CALIFORNIA URBAN WATER AGENCIES

URBAN WATER CONSERVATION POTENTIAL

Final Report

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FOREWORD

CALIFORNIA URBAN WATER AGENCIES

REPORT ON URBAN WATER CONSERVATION POTENTIAL IN CALIFORNIA June 2001

The accompanying November 2000 report was funded by and prepared for California Urban Water Agencies (CUWA) as part of a multi-step process to further develop estimates of the extent to which water conservation measures can assist in achieving a balance between water needs and water supplies in the state. CUWA has long supported integrated water resource planning and recognizes the importance of a balanced approach toward demand reduction and supply reliability measures.

The report presents a wealth of information that will be used by CUWA and hopefully, with the support of others, will be helpful in further defining statewide conservation potential. The report provides added precision in research and empirical data collection methodologies required in support of the CALFED Water Use Efficiency (WUE) Plan. It is hoped that the information provided will serve as a catalyst for on-going research, and that technical and financial assistance will be provided through the CALFED process to assist in meeting long-term water resource management solutions.

CUWA Board Members and member agency staff have reviewed the report and wish to thank the consultant team for its thorough analysis which, despite being limited by availability of information and funding, covers a wide range of subjects. The following comments present the CUWA perspective as to how the information can best be used and areas for additional study for future conservational potential research.

GENERAL COMMENTS

When reviewing the report, an important factor to bear in mind is that analysis of statewide conservation potential and program costs is conducted for hydrologic regions and for the subset of Best Management Practices (BMPs) that are quantifiable. As such, the results may not generalize well to any individual water agency within these regions, where individual agency cost and savings data may vary substantially.

It is also important to recognize that due to time and other project constraints, a number of simplifying assumptions were made. For example, marginal supply cost estimates for each region assume that conservation displaces water than would otherwise be drawn from the State Water Project or the Central Valley Project. To the extent individual water agencies use conservation to displace other sources of supply, the avoided cost of supply and corresponding cost-effectiveness of individual BMPs will likely differ from the estimates developed by the report.

Project constraints also made it impractical to gather and incorporate information from individual agencies about proven conservation savings already achieved from utility-funded programs or natural replacement. This will cause estimates of conservation potential developed by the study to overstate actual potential. Conversely, it is important to note that the difficulty in quantifying savings attributable to measures such as education and water pricing may be a source of underestimate.

Finally, it must be recognized that a number of assumptions had to be made which drive conclusions regarding such things as decay of savings, natural replacement of devices and market saturation. Project limitations did not allow for conducting sensitivity analyses to evaluate the extent to which changes in assumptions would change conclusions regarding water savings potential and cost effectiveness.

In summary, users of the report are cautioned to refine the data to fit local conditions, insofar as possible, when applying the valuable techniques presented in the report. The general methodology developed by the study should be combined with data that best describes local operating characteristics and service areas to obtain the most accurate estimates of quantifiable BMP water savings and their corresponding costs and benefits. It should be recognized that report findings suggest a continuing need for additional supplemental funding sources to achieve the potential conservation savings from full implementation of the statewide Urban Conservation Memorandum of Understanding.

AREAS OF SUGGESTED ADDITIONAL STUDY

The following examples are not intended to be a complete listing, but rather suggested areas of work that should be undertaken to address questions the consulting team and the study referenced herein has brought forth.

- Extend the current study methodology to permit sensitivity analysis involving key variables and assumptions.

- Continue to improve current estimates of conservation device and activity water savings and program costs. Attempt to quantify savings associated with BMPs not explicitly considered in the current report.

- Develop more refined estimates and categories of agency-specific avoided costs and benefits attributable to utility-funded BMP measures.

- Develop estimates of the current saturation of conservation devices and of other factors affecting program cost-effectiveness, including rates of natural replacement, program free-ridership and accelerated savings.

- Incorporate conservation savings from conservation already achieved by utility-funded programs into estimates of future conservation potential, which is key in refining estimates and accounting for demand hardening.

- Develop more information and clarify analytical methods with respect to residential audits.

- Expand the analysis of conservation-induced reductions in inflow to wastewater treatment plants. Site-specific considerations include looking at the effect of conservation on the need for plant expansions resulting from capacity limitations. The resulting effectiveness will likely vary between growing and non-growing communities and will require multi-perspective analyses from both water and wastewater agencies.

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APPENDICES

EXECUTIVE SUMMARY

The California Urban Water Agencies (CUWA) commissioned this study of urban water conservation savings to achieve five objectives:

- Provide an estimate of the maximum potential savings for each urban water conservation Best Management Practice (BMP) assuming full implementation of the Memorandum of Understanding Regarding Urban Water Conservation in California ("the MOU") within the seven hydrologic regions which correspond to the Bay-Delta solution area identified by CALFED Program.

- Compare these estimates to estimates developed by the California Department of Water Resources (DWR).

- For each BMP, estimate the savings that are economically justified, based on the cost-effectiveness criteria set forth in the MOU.

- Estimate the financial contribution required to cost-effectively achieve the "full MOU implementation" level of savings.

- Identify the savings associated with different levels of unit financial contributions.

The study estimates potential savings for only a subset of the BMPs. Savings for the remaining BMPs were not quantified either because the MOU's description of the BMP's existing coverage requirement is not sufficiently precise to permit quantification or because the available savings data are either unavailable or inadequate. Thus, the study's "full MOU" savings refers to the savings potential of the subset of BMPs shown in Table ES-1 to be quantified for purposes of this analysis.

As shown in Table ES-2, year 2007 gross and net savings assuming full MOU implementation are estimated as 979,000 and 681,000 acre-feet respectively. Corresponding figures for 2020, assuming MOU renewal, are 1,252,000 and 802,000 acre-feet. If the MOU is not renewed, 2020 gross and net savings decline to 768,000 and 351,000 acre-feet respectively. The year 2020 savings estimates are approximately 22% below the DWR estimates for the same year.

The study's economic analysis was based on the cost-effectiveness of each BMP from the perspective of the local water supply agency and considered cost-sharing with wastewater agencies. As shown in Table ES-2, about 75% of gross savings and 65% of net savings were found to be cost-effective from the local agency perspective.

Table ES-1
BMPS WITH QUANTIFIABLE OR NON-QUANTIFIABLE SAVINGS

BMP NAME	SAVINGS POTENTIAL QUANTIFIED?	REASON FOR EXCLUSION
1. Water Survey Programs for Single-Family Residential and Multi-Family Residential Customers	Yes	
2. Residential Plumbing Retrofit	Yes	
3. System Water Audits, Leak Detection and Repair	Yes	
4. Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections	Yes	
5. Large Landscape Conservation Programs and Incentives	Yes	
6. High-Efficiency Washing Machine Rebate Programs	No	Coverage requirement not specified.
7. Public Information Programs	No	Non-quantifiable unit savings and non-quantifiable coverage requirement
8. School Education Programs	No	Non-quantifiable unit savings and non-quantifiable coverage requirement
9. Conservation Programs for Commercial, Industrial, and Institutional (CII) Accounts	Yes	
10. Wholesale Agency Assistance Programs	No	Non-quantifiable unit savings
11. Conservation Pricing	No	Non-quantifiable coverage requirement
12. Conservation Coordinator	No	Non-quantifiable unit savings
13. Water Waste Prohibition	No	Non-quantifiable unit savings
14. Residential ULFT Replacement Programs	Yes	

Table ES-2
COMPARISON OF TOTAL AND ECONOMIC CONSERVATION SAVINGS POTENTIAL

	GROSS SAVINGS		NET SAVINGS	
YEAR	FULL-MOU (AF)	ECONOMIC (AF)	FULL-MOU (AF)	ECONOMIC (AF)
2007	979,000	733,000 *(75%)*	681,000	435,000 *(64%)*
2020	1,252,000	957,000 *(76%)*	833,000	538,000 *(65%)*

The impact of economics varies substantially from BMP to BMP and across hydrologic regions. Contributions from wastewater utilities increase the economically-achievable savings somewhat, but not substantially. Required annual financial contributions to render the full-MOU coverage levels economic range from $56 million to $93 million per year. The largest share of these contributions are in the Central Valley to pay for individual metering, as called for by BMP 4. BMP 1 (residential surveys) also requires a large contribution throughout the period.

The return on these contributions varies substantially by BMP and region. BMPs 3, 4, 5, and 9 show the highest returns (i.e. lowest unit conservation costs). BMPs 1 and 2 show the lowest returns (i.e. highest unit costs). These variations can be used to guide future state investments in urban conservation. Table ES-3 shows that the vast majority of the 2007 and 2020 savings potential beyond that which is considered locally cost-effective can be achieved with financial contributions ranging between zero and $200 per acre-foot.

These results do not necessarily apply to any individual agency and should be considered preliminary in nature. While the report relies on the best available estimates of BMP savings and costs, additional research is needed to confirm the assumptions used herein.

