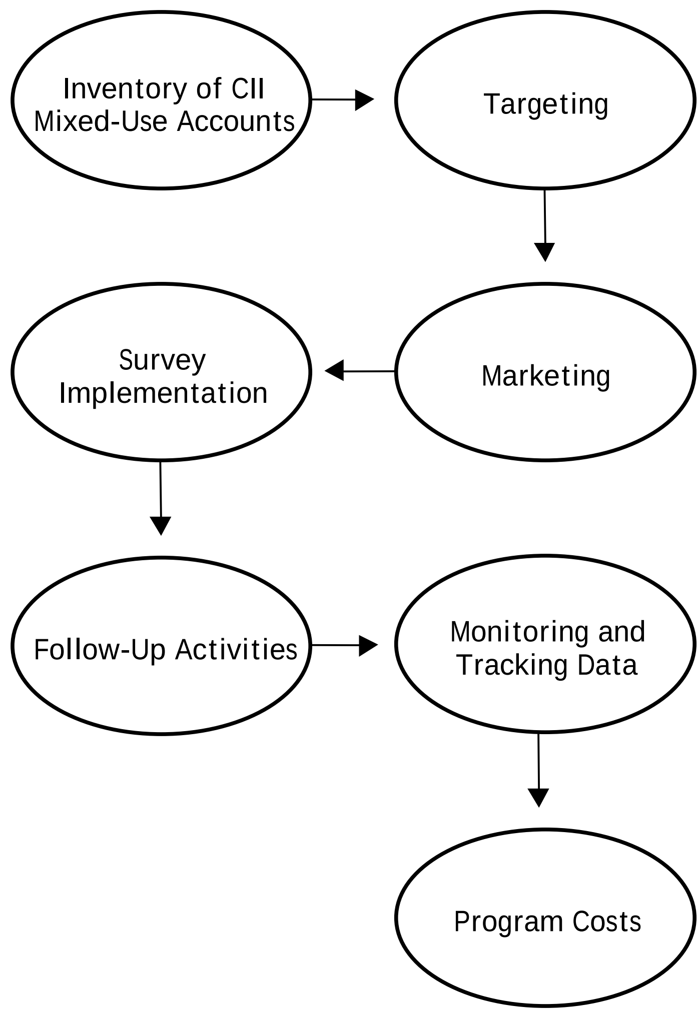

Figure 3-1. Steps in Developing a Water Use Survey Program

studies of California agencies currently running water survey programs. In Chapter 4, we discuss how water surveys can be integrated with other landscaping programs to offer a comprehensive set of services to landscape customers.

3.1 Inventory of CII Mixed-Use Accounts

The first step is to identify the number of ***CII mixed-use meters*** served by the agency. This is one of the data elements included in the BMP 5 reporting requirements shown in Table 1-2.

To start, first identify the total number of CII accounts. Most water agencies have billing systems that contain a customer code field from which CII accounts can be flagged. Next, subtract out CII accounts with ***dedicated irrigation meters***. Code fields related to wastewater charges can be a useful source of information for identifying customers with dedicated irrigation meters. Remember that neither single family nor multifamily residential accounts are to be included.[9]

After identifying these CII accounts, the next task is to identify which of them are associated with some level of outdoor landscape irrigation. In most cases, there will be no direct way of identifying mixed-use meters, and water agencies will have to use one or more of the following approaches:

1. Assume all CII accounts without dedicated irrigation meters may have some irrigation component.
2. Identify likely irrigation customers by examining historical water use billing records.
3. Conduct a census asking customers to specify their end water uses (e.g., mail survey).
4. Conduct a comprehensive landscape measurement program linking all water use accounts to estimates of landscape area (see Section 2.2).

The first approach works as a default for agencies with little or no information from which to identify landscape sites. The second approach, examining water use records, may prove to be the best course for many agencies. Evaluating the magnitude and seasonal pattern of water consumption provides not only evidence of irrigation end uses, but also information that may be useful in targeting and marketing surveys to customers. Customers with high summer water use relative to winter water use are likely to have irrigation end uses, as illustrated in Figure 3-2. The third

9. Strictly speaking, a multifamily residential site is not in the CII sector and hence is not subject to the BMP 5 water surveys—multifamily sites are covered under water surveys in BMP 1. However, there are likely to be multifamily sites with mixed-use meters with large landscapes (e.g., homeowners' associations) that are best served by a BMP 5 type of landscape survey.

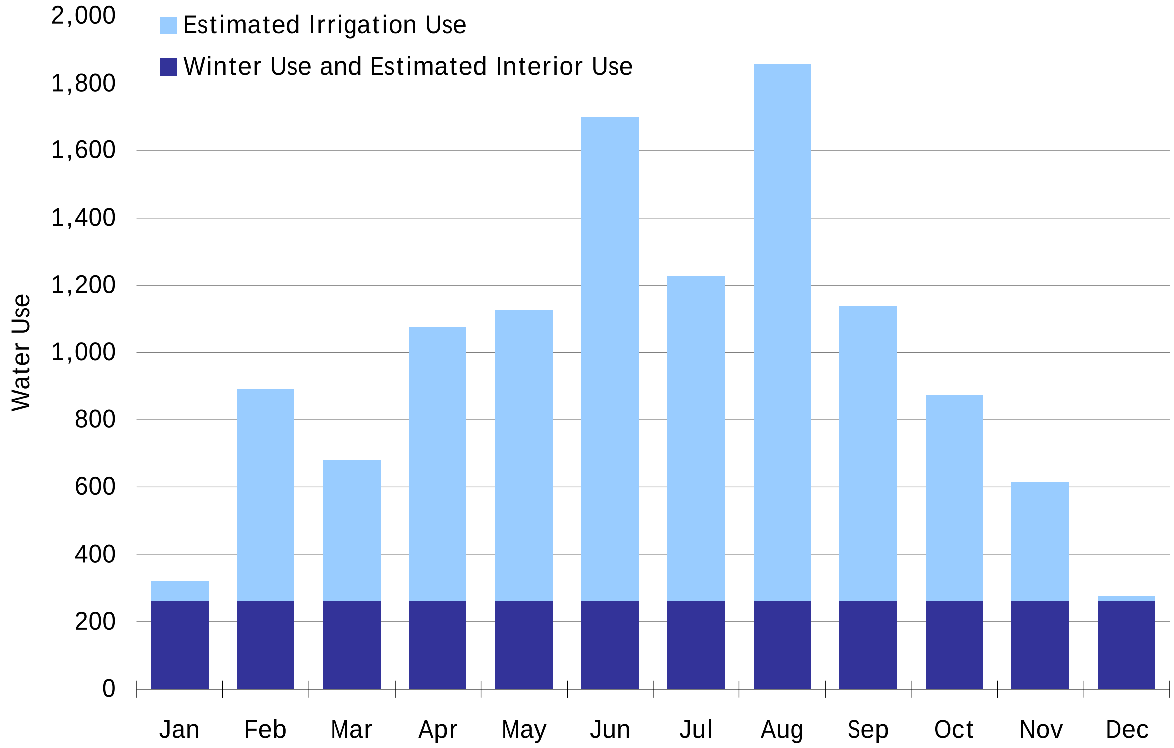

Figure 3-2. Mixed-Use Water Meter Illustration

approach, conducting a census, will probably lead to an incomplete assessment. The fourth approach is the preferred approach if the background databases exist.

3.2 Targeting

BMP 5 stipulates that agencies offer water surveys to at least 20% of CII mixed-use accounts each reporting period (two years). To maximize the cost-effectiveness of the water survey program, agencies should target sites likely to provide the greatest water use savings. This section considers four factors that agencies can use to target prospective sites: water use analysis, site size, site management, and preliminary surveys.

Water Use Analysis

Although estimates of the amount of water used for irrigation at mixed-use sites are often inexact, having an approximate assessment of the magnitude of irrigation can be useful in targeting. In general, it is more cost-effective to conduct surveys at larger landscape sites because survey costs do not increase significantly with site size (i.e., surveys have many fixed costs) and the amount of water to be potentially saved tends to be greater at larger sites. Hence, water agencies can develop targeting strategies that rank water customers by estimated irrigation use, giving higher priority to higher water using sites.

However, cost-effectiveness does not always improve with site size. In fact, it may be that water surveys of midsized landscape sites (0.5 to 3 acres) offer the best returns. Because the largest sites (over 3 acres) are more likely to be run by concerned and motivated site managers, irrigation performance tends to be good.[10] It is in the midrange where irrigation use is still significant and site managers tend to be less attentive to irrigation performance that water surveys may provide the most "bang for the buck." Figure 3-3 shows applied water use for different sized sites served by the Contra Costa Water District, illustrating and supporting this hypothesis.

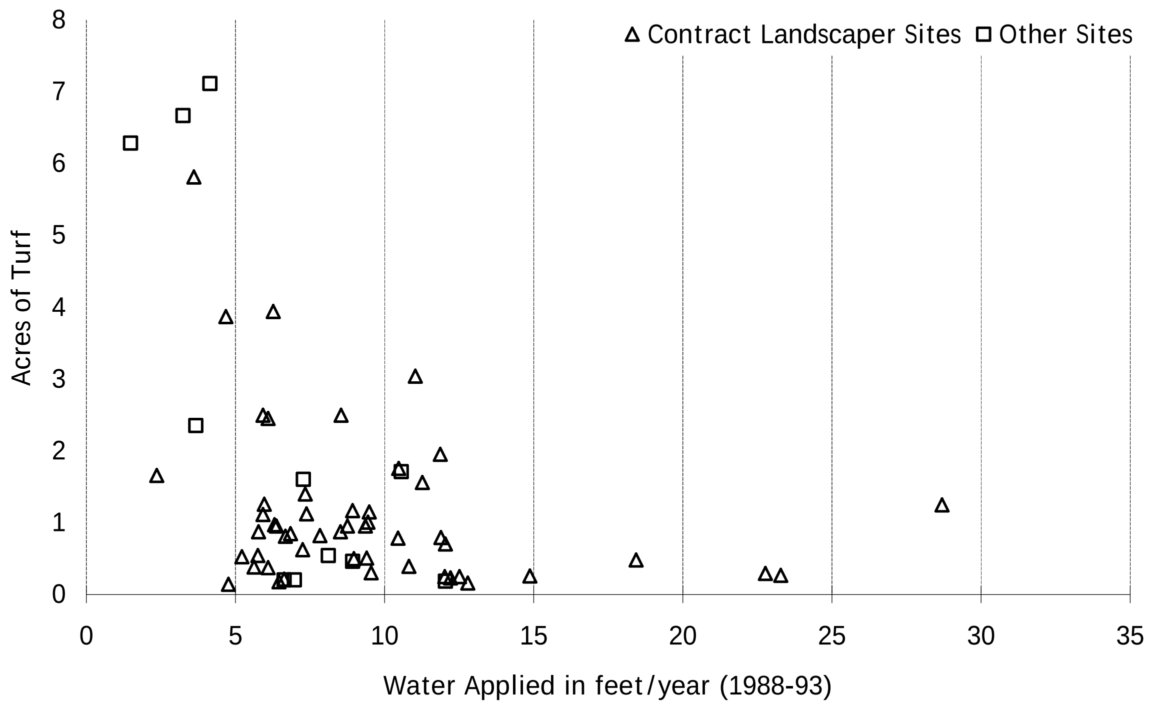

Figure 3-3. Irrigation Applied as Function of Site Size

10. In addition, large sites tend to have on-site personnel and larger landscape subareas, employ rotor sprinklers of higher sprinkler uniformity, and lose less water through spray drift and runoff. Park and school sites are excellent examples of large sites with generally little savings potential.