Table ES-3
CONSERVATION POTENTIAL ATTRIBUTABLE TO FINANCIAL CONTRIBUTIONS

BMP	FINANCIAL CONTRIBUTION AND RESULTING 2007 & 2020 SAVINGS (AF)							
	$0-$200		$200-$400		$400 +		TOTAL	
	2007	2020	2007	2020	2007	2020	2007	2020
1. Water Survey	0	0	0	0	11,000	16,000	11,000	16,000
2. Residential Plumbing Retrofit	1,000	0	1,000	0	2,000	1,000	4,000	1,000
3. Audits, Leak Detection and Repair	24,000	0	0	0	0	0	0	0
4. Metering	87,000	120,000	0	0	0	0	87,000	120,000
5. Landscape Conservation	17,000	32,000	0	0	0	0	17,000	32,000
9 Commercial, Industrial, and Institutional	88,000	83,000	0	0	0	0	39,000	52,000
14. ULFT Replacement	15,000	43,000	0	0	0	0	15,000	43,000
TOTAL	**232,000**	**278,000**	**1,000**	**0**	**13,000**	**17,000**	**246,000**	**295,000**

INTRODUCTION

The California Urban Water Agencies (CUWA) commissioned this study of urban water conservation savings to achieve the following objectives:

1. Estimate the maximum potential savings for the years 2007 and 2020 for each urban water conservation Best Management Practice (BMP) in each of seven hydrologic regions assuming full implementation of the Memorandum of Understanding Regarding Urban Water Conservation in California ("the MOU").[1]

2. Compare these estimates to estimates developed by the California Department of Water Resources (DWR).

3. For each BMP in each region, estimate the savings that are economically justified, based on the cost-effectiveness criteria set forth in the MOU.

4. Estimate the financial contribution required to enable the state's water providers to cost-effectively achieve the "full MOU implementation" level of savings.

5. Provide guidance to state policymakers regarding the economic return on investments in particular BMPs in each region.

It is important to note that the basic unit of analysis for this study was the hydrologic region. The seven regions on which the study focused include virtually all of the state's urban population. They include:

- Central Coast
- San Francisco Bay
- South Coast
- Sacramento River
- San Joaquin River
- South Lahontan
- Tulare Lake

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1 California Department of Water Resources. *California Water Plan Update, Bulletin 160-98*. November 1998. No attempt is made to distinguish between agencies that have and have not signed the MOU. Rather, the savings estimates are based on counts of all water customers in each region. This reflects both the constraints of this study and the fact that the vast majority of water customers in the state are served by agencies that have signed the MOU.

When combined, these regions roughly correspond to the Bay-Delta solution area identified in CALFED program documentation.

The focus on hydrologic regions rather than individual water utilities was required by the study's resource limitations. Inherent in this regional level of aggregation is a high level of approximation of the results. It is likely that the assumptions that underlie the analysis and the resulting estimates do not apply *in toto* to any single water provider.

Thus, in addition to this report, the other major product of the project is a set of linked MS Excel® spreadsheet models to permit future assumption changes and to allow CUWA member agencies to tailor the analyses to their own unique circumstances. The savings models for each BMP are described in Appendix A. The economic analysis spreadsheets are described in Appendix B.

Between November 1999 and August 2000, the foregoing tasks were completed by a consulting team consisting of the following firms:

- Gary Fiske & Associates
- M-Cubed
- Foster Associates
- A&N Technical Services

The consulting team benefited from the insights and advice of a Project Advisory Committee (PAC), consisting of representatives of the state's urban water agencies, the California Urban Water Conservation Council (CUWCC), the state's environmental community, the California Department of Water Resources, and the U.S. Bureau of Reclamation. PAC members are listed in Appendix C. The consulting team is grateful for their help.

STUDY LIMITATIONS

Because of resource and data limitations, it is important that the reader understand the following caveats and limitations.

The results should be considered as preliminary. Although the report relies on the best available estimates of BMP savings and costs, many of these estimates are still very uncertain. As better information becomes available, the analysis should be refined.

The results do not necessarily apply to any individual agency. Since the unit of analysis was the hydrologic region, estimates of savings, program costs, and marginal costs of water and wastewater may not reflect conditions faced by any single agency. The assumptions and results that follow are therefore not intended to be used by signatory water agencies in fulfilling their MOU responsibilities.

The study estimates potential savings for only a subset of the BMPs. Savings for the remaining BMPs were not quantified either because the MOU's description of the BMP's existing coverage requirement is not sufficiently precise to permit quantification or because the available savings data are either unavailable or inadequate.[2] Thus, the study's "full MOU" savings underestimate the total savings that could be achieved through implementation of all BMPs prescribed by the urban MOU. In summary, "full BMP implementation" should be understood as referring to the savings potential only of the subset of BMPs that were able to be quantified for purposes of this analysis.

The study's economic analysis was based on the cost-effectiveness of each BMP from the perspective of the local water supply agency. Exhibit 3 of the MOU indicates that this perspective is to consider environmental benefits and costs of the BMP. This could not be done by the current study because CUWCC has not yet developed a suitable framework for identifying and valuing these types of costs and benefits. Once this is done, the economic analysis summarized in this report should be updated to account for this information.

The MOU also states that exemptions from implementation of particular BMPs will be granted if the program is not cost effective either overall or to the local agency. However, in the latter case, signatories must demonstrate that they have used "good faith efforts" to share BMP costs with other program beneficiaries.

This study has considered cost-sharing with wastewater agencies; it has not examined other cost sharing possibilities. For a BMP that is cost-effective overall but not to the local agency, there is at least a theoretical possibility of transfer payments that would render the program cost-effective to the local agency as well. The practical difficulties and transaction costs associated with some of these transfers may be high. In making its decisions on individual exemption applications, the California Urban Water Conservation Council would have to determine whether the cost-sharing efforts made by the applicant agency are sufficient. This study has made no attempt to assess these issues.

2 Specifically, BMPs 6, 7, 8, 10, 11, 12, and 13 were not quantified.

"FULL MOU IMPLEMENTATION" SAVINGS POTENTIAL

INTRODUCTION

The MOU identifies 14 water conservation BMPs that urban water supplier signatories agree to implement over ten years if locally cost-effective. Each BMP definition includes target levels of activity and implementation schedules to achieve those targets during the term of the MOU. The MOU refers to these targets as BMP coverage or coverage requirements. The objective of this initial task was to combine each BMP's coverage requirement with information on water savings for the BMP activity in order to estimate the water savings potential at the specified coverage. That is, ignoring program economics, how much water savings would we expect the BMPs to yield if they were implemented to the levels of coverage currently specified in the MOU?

As described below, the saving estimates assume an implementation start date of 1997. This means that the post-1997 savings for those agencies that had significant coverage for one or more BMPs prior to that year will be somewhat overstated. However, the focus of this effort is to estimate *total* savings potential for the BMPs, regardless of the actual timing of water agencies' conservation programs.

To facilitate comparison with estimates of BMP savings potential prepared by the California Department of Water Resources (DWR) and CALFED we developed estimates for two reference years: 2007 and 2020. The 2007 reference year roughly corresponds with the end of Stage 1 implementation of the CALFED Bay-Delta program. It also roughly corresponds with the end of the current 10-year term of the MOU. The 2020 reference year corresponds to the forecast period used by DWR for Bulletin 160-98.[3] The assumption of full implementation without regard to program economics allows comparison with estimates of savings potential prepared by DWR for Bulletin 160-98.

MAXIMUM REGIONAL VERSUS TOTAL MOU SAVINGS POTENTIAL

It is important to emphasize, however, that full coverage requirement implementation is not the same as total conservation potential for a region. Increased potential beyond the MOU could be realized by raising the coverage requirements, implementing potential BMPs (PBMPs) listed in

[3] Page 4-11 of Bulletin 160-98 states: "Bulletin 160-98 estimates water savings due to BMP implementation based on the assumptions set forth in Exhibit 1 of the urban MOU, and assumes that California will achieve a level of water conservation equivalent to that expected from full BMP implementation by 2020." On Page 4-8 the bulletin makes the additional point that "urban forecasts in Bulletin 160-98 assume that water users statewide will implement BMPs by 2020, as set forth in Exhibit 1 of the MOU, whether or not the BMPs are cost-effective from a water supply standpoint. In making this assumption, the Bulletin recognizes that water conservation measures have potential benefits in addition to water supply, such as reduced water and wastewater treatment costs, other water quality improvements, reduced entrainment of fish at urban points of diversion, and greater control of temperature and timing of wastewater discharges. The Department [DWR] believes this assumption is reasonable, given that funding sources for non-water supply benefits could help support BMP implementation, and that the planning horizon over which the Bulletin assumes that BMPs would be implemented (from 1995 to 2020) provides more time for implementation than does the MOU."

the MOU, or implementing measures in addition to the BMPs and PBMPs. Under the current terms and definitions of the MOU, full coverage requirement implementation will be less than total conservation potential.

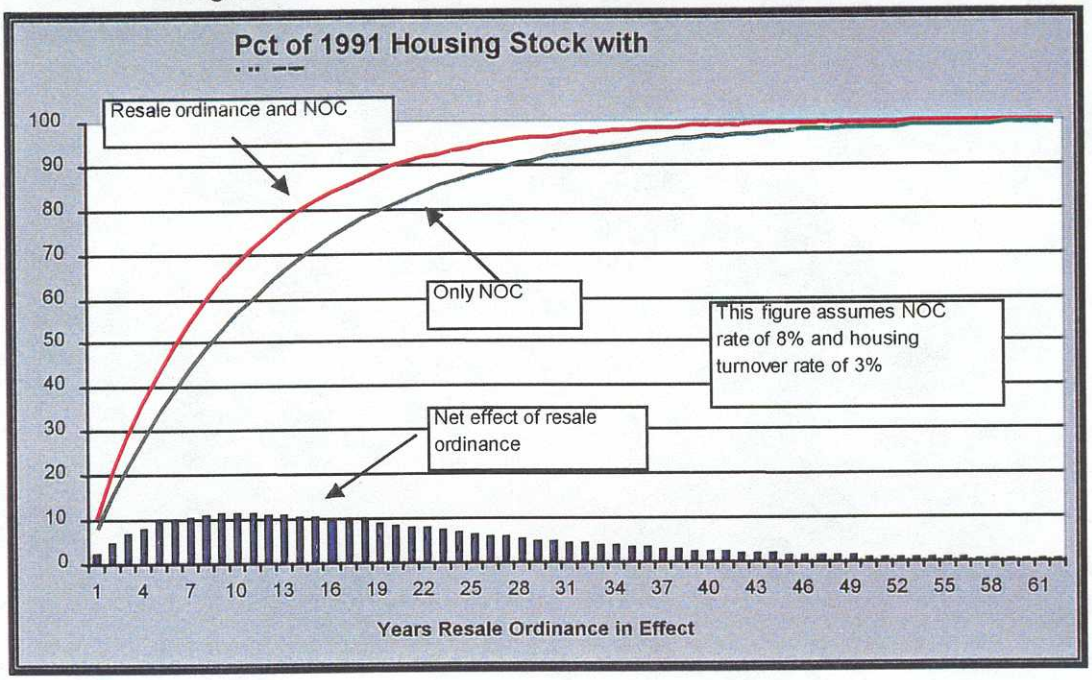
Gross Versus Net Savings Potential

The estimates of savings potential developed under Task 1 differentiate between gross and net savings potential. Estimates of gross savings potential do not adjust for the effects of naturally occurring conservation (NOC), whereas the estimates of net savings potential do. NOC refers to the amount of background conservation activity occurring regardless of or in addition to activity motivated by water-supplier-financed BMP programs. Estimates of gross savings are useful for regional demand projections. They can help answer the question: how much water is being saved in a given region because of conservation programs, changes in technology, changes in preferences, and changes in socio-economic factors? Estimates of net savings, on the other hand, are useful for analyzing the economics of a specific program. They are meant to isolate the savings directly attributable to the program in question. They can help answer the questions: how much of the savings occurring in a given region is attributable to one or more conservation programs and how much does this cost?

Because of state plumbing code requirements, differentiating between gross and net savings is particularly important for BMPs 2 (residential plumbing retrofits) and 14 (residential ULFT programs). These BMPs accelerate NOC rates rather than create additional long-term savings. That is, they allow regions to realize water savings due to replacement of high-flow plumbing fixtures with their low-flow counterparts sooner than would have been the case if only natural replacement was relied upon. For example, a retrofit-on-resale ordinance or equivalent program for toilets (BMP 14) accelerates the rate at which the existing stock of high-flow toilets turns over. But it is also the case that this existing stock would eventually turn over even without the ordinance as a result of age-related device failure. From an implementing agency's point of view, the effectiveness of the ordinance depends on how fast high-flow toilets are being replaced naturally. The slower the rate of natural replacement the more effective the ordinance over time and vice versa.

Figure 1 illustrates this. The figure assumes a retrofit-on-resale ordinance in effect since 1991 and an annual rate of housing turnover of 3%. The top line in the figure shows the combined effect of the retrofit-on-resale ordinance and NOC. This would be used to calculate gross savings potential for the region. The line below this shows the effect of only NOC. The difference between these two lines is the net effect of the ordinance. It is this difference, shown as vertical bars on the bottom of the figure, that would be used to calculate the net savings potential of the ordinance.

Figure 1. Percent of Pre-1991 Housing Stock with ULFTs



ESTIMATION ISSUES

There are numerous estimation issues that make quantification of MOU savings potential difficult. This section identifies the major issues and briefly describes how each one was addressed by the Task 1 analysis. More detailed model descriptions and discussion of assumptions for each BMP for which we developed water savings estimates are presented in Appendix A.

MOU Renewal Beyond 2007

Developing estimates for the 2020 reference year required us to make assumptions about continuation of the MOU. The MOU defines BMP coverage in 10-year intervals, with the current coverage period ending around 2007 for most MOU signatories. The existing MOU agreement does not obligate water supplier signatories to continue with BMP implementation once they have satisfied the BMP coverage requirements. That is, agencies achieving their coverage requirements after 10 years of implementation could choose to stop implementing the BMPs unless they agree to renew the MOU. We therefore constructed two different estimates of savings potential. The first assumes agencies stop implementing the BMPs once their current coverage requirements are satisfied around 2007. The second assumes the MOU is renewed at least through 2020 and that BMP implementation continues through this period. For this latter case, we assumed BMP coverage requirements were updated in 2007 to reflect changes in regional population and housing growth.

BMPs with Non-Quantifiable Savings and/or Non-Specific Coverage

Savings for several BMPs cannot be quantified. In some instances, such as public information (BMP 7) and school education (BMP 8) programs, estimates of unit savings (e.g., water savings per school presentation) could not be constructed. In other cases, the BMP's coverage requirement is non-specific and could not be quantified. Ultimately, we were able to estimate savings for BMPs 1 (residential audits), 2 (plumbing device retrofits), 3 (system leak detection and audits), 4 (metering), 5 (large landscape programs), 9 (commercial, industrial, and institutional programs),[4] and 14 (ULFT programs). Table 1 summarizes the study's BMP coverage.

Table 1
BMPS WITH QUANTIFIABLE OR NON-QUANTIFIABLE SAVINGS

BMP NAME	SAVINGS POTENTIAL QUANTIFIED?	REASON FOR EXCLUSION
Water Survey Programs for Single-Family Residential and Multi-Family Residential Customers	Yes	
Residential Plumbing Retrofit	Yes	
System Water Audits, Leak Detection and Repair	Yes	
Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections	Yes	
Large Landscape Conservation Programs and Incentives	Yes	
High-Efficiency Washing Machine Rebate Programs	No	Coverage requirement not specified.
Public Information Programs	No	Non-quantifiable unit savings and non-quantifiable coverage requirement
School Education Programs	No	Non-quantifiable unit savings and non-quantifiable coverage requirement
Conservation Programs for Commercial, Industrial, and Institutional (CII) Accounts	Yes	
Wholesale Agency Assistance Programs	No	Non-quantifiable unit savings
Conservation Pricing	No	Non-quantifiable coverage requirement
Conservation Coordinator	No	Non-quantifiable unit savings
Water Waste Prohibition	No	Non-quantifiable unit savings
Residential ULFT Replacement Programs	Yes	

[4] As discussed below, CII ULFT savings were not assessed.

Several of the BMPs for which we were unable to quantify savings can be viewed as at least partially supportive of the BMPs for which we could estimate savings. These include BMPs 7 (Public Information), 8 (School Education), 10 (Wholesale Agency Assistance), 11 (Conservation Pricing), and 12 (Conservation Coordinator). Savings from these BMPs are therefore partially indirectly captured by our estimates of savings for the BMPs they support.

BMPs 6 (washing machine rebates), 11 (conservation pricing), and 13 (water waste prohibition) can clearly provide incremental savings to full MOU implementation. In the cases of BMPs 6 and 11, coverage requirements are not specified, thus preventing estimation. In the case of BMP 13 (water waste prohibition), we had no reasonable estimate of potential savings from this BMP activity. We therefore excluded it from the analysis. As a result, our analysis provides a conservative estimate of total MOU savings potential.

BMPs with More than One Coverage Option

BMP 9 (CII programs) provides agencies with two coverage options -- agencies can choose to provide water audits to 10% of their CII customers or they can achieve a 10% reduction in CII water consumption relative to a 1989 baseline. Each option implies a different level of potential savings and it is too early to know the proportion of agencies likely to implement either option. Therefore to estimate savings potential for this BMP, we estimated the savings potential for each option and then averaged the results.