Given that most large landscape areas have dedicated irrigation meters,[11] most mixed-use metered sites will generally have 3 acres of landscaping or less. Hence ranking sites in descending order of estimated landscape water use would be prudent. In addition, many water agencies have numerous CII mixed-use metered sites with little or no irrigated landscaping, and ranking will minimize the chance of conducting landscape surveys at these sites.

Site Size

If a water agency has universally measured landscape areas (see Section 2.2) and linked these measurements with water accounts, this information can be used to rank potential mixed-use sites based on the rationale of the previous section.

Site Management

Type of landscape management can be an indicator of irrigation performance. At some sites, landscape managers pay prompt attention to irrigation system performance, leaks, and irrigation scheduling. At other sites, decision makers are far removed from field operations and irrigation performance lags. It is at these neglected sites that water surveys might be most beneficial. Hence, surveys should be targeted toward those types of sites when possible.

Sites that may be particularly worthy of water surveys are ones where ***irrigation scheduling*** is conducted by landscape contractors. Typical contract arrangements do not provide direct incentives to landscape maintenance firms to use water efficiently. In fact, the additional time and education required to reset irrigation controllers to reflect changes in weather is a disincentive. Irrigation schedules often are “padded” to reduce the necessity of coming back to increase runtimes should the weather turn hot and water demands increase.

In addition, landscape contractors are often solely judged on the appearance of green, lush turfgrass, and are not responsible for paying the water bill. Given that most CII water bill payers have limited knowledge of landscape irrigation, it is difficult for them to make informed judgments regarding their maintenance firm’s irrigation efficiency performance. Hence, a water survey can be a valuable tool in bridging this gap and encouraging that contractors’ performance measures include irrigation efficiency and lower water bills.

Networking and performing water surveys for landscape contractors can also be a positive win-win experience (Ash, 1999). Contractors often manage many sites within an agency’s service area. Hence, working with a firm’s staff at one site on water efficiency might ripple into positive impacts at other

---

11. Large landscapes often are on dedicated irrigation meters to avoid wastewater charges.

sites (i.e., multiplier effect). Landscape contractors can also be a powerful marketing entity if they recommend water surveys to clients. Such an arrangement may improve a contractor's relationship with their client.

Preliminary Surveys

For some well-maintained or small sites, it is not worth conducting a full water use survey. One option is to allow surveyors to conduct preliminary surveys (or pre-surveys) to quickly gauge the need for a full survey. A preliminary survey consists of obtaining a reasonable estimate of irrigated area and combining this with local weather data to generate an expected water budget. This budget is then compared to historical water consumption to gauge the potential water savings rewards from conducting the full survey. If a site shows little reward, then the survey is not conducted. The benefit of this screening technique is that a preliminary survey typically costs about 25% of full survey cost.

3.3 Marketing

Marketing to customers most likely to benefit from an irrigation system survey maximizes the efficiency and return of a water survey program. Targeting the appropriate customer:

- reduces marketing costs because the program contacts customers with high potential savings
- decreases the chances for wasted water survey effort due to low customer enthusiasm and lack of savings potential
- limits the number of customers who become frustrated by program participation when they discover limited or no savings potential.

All of the following marketing mechanisms have been used over the last decade:

- targeted direct mail
- coordinating with landscape contractors
- education programs
- CIMIS based scheduling information
- water budgets
- bill stuffers
- broadcast media.

Direct mail, landscape contractors synergies, education programs, and CIMIS based scheduling information tend to be the most effective mechanisms because they direct their efforts to customers who are likely to have an interest in irrigation water conservation. Water budgets can generate interest in surveys by allowing the customer to compare their nominal consumption with a calculated budget. Bill stuffers and broadcast media cast their nets wide and are less likely to attract the customer who would benefit from an irrigation system survey.

Mailing Approaches

Mailings with a purpose-designed brochure have been successful in garnering a response from customers who need help. Most programs have a limited capacity to survey sites. Since customers expect a survey within a reasonable time period, phasing into several distinct mailings is suggested. The more accurate the targeting, the higher the percentage of positive returns.

Landscape Contractor Synergies

Several agencies have made landscape contractors a cornerstone of their marketing campaign. They're important for two reasons. First, they may serve many sites within a service area. Second, they may transfer new water efficiency practices to hitherto unconsidered sites. Connecting with landscapers can reduce the costs of marketing because they will bring more sites to the agency's attention. Contractor personnel increase their landscape water management knowledge with each succeeding site survey. Ultimately, the landscape industry must solve its water management problems, and encouraging their participation hastens that day (Council for a Green Environment, 1997).

Overcoming some contractors' apprehension regarding an irrigation survey is a challenge. Some interpret the water survey as a "fishing operation" looking for defects in their maintenance and operations. Portraying the survey as an opportunity to correct longstanding defects in the irrigation system is a good way of overcoming this problem. Often, a contractor has brought problems to the customer's attention to no avail for years. A survey serves to confirm that previously identified defects do indeed require attention.

Conservation coordinators can obtain information on local contractors from the California Landscape Contractors Association internet site at www.clca.org.

Other Approaches

Irrigation repair, retrofit, and irrigation scheduling workshops are excellent venues for marketing a survey program. A number of agencies offer training that complements the extensive classes offered by California Polytechnic University at San Luis Obsipo's ITRC. ITRC has been responsible for advancing state-wide knowledge of irrigation problems and scheduling. As a result, an increasing number of personnel in the landscape maintenance industry understand the basics behind improving irrigation efficiency.

Examples of ongoing agency education programs include the Metropolitan Water District of Southern California's "Protector del Aqua" and Marin Municipal Water District's education program. ITRC training and certification is also available at a number of venues (www.itrc.org). The California Landscape Contractors Association offers classes and certification regarding irrigation equipment installation (www.clca.org). The U.C. Cooperative Extension and many junior colleges also offer horticultural/irrigation classes and events.

3.4 Survey Implementation

The biggest cost component of a survey program is the labor involved in its day-to-day administration (e.g., scheduling surveys with customers) and actual field work. Hence, staffing strategy is a key decision in survey implementation.

Water survey programs can be staffed with agency employees, outside contractors, or both. Staffing can also vary with function. For example, agency staff can run program administration and outside contractors can be used as the in-field surveyors.

The approach that will work best for each agency will depend on many factors. Major factors to consider include cost, quality of service, reliability, flexibility, and the ability to synchronize and use in-house staff on other projects. Conservation coordinators should recognize that there could be significant seasonal fluctuations in customer interest in surveys (high in the summer). Scheduling surveys so in-field surveyors have a constant work load can also be challenging, especially because each landscape site has unique characteristics requiring different time commitments from the surveyor. In general, conservation coordinators may find using contractors offers more flexibility in matching labor supply with survey demand. Conservation coordinators may also find, however, that using in-house staff may be more cost-effective under certain conditions, such as when a consistent survey workload can be established or in-house staff can be used effectively on other projects. Contractors may also have more appeal to smaller water agencies where the small number of surveys expected does not warrant an in-house survey specialist.

Table 3-1 lists the current water survey staffing arrangements of some large California water agencies.

Table 3-1. Examples of Water Survey Staffing

Agency	Staffing Strategy
East Bay Municipal Utility District	In-house
Costra Costa Water District	In-house
Santa Clara Valley Water District	Contractor
San Diego County Water Authority	Contractor
Las Virgenes Municipal Water District	Contractor and in-house
Marin Municipal Water District	In-house
City of Palo Alto	Contractor
City of San Jose	Contractor

Case Study: San Diego County Water Authority

San Diego County Water Authority is a wholesale water agency that has used outside consultants to run its water survey program on behalf of its member agencies.

Its Large Turf Audit Program began in 1990 with the Mission Conservation District providing survey services in the northern part of the county. In 1992 the South County program was added with a private consultant, Schmidt Design. Selection was by RFP process. In 1998 the North and South County programs were merged under AquaMetrics LLC, a private consultant again chosen through a RFP process. Renamed Professional Assistance for Landscape Management (PALM), the program is administrated by the Authority for its member agencies.

In the eight years since its inception, over 400 sites have been surveyed in both programs. Initially, a screening process was not used to qualify sites based on expected cost-effectiveness. Later, a pre-survey stage was added to eliminate sites with little or no apparent savings. As a result, the focus has shifted from parks and schools to homeowner associations and business park sites. Potential savings have increased for the program because of this and other refinements.

Other activities include site reviews for customers at mixed-use metered locations and follow-up surveys for customers who require continuing assistance. Phone contacts follow the initial audit or survey at 3 to 6 month intervals. More information can be obtained about this program at (619) 682-4152.

3.5 Follow-Up Activities

Good landscape water management requires a continuing commitment year after year. This contrasts with “hardware” based water conservation programs that focus on replacing water fixtures and equipment (e.g., ultra-low flush toilets). After a customer has entered a survey program, maintaining their interest in the long haul is a challenge. Providing financial incentives, additional training opportunities, follow-up help, and feedback can help.

Follow-Up Surveys

Follow-up surveys are intended to help customers implement and reinforce efficient irrigation practices. They tend to be much shorter than full water surveys. Follow-up surveys are most appropriate when technical repairs and retrofits have been carried out, but irrigation scheduling usually remains a longstanding problem. Since the initial survey often includes schedules for only a representative sample of stations, extending schedules to more stations and controllers is likely to help the customer. Additional testing can document improvements from retrofits and repairs. The key is to flexibly address site problems with the customer's irrigation needs in mind.

At sites with equipment upgrades tied to agency financial incentives, the follow-up survey provides a forum for protecting the agency's investment. Equipment upgrades often include more sophisticated controllers, placing increased strains on a customer's scheduling skills. This suggests that testing and scheduling are essential to effective follow-up surveys.

Follow-up surveys can also be useful when there is a changeover in property or landscape manager at a site. This may include having to provide a new copy of the information provided from the original survey.

Seasonal Notices

Another way to help irrigation customers is to provide seasonal notices to adjust irrigation runtimes or frequency. If budgets have been generated, combining the two is even more helpful. Irrigation schedules require approximately 10% reductions per week to keep pace with ETo declines in late summer to early winter periods in most years. Inexpensive faxes can be timelier than standard mail options.

3.6 Monitoring and Tracking Data

Under BMP 5, survey summary data must be submitted each reporting period (Table 1-2). The summary data include number of CII mixed-use accounts, number of surveys offered, number of surveys accepted, and the estimated annual water savings resulting from surveys.

Agencies will find it prudent to record other data for evaluation and tracking. Periodic evaluation can help steer and fine-tune a program over time to improve its efficacy. This includes improving targeting/marketing activities and obtaining estimates of water savings and cost-effectiveness.

Data collection needs and associated protocols are best identified at the beginning of a program. After the fact, data collection is often more expensive, less reliable, and often not possible.

Critical additional data elements to collect include:

- date of survey
- type of site (e.g., commercial building, park, street meridian, homeowners' association)
- landscape area (turf and groundcover)
- type of site management (e.g., maintenance contractor)
- measures of technical irrigation performance (e.g., distribution uniformity)

- dates and descriptions of follow-up activities, including financial incentives
- how and why customer participated in water survey program.

3.7 Program Costs

Program costs can vary greatly, depending on program circumstances. In this section we present information to assist conservation coordinators in constructing water survey program budgets.