Double Counting Potential Savings

Savings from several of the BMPs clearly overlap. For example, most of the indoor water savings for BMP 1 are attributable to actions taken under BMP 2. Similarly, savings from installing toilet dams (BMP 2) will be eliminated if the toilet is replaced with a ULFT (BMP 14). Savings from BMP 9 CII surveys to the extent those surveys include outdoor water use will overlap with savings from BMP 5 landscape surveys. Savings from pricing (BMP 4 and 11) cannot be easily separated from savings from all the other BMPs, since price may motivate many conserving action undertaken by end users. We took the following actions to minimize the potential to double count water savings:

1. For BMP 1 count only savings that cannot be associated with BMP 2. Savings will be mostly from changes in outdoor water use.

2. For BMP 2 count only savings from showerheads and faucet aerators (adjusted for natural replacement). Exclude savings from toilet dams to avoid doubling counting BMP 14 savings.

3. For BMP 9 count only non-landscape savings. We assume any landscape savings realized from CII audits will be credited towards BMP 5 coverage.

Starting Period for BMP Implementation

Urban water suppliers have started implementation of the BMPs at different points in time. Many started as early as 1991 with the initial signing of the MOU. Others have only begun recently. The distribution of agency start dates has implications for estimates of savings potential, both because of NOC effects and because of potential decay in savings for some BMPs. The earlier implementation starts the more NOC and savings decay effects come into play. Ideally, our estimates would account in some way for these differences. However, the data requirements for such an analysis were well beyond the scope of this project. Our estimates therefore assume all agencies begin implementation in 1997. We chose 1997 because this was the year the BMPs were substantially revised by the CUWCC and new coverage schedules were initiated.[5] As a result, our estimates probably somewhat overstate <u>net</u> savings potential. Estimates of gross savings potential would be less affected by this assumption.

This assumption has the most significance for BMPs 2 (residential plumbing retrofits) and 14 (residential ULFTs). The models account for natural replacement occurring between 1992 and 1997, but not showerheads and toilets distributed through active conservation programs. The effect is to potentially overestimate the amount of post-97 water savings that will result from low-flow showerhead and ULFT programs. Overestimation is expected to be greatest in Southern California, where early investments have already tapped a significant fraction of the savings potential.

Decay of Water Savings

Due to the shorter-run nature of behavioral changes, water savings for BMPs with a heavy survey component (BMPs 1, 5, 9) are expected to decay over time. Savings decay interacts with a BMP's coverage requirement to have a fairly profound effect on the BMP's annual yield overtime. If an agency reaches a BMP's coverage requirement and then stops implementation (for example, residential surveys cease once 15% of residential customers are surveyed), the annual yield from the BMP will decrease from that point forward.

A simple model for BMP 1 illustrates this effect. Assume we know the average savings per survey to be σ and we know that these savings decay each year at an average rate δ (published data allow us to estimate both σ and δ). BMP 1 requires current signatories to survey 15% of their residential customers by 2008. Suppose an agency develops a program to survey 1.5% of its base year customers, x_0, each year with plans to discontinue the program after year 10. Then program savings in year t [10 are:

$$s_t = \sigma \cdot x_0 \cdot \left[0.015 \cdot \sum_{n=1}^{t} (1-\delta)^{n-1} \right] \text{for } t \leq 10$$

[5] We note that DWR's analysis for Bulletin 160-98 assumes implementation begins in 1995.

The term in brackets diminishes savings per household to reflect the decay in savings. Multiplying average savings per survey by base year households by this decay factor yields the estimated savings (AFY) for year t.

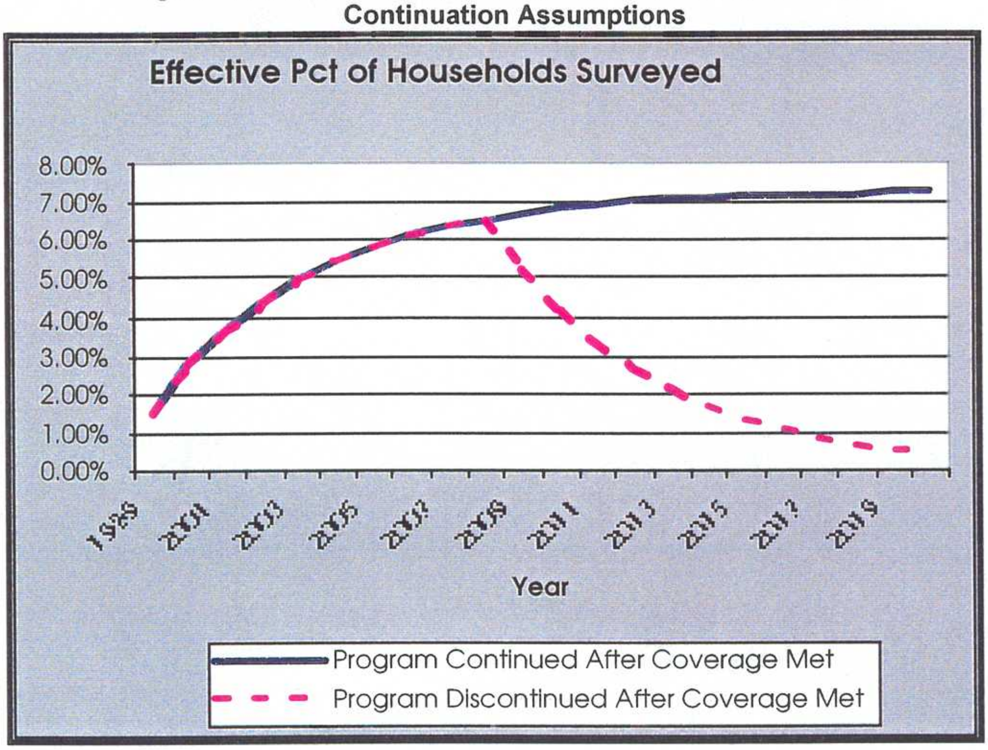
If we assume the program is discontinued after the coverage is met in year 10, then program savings for year t µ 10 are:

$$s_t = \sigma \cdot x_0 \cdot \left[0.015 \cdot \sum_{n=1}^{t} (1-\delta)^{(n-1)+(t-10)}\right] \text{ for } t > 10$$

This latter equation shows what happens when the agency stops investing in new surveys. Only savings from past surveys contribute to regional savings, and these savings are decaying by δ percent each year. Eventually the savings from the program will decay to zero.

Figure 2 illustrates this graphically. It assumes savings decay at a rate of 20% per year. If the agency continues its program after meeting the coverage requirement, continually replacing decayed savings with savings from new surveys, total savings per year will level out over time. However, if the agency stops new surveys once the coverage requirement is met, the savings will drop off. The rate of drop off depends on how fast savings decay. Empirical evidence for residential and landscape surveys suggest the decay is fairly rapid, though it must be emphasized that the empirical evidence is very limited and substantial uncertainty remains.

Figure 2. Effect of Savings Decay Under Alternative Program Continuation Assumptions



The estimation models account for savings decay whenever its effect is expected to be strong. Models for BMPs 1, 5, and 9 explicitly account for savings decay and allow for alternative savings decay assumptions.

CII ULFT Savings

The estimates of potential savings do not include potential savings from CII ULFT installations. These potential savings were excluded from the analysis because the MOU does not currently include a coverage requirement for their installation. We note, however, that the CUWCC is in the process of adopting a requirement for CII ULFT programs. Savings estimates will require updating once such a requirement becomes part of the MOU.

SUMMARY OF SAVINGS ESTIMATES

Table 2 shows the underlying savings, decay, and natural replacement assumptions.

Table 2

MAJOR BMP SAVINGS ASSUMPTIONS FOR "FULL MOU" ANALYSIS

BMP	UNIT SAVINGS	NATURAL REPLACEMENT RATE	SAVINGS LIFE OR ANN. DECAY RATE
1 - Res. Surveys: Single Family	15 gpd per survey	NA	15% per yr
1 - Res. Surveys: Multi Family	6.64 gpd per survey	NA	15% per yr
2 - Res. Plumbing Retrofits	5.65 gpd per survey	10% per yr	10 years
3 - System Leak Detection & Repair	NA	NA	NA
4 - Metering	15% demand reduction per meter installed	NA	50 years
5 - Budgets	NA	NA	NA
5 - Surveys	0.53-1.13 AFY per survey	NA	10% per yr
9 - Surveys	1.27 AFY per survey	NA	12 years
9 - Target	10% of 1989 baseline use	NA	NA
14 - Res. ULFT Retrofits	35-45 gpd per toilet installed	4% per yr	25 years

Tables 3 and 4 show the gross and net BMP savings estimates by region for the years 2007 and 2020 respectively. The gross savings in 2007 are close to 1 million acre-feet, but only about 700,000 acre-feet are attributable to BMP implementation. By 2020, assuming MOU renewal, the gross savings increase to 1.25 million acre-feet, while the net savings are 833,000 acre-feet.

If, however, the MOU is not renewed, Table 5 shows that gross savings decay to 768,000 acre-feet, while net savings decline to 350,000 acre-feet.