The approximate cost of a typical water survey is about $1,000 per site when all direct and indirect factors are considered. This estimate could easily vary between $500 and $1,500 depending on circumstances. Because water surveys are labor intensive, by far the greatest cost component is the labor cost for the surveyors. So, the primary cost drivers are the surveyor’s labor rate and the average hours spent per site.

Table 3-2 illustrates an example budget broken out by water survey task. The labor rates include all overhead and indirect costs (e.g., equipment and transportation). In this example, the water survey program costs are $13,200 plus $755 per survey. If 100 surveys are completed, the unit survey cost is $887 per survey.

Table 3-2. Water Survey Program Budget Example

Task	Fixed Cost	Cost per Site	Notes
Inventory of CII Mixed Use Accounts	$2,400		40 hours x $60/hour
Targeting	$2,400		40 hours x $60/hour
Marketing	$2,400	$25	40 hours x $60/hour plus direct costs
Survey Implementation		$720	12 hours x $60/hour
Follow-Up Activities			Not Included
Monitoring and Tracking	$6,000	$10	100 hours x $60 which includes 1 basic analysis
Total	$13,200	$755	

Conservation coordinators should factor into their budgets that it is difficult to schedule surveys so that their surveyors are constantly working on surveys. Work loads can fluctuate because of the random nature of customers requesting surveys. In addition, during the winter months there is generally less interest in water surveys, causing seasonal work differences.[12] Agencies that can use surveyors productively on other work or contract with outside consultants on an as-needed basis can minimize this exposure.

Another factor to consider is the size and complexity of CII mixed-use landscape sites in the local service area. This example budget is for conducting a survey at a typical one acre site. If the

sites surveyed tend to be smaller, the surveyor will need less time for landscape measurement and station inspections. In addition, if a database exists with comprehensive landscape measurements (see Section 2.2), the surveyor will need significantly less time for landscape measurements (just time spent in validation).

12. Seasonal differences are probably more pertinent in northern California, where greater rainfall and lower ETo general occur in winter.

Case Study: Marin Municipal Water District

Marin Municipal Water District (MMWD) uses in-house staff to run its water survey program. An early innovator with landscape “audits,” as they were then called, MMWD has offered surveys since the late 1980s. Initially, surveys concentrated on changes in management and irrigation scheduling. Now a more broad-based Conservation Assistance Program (CAP) is offered which includes field testing, water budgets, financial incentives, and education. In addition, the water budgets are linked with water rates so that a customer pays significantly more for water over the budgeted amount. Specifically, CAP activities include the following:

- **Water budgets**. Budgets are assigned to all irrigation account customers. They are based on either historical use for older accounts or a calculated function based on climate zone and landscaped area.

- **Financial incentives**. To encourage the customer to actively address problems in the systems, the district offers up to $5,000 per project toward hardware improvements. Justification for offering incentives to a customer is based on projected water savings.

- **Surveys**. When the customer receives financial incentives, MMWD assists the customer in setting up their new equipment with a system survey. This provides added insurance that installed hardware is properly calibrated and used. Surveys might include “catch cup” tests or other field related work.

- **Education**. Classes in irrigation maintenance and management are periodically offered to customers. The objective is to develop customer understanding of the requirements for operating irrigation systems efficiently. Current classwork includes system evaluation, testing, and schedule development on personal computers.

More information about this program can be obtained from (415) 924-4600.

4 Additional Landscape Programs

4.1 Integrating Multiple Landscape Programs

Fostering efficient landscape irrigation requires multiple approaches. BMP 5 identifies several approaches, including ***water use budgets*** (Chapter 2), ***water surveys*** (Chapter 3), financial incentives, training, and ***dedicated irrigation meter*** conversion. The last three programs are covered in this chapter.

It is important to integrate these approaches to tap into marketing and functional synergies. For example, the objective of water budgets is to make customers aware of irrigation efficiency performance. Most managers of inefficiently run landscape sites are likely to be unaware of the magnitude of water and dollar losses associated with irrigation inefficiency. Once water managers are aware of the problem, the next logical question is, "What can we do to improve irrigation performance?" This is when water agencies can assist by offering water surveys to conduct site-specific diagnostics and generate recommendations to improve performance. Surveys can be very useful in improving ***irrigation scheduling***. They can also identify problems with irrigation system hardware. Once site managers are cognizant of hardware problems, they sometimes encounter financial barriers in making needed changes. Where it is in the agency's self-interest, financial incentives can be used to motivate and expedite site managers to make needed improvements. Hence, water agencies can benefit from linking and marketing a holistic set of landscape programs, as illustrated in Figure 4-1.

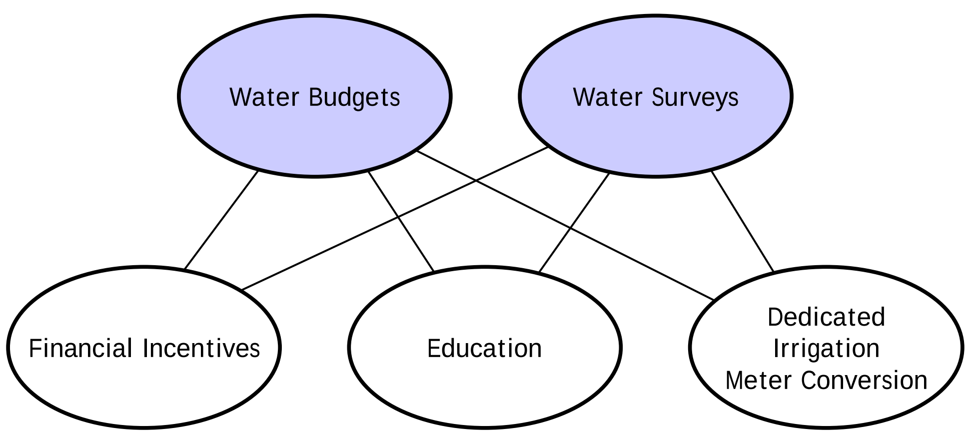

Figure 4-1. Integrated Landscape Programs

4.2 Financial Incentives

A variety of barriers exist in getting landscape customers to adopt and use water efficient technologies and behaviors. Financial impediments, insufficient knowledge or skills, interference with established patterns and lifestyles, mistrust of conservation technologies, and separation between the water bill payer and the field irrigator are some of the more common barriers. Financial incentives can be used by water agencies to address the first barrier.

Financial incentives can reduce the payback period related to customer investments in water conserving technologies. We define a financial incentive as a transfer of something of value from a water agency to a customer for the express purpose of encouraging participation or installation of a conservation measure. The three primary incentive mechanisms are rebates, direct installation programs, and low-interest loans. A general discussion of financial incentives can be found in *A Guide To Customer Incentives For Water Conservation*, published jointly by the CUWCC, California Urban Water Agencies, and the U.S. EPA in 1994.

With respect to BMP 5, once water inefficient sites are identified via water budgets, water surveys, or other means, offering financial incentives is a logical way to induce more customers to take actions to improve the mechanical performance of their irrigation systems. It should be noted that financial incentives, as defined here, target actions related to improving and upgrading irrigation equipment and capabilities (i.e., hardware), not behavioral operation of the system (e.g., irrigation scheduling). Hence financial incentives target only part of the problem.[13]

Historically, most water agencies that developed financial incentive programs for landscape customers chose some type of rebate program. The relative disadvantage of direct installation is that it entails the complexity and liability of working with heterogeneous site circumstances. The relative disadvantage with loans is that they require more administration and loan amounts may not be necessarily large.

4.3 Training

Training and education in landscape water efficiency can be one of the most effective long-run elements of a water agency’s conservation efforts. Many opportunities exist for water agencies to encourage and foster training of landscape staff within their service areas.

---

13. Water rates are not included in our definition of a “financial incentive,” although they do provide a financial incentive to minimize both mechanical and behavioral inefficiencies.

Case Study: MWD Financial Incentives

The Metropolitan Water District of Southern California (MWD) offers a program of rebating up to one-half the cost of purchasing and installing irrigation retrofit equipment. The interesting twist of this program is that water savings need to be verified. Water savings are verified by comparing pre-installation and post-installation water use records.

Eligible equipment for funding includes new conservation irrigation controllers, central computer control systems, moisture sensors, and other items as long as they can be shown to increase irrigation water efficiency. MWD's financial assistance for verified water savings is $154 for each acre-foot saved, up to one-half of the total cost of the project, for up to five years. Landscape sites eligible for funding must either have separate landscape water meters or have a justifiable way of separating outdoor water use. Sites using reclaimed water can be submitted for funding, but are considered on a project-by-project basis. This financial assistance program is available to all MWD member agencies and subagencies. For more information contact MWD at (213) 217-6716.

A number of agencies offer training that complements the extensive classes offered by the ITRC, California State Polytechnic University at San Luis Obispo. ITRC has been responsible for advancing state-wide knowledge of irrigation problems and scheduling. As a result, an increasing number of personnel in the landscape maintenance industry understand the basics behind improving irrigation efficiency.

Examples of ongoing agency education programs include the Metropolitan Water District of Southern California's "Protector del Aqua" and Marin Municipal Water District's education program. ITRC training is also available at a number of venues (see its internet site at www.itrc.org).

4.4 Dedicated Irrigation Meter Conversion

Many CII mixed-use metered sites in California use significant amounts of water for irrigation. If landscape water were measured separately by using a dedicated meter at these sites, it could potentially provide the customer with a much better understanding and accounting of how water is used. In particular, it would allow for an assessment of irrigation performance via the water budgeting process. As a complementary benefit, subtracting irrigation water from the main meter can significantly reduce associated wastewater charges in most situations.

The historical reasons for employing mixed-use meters are varied. The obvious reason is that using a mixed-use meter can save on installation costs: installing two meters instead of one almost always costs more. In addition, the size of the main (indoor) meter is not often not reduced when an irrigation meter is added because of building code restrictions. Moreover, meter cost is only part of the total cost calculation. Installing an irrigation meter often includes additional connection fees

Case Study: East Bay Municipal Water District

Since 1991, the East Bay Municipal Water District (EBMUD) has offered a financial incentive rebate program to its landscape customers with sites larger than one acre. For fiscal year 1997/1998, the budget for this program was $100,000.

To participate in this program, EBMUD landscape customers must:

- conduct an EBMUD water survey (audit) at the site
- submit a form to EBMUD showing proposed equipment upgrades and cost
- complete equipment upgrades within 90 days of EBMUD approval of proposal
- allow EBMUD to inspect upgraded equipment upon request.

EBMUD offers to pay between 50 and 100 percent of the materials cost of installing water-efficient irrigation equipment (not labor) as shown below.

EBMUD Financial Incentive Rates

EBMUD % Contribution	Type of Equipment
50%	Irrigation controllers and sprinkler heads needed to standardize head precipitation rates
75%	Drip irrigation systems and pressure regulation devices
100%	Moisture sensors, rain shut-off devices, check values, and nozzles that improve coverage

Further information about this program can be obtained via the internet at www.ebmud.com or by phone at (510) 287-0590.

(also known as system development charges, among other terms) and ongoing fixed service charges assessed each billing period. Hence, water agencies often make it prohibitively expensive for dedicated irrigation meters to be installed, even after considering potential wastewater savings.

A potential tactic water agencies can use to stimulate existing customers with mixed-use meters to install separate irrigation meters is to eliminate or scale back any associated connection fee in the transaction. Given that landscape area at the site is not expanded because of the transaction, the water agency has little to lose. And because the change will allow for closer water use accounting and potentially the development of water use budgets, net water use at a site may decrease.