Table 3
FULL-MOU SAVINGS ESTIMATES FOR 2007

Gross Savings	BMP 1	BMP 2	BMP 3	BMP 4	BMP 5a	BMP 5b	BMP 9	BMP 14	
Hyrdologic Region	Residential Surveys	Low Flow Showerhead Distribution	System Leak Detection & Repair	Metering & Billing by Volume	Landscape Budgets	Landscape Surveys	CII Water Use Efficiency Programs	Residential ULFT replacement	Total 1/
Central Coast	488	3,017	5,836	0	2,465	2,568	6,692	10,785	32,000
San Francisco Bay	2,268	17,522	22,675	0	7,445	9,514	29,607	67,666	157,000
Sacramento River	1,002	6,579	16,679	26,524	8,566	4,393	15,118	23,882	103,000
San Joaquin River	527	3,383	13,350	21,735	4,001	3,622	7,969	11,561	66,000
Tulare Lake	663	4,084	15,643	39,091	6,106	9,193	12,378	14,816	102,000
South Coast	6,259	47,311	86,586	0	50,332	31,844	80,450	197,471	500,000
South Lahontan	14	102	7,428	0	3,627	2,568	5,190	391	19,000
Total 1/	11,000	82,000	168,000	87,000	83,000	64,000	157,000	327,000	979,000

Net Savings	BMP 1	BMP 2	BMP 3	BMP 4	BMP 5a	BMP 5b	BMP 9	BMP 14	
Hyrdologic Region	Residential Surveys	Low Flow Showerhead Distribution	System Leak Detection & Repair	Metering & Billing by Volume	Landscape Budgets	Landscape Surveys	CII Water Use Efficiency Programs	Residential ULFT replacement	Total 1/
Central Coast	488	106	5,836	0	2,465	2,568	6,692	2,536	21,000
San Francisco Bay	2,268	618	22,675	0	7,445	9,514	29,607	21,856	94,000
Sacramento River	1,002	232	16,679	26,524	8,566	4,393	15,118	7,667	80,000
San Joaquin River	527	119	13,350	21,735	4,001	3,622	7,969	3,151	54,000
Tulare Lake	663	144	15,643	39,091	6,106	9,193	12,378	4,010	87,000
South Coast	6,259	1,668	86,586	0	50,332	31,844	80,450	68,758	326,000
South Lahontan	14	4	7,428	0	3,627	2,568	5,190	154	19,000
Total 1/	11,000	3,000	168,000	87,000	83,000	64,000	157,000	108,000	681,000

1/ Totals rounded to nearest 1,000 AF. Columns and rows therefore do not sum to totals.

Table 4

FULL-MOU SAVINGS ESTIMATES FOR 2020: MOU RENEWAL

Gross Savings	BMP 1	BMP 2	BMP 3	BMP 4	BMP 5a	BMP 5b	BMP 9	BMP 14	
Hyrdologic Region	Residential Surveys	Low Flow Showerhead Distribution	System Leak Detection & Repair	Metering & Billing by Volume	Landscape Budgets	Landscape Surveys	CII Water Use Efficiency Programs	Residential ULFT replacement	Total 1/
Central Coast	723	3,500	6,689	0	2,825	4,156	8,620	15,094	42,000
San Francisco Bay	3,174	20,330	23,244	0	7,631	14,221	35,272	90,246	194,000
Sacramento River	1,533	7,634	20,103	35,520	10,324	7,412	18,420	31,825	133,000
San Joaquin River	825	3,925	16,837	30,459	5,046	6,371	10,389	15,924	90,000
Tulare Lake	1,000	4,739	19,397	53,856	7,571	15,913	17,422	20,428	140,000
South Coast	8,936	54,893	97,407	0	56,622	50,790	98,960	257,963	626,000
South Lahontan	19	118	10,925	0	5,335	4,156	6,950	489	28,000
Total 1/	16,000	95,000	195,000	120,000	95,000	103,000	196,000	432,000	1,253,000

Net Savings	BMP 1	BMP 2	BMP 3	BMP 4	BMP 5a	BMP 5b	BMP 9	BMP 14	
Hyrdologic Region	Residential Surveys	Low Flow Showerhead Distribution	System Leak Detection & Repair	Metering & Billing by Volume	Landscape Budgets	Landscape Surveys	CII Water Use Efficiency Programs	Residential ULFT replacement	Total 1/
Central Coast	723	27	6,689	0	2,825	4,156	8,620	2,823	25,863
San Francisco Bay	3,174	157	23,244	0	7,631	14,221	35,272	22,104	105,804
Sacramento River	1,533	59	20,103	35,520	10,324	7,412	18,420	7,704	101,074
San Joaquin River	825	30	16,837	30,459	5,046	6,371	10,389	3,414	73,371
Tulare Lake	1,000	37	19,397	53,856	7,571	15,913	17,422	4,356	119,552
South Coast	8,936	424	97,407	0	56,622	50,790	98,960	66,503	379,641
South Lahontan	19	1	10,925	0	5,335	4,156	6,950	137	27,523
Total 1/	16,000	1,000	195,000	120,000	95,000	103,000	196,000	107,000	833,000

1/ Totals rounded to nearest 1,000 AF. Columns and rows therefore do not sum to totals.

Table 5
FULL-MOU SAVINGS ESTIMATES FOR 2020: NO MOU RENEWAL

Gross Savings	BMP 1	BMP 2	BMP 3	BMP 4	BMP 5a	BMP 5b	BMP 9	BMP 14	
Hydrologic Region	Residential Surveys	Low Flow Showerhead Distribution	System Leak Detection & Repair	Metering & Billing by Volume	Landscape Budgets	Landscape Surveys	CII Water Use Efficiency Programs	Residential ULFT replacement	Total 1/
Central Coast	73	3,500	5,902	0	0	771	0	13,885	24,000
San Francisco Bay	337	20,330	22,719	0	0	2,857	0	81,952	128,000
Sacramento River	149	7,634	16,942	27,216	0	1,319	0	28,961	82,000
San Joaquin River	78	3,925	13,387	22,406	0	1,088	0	14,513	55,000
Tulare Lake	99	4,739	15,932	40,227	0	2,761	0	18,622	82,000
South Coast	931	54,893	87,418	0	0	9,562	0	234,724	388,000
South Lahontan	2	118	7,697	0	0	771	0	448	9,000
Total 1/	2,000	95,000	170,000	90,000	0	19,000	0	393,000	768,000

Net Savings	BMP 1	BMP 2	BMP 3	BMP 4	BMP 5a	BMP 5b	BMP 9	BMP 14	
Hyrdologic Region	Residential Surveys	Low Flow Showerhead Distribution	System Leak Detection & Repair	Metering & Billing by Volume	Landscape Budgets	Landscape Surveys	CII Water Use Efficiency Programs	Residential ULFT replacement	Total 1/
Central Coast	73	27	5,902	0	-	771	0	1,615	8,000
San Francisco Bay	337	157	22,719	0	-	2,857	-	13,810	40,000
Sacramento River	149	59	16,942	27,216	-	1,319	0	4,840	51,000
San Joaquin River	78	30	13,387	22,406	-	1,088	(0)	2,003	39,000
Tulare Lake	99	37	15,932	40,227	-	2,761	0	2,549	62,000
South Coast	931	424	87,418	0	-	9,562	(0)	43,264	142,000
South Lahontan	2	1	7,697	0	-	771	0	96	9,000
Total 1/	2,000	1,000	170,000	90,000	0	19,000	0	68,000	351,000

1/ Totals rounded to nearest 1,000 AF. Columns and rows therefore do not sum to totals.

COMPARISON TO DWR BULLETIN 160-98 ESTIMATES

Table 6 shows DWR's estimate of BMP savings potential for 2020, as reported in Bulletin 160-98. According to DWR staff, this estimate includes conservation from both BMP implementation and from natural replacement.[6] In this regard, it is comparable to the estimate for gross savings shown in Table 4. However, there are several key differences between the Table 4 results and the DWR analyses that make direct comparison inappropriate. These include:

- The DWR estimate does not account for landscape water savings outside of the residential sector. According to Bulletin 160-98 "insufficient base year data on landscape water use and acreage" prevented modeling BMP 5 savings potential.[7] In Task 1 we developed what we believe is a credible estimation method for BMP 5. BMP 5 is therefore included in the Task 1 estimate. Our estimate of landscape savings potential under BMP 5 is approximately 192,000 AFY.

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6 Personal Conversation with Scott Matyac, California Department of Water Resources, March 1, 2000.

7 California Department of Water Resources, "The California Water Plan Update," Bulletin 160-98, Table 4B-2.

- DWR did not estimate savings from BMP 3 because, again according to Bulletin 160-98, "average unaccounted water loss currently meets the MOU target value."[8] We note that while the statewide average unaccounted water loss is within the MOU target value, many systems are above this target, while others are below it. We used water system data from the Department of Health Services to estimate the percentage of total urban water delivered by systems with unaccounted water loss exceeding the MOU target. We then calculated the amount of water savings if these systems reduced their unaccounted water loss to the MOU target of 10 percent.[9] The Task 1 estimate of BMP 3 savings potential is approximately 194,000 AFY.