Another potential tactic is for mixed-use metered customers to install ***submeters***. A submeter is a customer-owned and installed meter that can be used to track the irrigation portion of mixed-use meter flows. This will allow site staff to create and monitor water use budgets. Water agencies can promote submeters by financially assisting with the submeter costs or perhaps assisting with its installation.

4.5 Information for New or Change in Service Accounts

Perhaps the most effective time to influence irrigation design and scheduling decisions is at the start. For new developments establishing new landscapes, water agencies can provide information related to plant selection (e.g., natives) and efficient landscape equipment and methods. Water agencies can distribute educational materials or offer other related services at the time a new customer applies for water service. These same educational materials and services can be offered to existing sites where there is a change in ownership. New occupants may be considering changes in landscaping to better reflect their tastes and preferences.

5 BMP 5 Exemptions

This chapter discusses exemption issues associated with BMP 5. In being elevated to BMP status, the programs contained within BMP 5 are presumed to be cost-effective for most water agencies. A signatory water supplier can be exempted from implementing BMPs, however, if it can substantiate each reporting period that its programs:

- are not cost-effective,
- cannot be reasonably funded, or
- cannot be implemented as agency does not have legal authority.

5.1 Cost-Effectiveness

Agencies do not have to implement BMP 5 programs if using a full cost-analysis it is determined that

- programs are not cost-effective when overall total program benefits and costs are considered, or
- programs are not cost-effective to the individual water supplier even after the water supplier has made good faith efforts to share costs with other program beneficiaries.

The first condition addresses the **total** cost-effectiveness of a conservation program by comparing the present value of total program benefits and costs as defined in Table 5-1. Programs are cost-effective if total benefits exceed total costs in present value terms.

The second condition considers costs and benefits from the perspective of an **individual water agency**. Programs are considered cost-effective if benefits exceed costs (as defined in Table 5-2) in present value terms.

The CUWCC has produced a document titled *Guidelines for Preparing Cost-Effectiveness Analyses of Urban Water Conservation Best Management Practices* (A&N, 1996). This document describes the steps of how to conduct a benefit-cost analysis. Agencies intending to conduct such evaluations for exemption purposes should consult this reference.

Table 5-1. Definition of Total Program Costs and Benefits

Total Program Costs	Total Program Benefits
Capital expenditures for equipment or conservation devices	Avoided capital costs of production, transport, storage, treatment, wastewater treatment, and distribution capacity
Operating expenses for staff or contractors to plan, design, or implement the program	Avoided operating costs, including but not limited to energy and labor
Costs of other water suppliers	Avoided costs to other water suppliers, including those associated with making surplus water available to other suppliers
Costs to the environment	Environmental benefits and avoided environmental costs
Costs to retail customers	Benefits to retail customers, including benefits to customers of other suppliers associated with making surplus water available to these suppliers

Table 5-2. Definition of Water Supplier Program Costs and Benefits

Water Supplier Costs	Water Supplier Benefits
Capital expenditures incurred by water supplier for equipment or conservation devices	Water supplier avoided capital costs of production, transport, storage, treatment, wastewater treatment, and distribution capacity
Operating expenses for staff or contractors to plan, design, or implement the program	Water supplier avoided operating costs, including but not limited to energy and labor associated with the water deliveries that no longer must be made
Financial incentives to other water suppliers or retail customers	Water supplier avoided costs of water purchases
Costs to the environment	Environmental benefits and avoided environmental costs
	Revenues from other entities, including but not limited to revenue from the sale of water made available by conservation program and financial incentives received from other entities

5.2 Program Funding

BMP 5 programs do not have to be implemented if adequate funds are not and cannot reasonably be made available from sources accessible to the water supplier including funds from other entities. However, this exemption cannot be used if new, less cost-effective water management options would be implemented instead of BMP 5.

5.3 Legal Authority

A BMP program does not have to be implemented if it is:

- not within the legal authority of the water supplier, and
- the water supplier has made a good faith effort to work with other entities that have the legal authority to carry out the BMP, and
- the water supplier has made a good faith effort to work with other relevant entities to encourage the removal of institutional barriers to the implementation of BMPs within its service area.

With respect to BMP 5 programs, we do not foresee situations where water suppliers do not have the legal authority to carry out its programs.

6 Bibliography

A&N, 1996, Guidelines for Preparing Cost-Effectiveness Analysis of Urban Water Conservation Best Management Practices, prepared by A&N Technical Services, Inc., for California Urban Water Conservation Council.

A&N, 1997a, Designing, Evaluating and Implementing Conservation Rates Phase II, prepared by A&N Technical Services, Inc., for California Urban Water Conservation Council.

A&N, 1997b, Landscape Water Conservation Programs: Evaluation of Water Budget Based Rate Structures, prepared by A&N Technical Services, Inc., for Metropolitan Water District of Southern California.

AquaMetrics LLC, in press, Landscape Measurement Techniques, prepared for U.S. Bureau of Reclamation and the Contra Costa Water District.

Ash, Tom, June 1996, Development and Implementation of the Irvine Ranch Water District Ascending Block Rate Structure, presented at the Conservation Based Rate Structure Workshop, Municipal Water District of Orange County.

Ash, Tom, 1999, Landscape Management for Water Savings, published by the Municipal Water District of Orange County.

Barakat & Chamberlin, February 1994, A Guide To Customer Incentives for Water Conservation, prepared for California Urban Water Agencies, California Urban Water Conservation Council, and U.S. Environmental Protection Agency.

CCWD (Contra Costa Water District), August 1994, Landscape Water Audit Evaluation, prepared by John B. Whitcomb.

Council for a Green Environment, 1997, Success in Landscape Water Conservation for Water Districts.

CUWCC (California Urban Water Conservation Council), April 1998, Memorandum of Understanding Regarding Urban Water Conservation in California (as amended).