- DWR included a savings estimate for BMP 11, while Task 1 did not. We note that BMP 11 requires neither a specific rate form nor a specific rate level, and thus is not quantifiable in its current definition. DWR's estimate of savings for BMP 11 is based on DWR water price forecasts and estimates of urban water demand price elasticity in California. To attribute savings to BMP 11, DWR must assume that the BMP will raise water rates between now and 2020 above what they would otherwise be. Otherwise, the BMP would not produce any savings within the context of the MOU. DWR's statewide estimate of savings from pricing is 183,000 AF.[10] If we prorate this quantity based on the percent of total average demand for the seven Hydrologic Regions included in the Task 1 analysis, the estimate for just those regions is 168,000.

Table 6
DWR FORECAST OF BMP CONSERVATION POTENTIAL BY 2020

		2020 Per Capita Use Forecast (GPD)		
Hyrdologic Region	2020 Population	without conservation	with conservation	Reduction in Applied Water (AF)
Central Coast	1,946	188	166	48,000
San Francisco Bay	7,025	188	166	173,000
Sacramento River	3,813	286	264	94,000
San Joaquin River	3,025	307	274	112,000
Tulare Lake	3,296	302	268	126,000
South Coast	24,327	219	191	763,000
South Lahontan	2,019	294	268	59,000
Total	45,451			1,375,000
Source: Tables 4-1, 4-10, The California Water Plan Update, Bulletin 160-98.				

8 Ibid.

9 The data from Department of Health Services was cross-checked with estimates of system unaccounted water from several water suppliers. In each instance, the two estimates were consistent. We assume that 70 percent of the estimated unaccounted water for a supplier is lost to its system.

10 Personal Conversation with Scott Matyac, California Department of Water Resources, March 1, 2000.

Adjusting the DWR estimate for these differences allows for direct comparison. These adjustments are shown in Table 7. The CUWA estimate is approximately 22 percent lower than the DWR estimate. There are several possible explanations for the difference, including:

- Differences in unit savings assumptions. The DWR analysis bases its savings estimates on the savings assumptions contained in Exhibit 1 of the MOU. The CUWA analysis draws primarily from the CUWCC Savings and Cost document, but also from other sources from the literature on urban water conservation. For example, we assume metering will reduce single-family demand in unmetered areas by 15% while DWR assumes it will reduce demand by 20%. Changing our assumption to match DWR's would increase our 2020 estimate by about 40,000 AF.

- Differences in savings decay rate assumptions. The Task 1 analysis assumes savings from surveys (residential, landscape, and CII) decay over time due to behavioral changes, employee turnover, and equipment wear. With one exception, the DWR analysis assumes savings persist over time.[11] In the case of residential audit leak detection, DWR assumes savings from repaired leaks persist for only one year. If our analysis were to assume no savings decay, our estimate of gross savings for 2020 would increase to 1,567,000 AFY. The difference from the adjusted DWR estimate would decrease to about 15 percent.[12]

- Our treatment of naturally-occurring conservation does not account for any savings attributable to new construction. The DWR analysis may include passive savings attributable to new construction.

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11 Personal Conversation with Scott Matyac, California Department of Water Resources, March 1, 2000.

12 Note that the adjusted DWR estimate changes if the CUWA estimate does not account for savings decay because the estimate for BMP 5, which is used to adjust the DWR estimate, increases significantly.

Table 7
COMPARISON OF CUWA ESTIMATE OF BMP SAVINGS POTENTIAL BY 2020 WITH DWR ADJUSTED FORECAST

Unadjusted DWR Estimate	1,375,000
Adjustments	
Add Task 1's BMP 5 savings estimate	198,000
Add Task 1's BMP 3 savings estimate	195,000
Subtract DWR's BMP 11 savings estimate	(168,000)
Adjusted DWR Estimate	1,600,000
Task 1 Estimate	1,253,000
Difference Between CUWA and DWR Estimates (AF)	(347,000)
Difference Between CUWA and DWR Estimates (%)	-21.7%

CONCLUSION

- The unadjusted difference between the CUWA estimate of 2020 gross savings and DWR's Bulletin 160-98 estimate is less than 10%.
- Adjusting the DWR estimate to remove price effects and account for landscape and system loss savings roughly doubles the difference, from 10% to almost 22%.
- By explicitly accounting for savings decay in BMPs 1, 5, and 9, the current analysis could be viewed as a more conservative approach to estimating BMP savings potential. Eliminating the decay assumptions reduces the difference between the Task 1 and adjusted DWR estimates from 22% to about 15%.

Both estimates contain substantial uncertainty, due in large part to the variability in per-participant savings estimates for many of the BMPs. While formal statistical methods for accounting for this uncertainty were beyond the scope of the present analysis, it would not be surprising to learn that the difference between the two estimates would not prove statistically significant at standard levels of confidence.

ECONOMIC SAVINGS POTENTIAL

INTRODUCTION

The "full MOU" savings described in the preceding section are estimated without regard to cost. The savings figures are estimates of the water that would be conserved if water utilities in each hydrologic region met the coverage requirements of the MOU. However, the MOU does recognize possible economic limitations. Section 4.5 states that:

> "A signatory water supplier will be exempt from the implementation of specific BMPs for as long as the supplier substantiates each reporting period that based upon then prevailing local conditions . . . :
>
> "A full cost-benefit analysis, performed in accordance with the principles set forth in Exhibit 3, demonstrates that either the program (i) would not be cost-effective overall when total program benefits and costs are considered; OR (ii) would not be cost-effective to the individual water supplier even after the water supplier has made a good faith effort to share costs with other program beneficiaries."

For the purposes of this study, CUWA has chosen to focus on cost-effectiveness from the perspective of the local water agency. Exhibit 3 of the MOU describes that perspective as considering the following benefits and costs:

Benefits:

a. Costs avoided by the water supplier of constructing production, transport, storage, treatment, distribution capacity, and wastewater treatment facilities, if any.

b. Operating costs avoided by the water supplier, including but not limited to, energy and labor associated with the water deliveries that no longer must be made.

c. Avoided costs of water purchases by the water supplier.

d. Environmental benefits and avoided environmental costs.

e. Revenues from other entities, including but not limited to revenue from the sale of water made available by the conservation measure and financial incentives received from other entities.

Costs:

a. Capital expenditures incurred by the water supplier for equipment or conservation devices.

b. Financial incentives to other water suppliers or retail customers.

c. Operating expenses for staff or contractors to plan, design, or implement the program.

d. Costs to the environment.

The analysis that follows makes no attempt to estimate environmental benefits and costs.

The cost-effectiveness from a local agency perspective of each BMP in each hydrologic region was estimated for each year over the 2000-2020 period. For each year in which a BMP was cost-effective in a region, it was assumed that that BMP would be fully implemented that year in that region consistent with the MOU coverage requirements. Conversely, in years in which the cost-effectiveness analysis yielded a negative result, it was assumed that, in that year in that region, the BMP would not be implemented at all. Cumulative savings in any year for each BMP represent the total of all savings attributable to current and past programs which are still producing water savings in that year.

Following are descriptions of the manner in which benefits and costs were estimated for the BMPs. Note that the economic analysis considers three alternative program designs for BMP 14. The MOU language for this BMP indicates that a utility's program shall be "at least as effective as requiring toilet replacement at time of resale." The "full MOU" savings estimates are therefore based on projections of housing turnover. However, the economic analysis can differ considerably depending on the specific program design chosen by a utility. For purposes of this analysis, three program designs were examined:

- ***"Retrofit on resale" ordinance.*** It is assumed that such a program will include an incentive to assist customers to comply. Program marketing or "search" costs are assumed to be low. Free ridership (see below) will be very low.
- ***Direct distribution program.*** This type of program will require somewhat higher search costs and have a higher incidence of free riders.
- ***Rebate program.*** Search costs are higher and will increase more rapidly over time. Free riders will be a much higher fraction of participants.

ESTIMATING ECONOMIC BENEFITS

Benefits consist of avoided capital, operating, and/or water purchase costs, and revenues from other entities. All of these are functions of the savings associated with each BMP.

Water Savings Assumptions

The assumptions regarding per-unit annual savings estimates, decay rates, natural replacement rates, and savings lives have already been discussed (see Table 2) These are shown again in Table 8 which also includes estimates of savings duration and "free ridership." "Free ridership" occurs when a customer takes advantage of a utility conservation incentive for an action the customer would have taken anyway. An example is a residential customer who would ordinarily replace his or her inefficient toilet at his or her own expense, and instead applies for and receives a rebate from the local water utility. The utility incurs a cost, but receives no incremental benefit, since the savings from that retrofit would have occurred without the program. That customer is considered a "free rider". The phenomenon of free ridership reduces a BMP's cost-effectiveness.

Table 8
MAJOR BMP SAVINGS ASSUMPTIONS FOR ECONOMIC ANALYSIS

BMP	UNIT SAVINGS	NATURAL REPLACE-MENT RATE	SAVINGS LIFE OR ANN. DECAY RATE	FREE RIDERSHIP
1 - Res. Surveys: Single Family	15 gpd per survey	NA	15% per yr	NA
1 - Res. Surveys: Multi Family	6.64 gpd per survey	NA	15% per yr	NA
2 - Res. Plumbing Retrofits	5.65 gpd per survey	10% per yr	10 years	NA
3 - System Leak Detection & Repair	NA	NA	10 *	NA
4 - Metering	15% demand reduction per meter installed	NA	50 years	NA
5 - Budgets	NA	NA	NA	NA
5 - Surveys	0.53-1.13 AFY per survey	NA	10% per yr	NA
9 - Surveys	1.27 AFY per survey	NA	12 years	NA
9 - Target	10% of 1989 baseline use	NA	NA	NA
14 - Res. ULFT Retrofits	35-45 gpd per toilet installed	4% per yr	25 years	
Ordinance				5%
Direct Distribution				20%
Rebate				50%

* *For purposes of the economic analysis, it is assumed that BMP 3 serves to accelerate repairs by 10 years.*

Marginal Water Supply Costs

As indicated above, this project focus on cost effectiveness to the local water provider. The interpretation of this is complicated by the differing institutional structures for delivering municipal water supplies throughout the state, and by different approaches taken for implementing conservation within each region. The marginal cost calculations for each region focused on the supply costs that would be avoided by those water agencies that have responsibility for implementation of conservation programs. For each of the seven hydrologic regions, the analysis focused on the larger water agencies that take water diverted from the

Bay/Delta estuary. The marginal costs for these agencies were then combined into a weighted-average regional marginal cost.

Thus, for example, the marginal supply cost in the South Coast region is based on the rate that Metropolitan Water District of Southern California (MWD) charges its member agencies, rather than MWD's own marginal cost of supply. The marginal costs for the Bay Area Water Users' Association (BAWUA) member agencies, which purchase water from the San Francisco Public Utilities Commission (SFPUC), were similarly based on the rate charged by SFPUC. On the other hand, the Santa Clara Water District (SCVWD) is a wholesale provider which assumes major or full responsibility for implementation, funding and administering the region's conservation programs for its member agencies. In this case, it is the SCVWD's own marginal supply costs that are relevant.

In the MWD and SFPUC cases, the local agency perspective does not necessarily lead to a societally-optimal level of conservation. Depending on the wholesale agency's rate structure,[13] the cost-effective level of conservation to the local agency may be larger or smaller than the level that is most beneficial to the total society. CALFED has recognized that the appropriate level of conservation may not be the same from local agency and societal perspectives. It has proposed using state and federal funding to supplement local spending when the appropriate level for local agency spending on conservation is below that which is appropriate for the wider community. MWDSC has also addressed this issue with the use of incentive payments to its local agencies. [14]

For retail agencies that make their own conservation decisions, the marginal cost is based on either the price each pays its wholesale provider, the agency's own marginal local supply, or the agency's cost of water that it imports on its own.

The supply situation in each region was assessed by reviewing agency-planning documents or conducting telephone interviews to determine the incremental supply source(s) for each agency. For many agencies the incremental supply source in some years was either the Central Valley Project (CVP) or the State Water Project (SWP).

The marginal supply costs for each region through 2040 are shown in Table 9. Detailed discussions of how the marginal costs were estimated are included as Appendix D. The avoided cost estimates are expressed in uninflated year 2000 dollars. CALFED's ongoing efforts to solve the Bay/Delta problems could ultimately lead to revisions in the marginal cost estimates.

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13 MWD's rate structure is under review and will likely be changing in the future. Its final form is at this time unknown.

14 The actual avoided cost for MWD's member agencies is therefore the sum of the MWD rate and the additional conservation financial incentive provided by MWD.

Table 9
MARGINAL SUPPLY COSTS BY REGION*

YR	BAY AREA	CENTRAL COAST	SACRA-MENTO	SAN JOAQUIN	SOUTH COAST	S. LAHONTAN	TULA
2000	$ 187.13	$ 140.72	$ 40.00	$ 121.36	$ 585.00	$ 53.00	$ 130.00
2001	$ 196.61	$ 139.25	$ 40.19	$ 122.12	$ 567.96	$ 53.26	$ 130.63
2002	$ 207.05	$ 138.91	$ 40.39	$ 122.89	$ 551.42	$ 53.52	$ 131.27
2003	$ 208.97	$ 135.54	$ 40.59	$ 123.66	$ 539.02	$ 53.78	$ 131.90
2004	$ 217.25	$ 140.20	$ 40.78	$ 124.44	$ 526.87	$ 250.93	$ 132.54
2005	$ 464.58	$ 135.78	$ 40.98	$ 125.23	$ 514.98	$ 252.15	$ 133.19
2006	$ 554.04	$ 136.66	$ 41.18	$ 126.02	$ 507.52	$ 253.38	$ 133.83
2007	$ 553.34	$ 141.20	$ 41.38	$ 126.83	$ 500.05	$ 254.61	$ 134.48
2008	$ 552.83	$ 142.33	$ 41.58	$ 127.64	$ 493.38	$ 255.84	$ 135.14
2009	$ 552.38	$ 142.70	$ 41.78	$ 128.45	$ 495.25	$ 257.08	$ 135.79
2010	$ 557.07	$ 143.06	$ 41.98	$ 129.28	$ 497.31	$ 258.33	$ 136.45
2011	$ 560.55	$ 157.46	$ 42.19	$ 130.11	$ 479.16	$ 259.59	$ 137.11
2012	$ 565.09	$ 174.44	$ 42.39	$ 130.95	$ 488.89	$ 260.85	$ 137.78
2013	$ 570.68	$ 194.44	$ 42.60	$ 131.80	$ 499.90	$ 262.11	$ 138.45
2014	$ 578.01	$ 218.03	$ 42.81	$ 132.66	$ 512.34	$ 263.39	$ 139.12
2015	$ 587.34	$ 245.85	$ 43.01	$ 133.53	$ 526.37	$ 264.66	$ 139.79
2016	$ 599.14	$ 278.68	$ 43.22	$ 134.40	$ 542.18	$ 265.95	$ 140.47
2017	$ 614.00	$ 317.43	$ 43.43	$ 135.28	$ 559.98	$ 267.24	$ 141.16
2018	$ 632.67	$ 363.17	$ 43.64	$ 136.18	$ 580.00	$ 268.54	$ 141.84
2019	$ 803.71	$ 417.18	$ 43.86	$ 137.08	$ 602.53	$ 269.84	$ 142.53
2020	$ 867.43	$ 1,090.00	$ 44.07	$ 137.99	$ 628.08	$ 271.15	$ 143.22
2021	$ 880.41	$ 1,090.00	$ 44.28	$ 138.91	$ 633.51	$ 272.47	$ 143.92
2022	$ 880.73	$ 1,090.00	$ 44.50	$ 139.84	$ 639.11	$ 273.79	$ 144.61
2023	$ 881.05	$ 1,090.00	$ 44.71	$ 140.77	$ 644.91	$ 275.12	$ 145.32
2024	$ 881.37	$ 1,090.00	$ 44.93	$ 141.72	$ 650.89	$ 276.45	$ 146.02
2025	$ 881.70	$ 1,090.00	$ 45.15	$ 142.68	$ 657.06	$ 277.80	$ 146.73
2026	$ 882.04	$ 1,090.00	$ 45.37	$ 143.64	$ 663.42	$ 279.14	$ 147.44
2027	$ 882.38	$ 1,090.00	$ 45.59	$ 144.62	$ 669.96	$ 280.50	$ 148.16
2028	$ 882.72	$ 1,090.00	$ 45.81	$ 145.61	$ 676.69	$ 281.86	$ 148.88
2029	$ 883.07	$ 1,090.00	$ 46.03	$ 146.61	$ 683.60	$ 283.23	$ 149.60
2030	$ 883.42	$ 1,090.00	$ 696.25	$ 147.61	$ 690.70	$ 284.60	$ 150.33
2031	$ 883.78	$ 1,090.00	$ 696.48	$ 148.63	$ 697.99	$ 285.99	$ 151.06

YR	BAY AREA	CENTRAL COAST	SACRA-MENTO	SAN JOAQUIN	SOUTH COAST	S. LAHONTAN	TULA
Continued							
2032	$ 884.15	$ 1,090.00	$ 696.70	$ 149.66	$ 705.46	$ 287.37	$ 151.79
2033	$ 884.52	$ 1,090.00	$ 696.93	$ 150.70	$ 713.12	$ 288.77	$ 152.53
2034	$ 884.89	$ 1,090.00	$ 697.16	$ 151.76	$ 720.97	$ 290.17	$ 153.27
2035	$ 885.27	$ 1,090.00	$ 697.39	$ 152.82	$ 729.01	$ 291.58	$ 154.01
2036	$ 885.66	$ 1,090.00	$ 697.62	$ 153.89	$ 737.23	$ 293.00	$ 154.76
2037	$ 886.05	$ 1,090.00	$ 697.85	$ 154.98	$ 745.65	$ 294.42	$ 155.51
2038	$ 886.45	$ 1,090.00	$ 698.08	$ 156.08	$ 754.25	$ 295.85	$ 156.27
2039	$ 886.85	$ 1,090.00	$ 698.31	$ 157.19	$ 763.05	$ 297.28	$ 157.02
2040	$ 887.26	$ 1,090.00	$ 698.55	$ 158.31	$ 772.04	$ 298.73	$ 157.79

* *All costs expressed in year 2000 dollars.*

Avoided Wastewater Costs

Section 4.5(a) of the MOU conditions exemption from any BMP on the utility making "a good faith effort to share costs with other program beneficiaries." Perhaps the most likely beneficiary aside from the water agency itself is the local wastewater utility. In addition to water supply costs, indoor water savings that result from BMPs may avoid wastewater capital and/or operating costs. While it was impossible to estimate these in detail, an attempt was made to develop a reasonable statewide estimate of the annual per-acre-foot avoided wastewater costs.