Kah, Gary, personal communication, March 1999.

Pagano, D.D. et al., May 1997, Efficient Turfgrass Management: Findings from the Irvine Spectrum Water Conservation Study, prepared by D.D. Pagano, James Barry, and Western Policy Research for Metropolitan Water District of Southern California.

Psomas, 1998, Annual Water Allocation and Methodologies, prepared by Psomas Engineering for Municipal Water District of Orange County, the Metropolitan Water District of Southern California, and the Moulton Nigel Water District.

Tubiolo, Jan, 1994, Otay Water District's Budget-Based Irrigation Ordinance: Sound Policy, Simple Solution, presented at California Landscape Contractors Association, 1994 Annual Convention.

Tubiolo, Jan, November 1994, Landscape Water: Will There Be Enough?, presented at Hyatt Lake Tahoe, Incline Village, Nevada.

U.C. DANR Leaflet 21503, 1992, Evaluating Turfgrass Sprinkler Irrigation Systems.

U.C. DANR Leaflet 21499, 1991, Managing Turfgrass during Drought.

U.C. DANR Leaflet 21492, 1991, Turfgrass Irrigation Scheduling.

Volt VIEWtech, 1996, Final Report, South County Residential Survey Program, prepared by Volt VIEWtech for San Diego County Water Authority.

Walker, R. and G.F. Kah, 1993, Landscape Water Management Handbook, California State Polytechnic University, San Luis Obispo, California.

Walker, R., December 1998, Evaluation of Techniques to Determine Landscape Areas, prepared for Irrigation Training and Research Center at California Polytechnic State University and the U.S. Bureau of Reclamation.

Appendix A
BMP 5 Extract from MOU

Appendix B
Weather Data

What is CIMIS? [1]

The California Irrigation Management Information System (CIMIS) is a repository of climatological data collected at about 100 computerized weather stations located in many areas of California. CIMIS was developed by the California Department of Water Resource and the University of California at Davis. Operational since 1982, it has recently been redesigned to use the latest database technology. Access is now possible with high-speed modems as well as through the internet. Use of CIMIS computer is free and the system operates 24 hours a day, every day of the year except during maintenance hours. CIMIS helps agricultural growers and turf managers administering parks, golf courses and other landscapes to develop water budgets for determining when to irrigate and how much water to apply. Providing information for improving water and energy management through efficient irrigation practices is the primary use of the CIMIS system.

How does CIMIS work?

Weather data is collected from each weather station site and automatically transmitted to a central computer located in Sacramento. The weather data is analyzed for accuracy, then stored to provide on-demand, localized information. Based on the weather data, the CIMIS computer estimates the amount of water evaporated from the soil and the amount used by irrigated grass (transpiration) at the weather station site. This combined value for pasture grass is called reference evapotranspiration or ETo. Changes in ETo can be used as a guide to changes in crop or landscape water use. Using a conversion factor(s) and ETo, water use by a given crop or landscape can be estimated. These conversion factors are called crop coefficients (Kc). The values of these factors have been developed and continue to be developed for many trees, vines, agronomic crops, grasses, landscapes, and vegetable crops. These values and descriptions for how to use them are available from CIMIS.

1. From http://wwwdla.water.ca.gov/cimis/cimis/hq/whatis.htm.

Appendix C
Detailed Water Budget Equation

There is a tradeoff between water budget simplicity and accuracy. The water budget equation shown in Section 2.3 is simplistic. More complex water budgets can be developed to be more reflective of the specific plant materials, irrigation systems, and weather (i.e., rainfall) for a given landscape site. Readers should recognize, however, that these embellishments require water agencies to collect more data about its landscape sites. Hence, the complexity may be more trouble than its worth. Each water agency will need to make its own determination concerning water budget simplicity and accuracy.

The detailed water budget equation as specified in the Irrigation Training and Research Center and the Irrigation Association Landscape Irrigation Auditor Training Manual[1] is summarized as follows:

Water Use Budget = Irrigated Area × Adjustment Factor × Conversion Factor ×

((ETo x K_L) – Effective Rainfall) ×

(1 / Irrigation Efficiency)

where:

Water Use Budget	=	applied water use requirement for hydrozone during billing period. Overall site water use budget is obtained by summing over all hydrozones.
Irrigated Area	=	landscape area irrigated in hydrozone (typically square feet)
Adjustment Factor	=	scalar between 1.0 and 0.0 determining the allowable stress on the plant material
Conversion Factor	=	number converting measurement units into consistent terms (see Table C-1)
ETo	=	Reference Evapotranspiration for the billing period. ETo is a measure of the weather's effect on the need for water by plants.
K_L	=	coefficient relating a specific plant type's water requirements to reference ETo

---

1. Landscape Water Management: Auditing; Bob Walker, Gary Kah, Mike Lehmkuhl. Irrigation Training and Research Center, California Polytechnic State University, San Luis Obispo, CA. 1995

Effective Rainfall	=	depth of rain effective in offsetting ETo during a billing period
Irrigation Efficiency	=	factor between 1.0 and 0.0 measuring the efficiency of irrigation system. Efficiency is defined as the amount of water stored in the rootzone and used by the plant divided by the total amount of water measured by the irrigation meter. Because the actual efficiency is hard to measure, an area-weighted distribution uniformity estimate is typically used instead, which approximates the true efficiency when good irrigation management (maintenance and scheduling) is practiced.

Table C-1 Conversion Factors

Area Units	Required Water Units	
	CCF	**Kgal**
Acres	36.3000	27.1543
SqFt	0.000833	0.000623

Estimates of K_L, effective rainfall, and irrigation efficiency can be obtained from ITRC, the U.C. Cooperative Extension, and other sources. Estimates for these factors were intentionally not provided in this document because of their complexity and changes resulting from emerging research.