The reduction of wastewater flows can reduce operating costs for collection, treatment and disposal systems, including reduced energy, chemical and labor costs. These avoided operational costs are assumed to be applicable to all wastewater utilities.. There is also the potential to delay the need for, or reduce the size of, capital improvements. However, these capital savings would only apply to wastewater utilities with a projected need for expanded wastewater treatment and/or disposal capacity.

Potentially-avoided capital costs include:

- Extended lives of pumping stations and trunk sewers;
- Delayed expansion of treatment plant processes; and
- Extended life of treated wastewater disposal systems.

The trunk sewer collection system is sized to accommodate wet weather flows. Therefore, the projected water conservation savings will not have a significant impact on the conveyance capacity of the trunk sewer. However, for a community that is projecting a need for expanded wastewater treatment and disposal capacity, water conservation can result in significant capital cost savings associated with the reduction or delay of these capital facilities.

As summarized in Table 10, for a growing community, the combined annualized cost savings for delay of capital facilities ranges from $100,000 to $200,000 per mgd per year of permanent reduction in wastewater flows. This is equivalent to $98 - $196 per acre-foot of indoor conservation savings.

Table 10
SUMMARY OF WASTEWATER UTILITY SAVINGS DUE TO WATER CONSERVATION
(YEAR 2000 DOLLARS)

CATEGORY	PROJECTED SAVINGS ($/YR/MGD)	PROJECTED SAVINGS ($/YR/GPD)	PROJECTED SAVINGS ($/YR/AF)
Avoided Capital Facilities	$100,000 - $200,000	$0.10 - $0.20	$98 - $196
Avoided Operational Costs	$10,000 - $20,000	$0.01 - $0.02	$9 - $18
Totals	$110,000 - $220,000	$0.11 - $0.22	$107 - $214

For a community that has does not have a need for expanded wastewater treatment and disposal capacity, the savings would be limited to avoided operational costs, ranging from $10,000 to $20,000 per mgd per year of permanent reduction in wastewater flows, or $9 - $18 per acre-foot of indoor conservation savings.

For the purpose of this analysis, it was assumed that half the wastewater agencies did, in fact, avoid capital expenditures. Using the midpoint of each avoided cost range $147/AF capital and $13.50/AF operating), the estimated avoided wastewater cost assumed for all indoor savings is:

½ x $147 + $13.50 = $87 per acre-foot

This assumption is obviously one that should be refined in future analyses.

ESTIMATING ECONOMIC COSTS

Table 11 shows the BMP cost assumptions expressed in year 2000 dollars, with annual real escalation rates shown for both administrative and incentive costs. It is assumed that direct costs do not escalate in real terms. The real escalation in administrative and incentive costs is intended to reflect increasing "search" and incentive requirements as it becomes more difficult to induce customers to enroll in a BMP.[15] For most BMPs, a 4% annual real escalation rate is assumed for both of these cost components, equivalent to a 50% increase after 10 years. The exceptions are the ordinance and direct distribution variants of BMP 14, the ULFT retrofit program, for which 1% and 2% real escalation rates are assumed respectively.[16]

Table 11
BMP COST ASSUMPTIONS (YEAR 2000 DOLLARS)

BMP	UNITS	DIRECT COSTS	ADMINISTRATION		INCENTIVES		TOTAL
			COST	ANNUAL REAL ESCALATION	COST	ANNUAL REAL ESCALATION	YEAR 2000
1 (Sf)	$ per survey	$100	$25	4%	$0		$125
1 (Mf)	$ per survey	$300	$30	4%	$0		$330
2	$ per household	$11	$1	4%	$0		$12
3	$ per acre-foot annual savings	$1,656		0	$0		$1,656
4	$ per meter installed	$600 plus $4 per year read costs		0	$0		$670
5 (Survey)	$ per survey	$300	$200	4%	$750	4%	$1,250
9 (Survey)	$ per survey	$1,000	$200	4%	$2,500	4%	$3,700
14 (Sf)							
▪ Ordinance	$ per toilet installed	$0	$10	1%	$50	1%	$60
▪ Direct Distribution	$ per toilet installed	$107		2%	$0		$107
▪ Simple Rebate	$ per toilet installed	$0	$25	4%	$75	4%	$100
14 (Mf)							
▪ Ordinance	$ per toilet installed	$0	$10	1%	$50	0	$60
▪ Direct Distribution	$ per toilet installed	$107		2%	$0		$107
▪ Simple Rebate	$ per toilet installed	$0	$25	4%	$75	4%	$100

[15] In other words, once the "low-hanging fruit" is picked, the less accessible fruit becomes more expensive to harvest.

[16] Neither of these variants can be expected to require as rapid an increase in search costs or incentives to continue to attract new participants.

COST-EFFECTIVE PROGRAM IMPLEMENTATION YEARS

Based on the foregoing benefit and cost assumptions, Table 12 shows the ranges of years for which each analyzed BMP is cost-effective. Two ranges are shown for each BMP. One ("water & wastewater") assumes that the water provider is successful in obtaining contributions from the local wastewater utility up to the full economic wastewater benefit, as described above. The other ("water only") is based only on the benefits to the water utility. Several interesting results emerge:

- ***Variation Among BMPs.*** While some BMPs (e.g. BMP 14 implemented through an ordinance) are cost-effective in most or all regions for most or all years, others (e.g. BMP 1) are expected to be cost-effective in few if any regions/years. These differences reflect the relationship between BMP costs and the stream of avoided cost benefits.

- ***Variation Across Regions.*** For many BMPs, the years in which implementation is expected to be cost-effective differs considerably from region to region, largely reflecting the avoided cost differences across regions. Thus, for example, the surveys of commercial customers called for in BMP 9 are cost-effective for virtually the entire period in the San Francisco Bay and South Coast regions, but are not cost-effective at all in the Tulare Lake, Sacramento River, and San Joaquin River regions.

- ***Participation by Wastewater Utilities.*** Participation by wastewater utilities increases the span of years in which the program is cost-effective. Depending on the region and the BMP, the magnitude of this expansion varies.

- ***BMP 14 Differences.*** The manner in which the water provider chooses to implement BMP 14 dramatically affects the cost-effectiveness of this BMP. The lower costs and free ridership percentages make the ordinance highly cost-effective across virtually all years in all regions. In contrast, the more traditional rebate program shows much more spotty cost-effectiveness results, with some regions showing no cost-effectiveness across the period. Direct distribution programs fall between these two extremes.

Table 12
BMP COST-EFFECTIVENESS YEARS BY REGION

BMP	CENTRAL COAST		SF BAY		SOUTH COAST		TULARE LAKE		SAC RIVER		SAN JOAQUIN R.		S. LAHONTAN	
	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY
1 (single family)	None	None	None	None	None	None	None	None	None	None	None	None	None	None
1 (multi-family)	None	None	None	None	None	None	None	None	None	None	None	None	None	None
2 (single family)	2011-2020	2012-2020	2000-2020	2003-2020	2000-2020	2000-2020	None	None	None	None	None	None	None	None
2 (multi-family)	2014-2020	2015-2020	2007-2020	2011-2020	2000-2003; 2010-2020	None	None	None	None	None	None	None	None	None
3		2007-2020		2000-2020		2000-2020		2000-2020		2008-2020		2000-2020		2002-2020
4							None		None		None			
5 (budget) *		2000-2020		2000-2020		2000-2020		2000-2020		2000-2020		2000-2020		2000-2020
5 (survey)		2000-2020		2000-2020		2000-2020		None		None		None		2000-2013
9	2008-2020	2009-2020	2000-2020	2001-2020	2000-2020	2000-2020	None	None	None	None	None	None	2004-2011	None

Continued

BMP	CENTRAL COAST		SF BAY		SOUTH COAST		TULARE LAKE		SAC RIVER		SAN JOAQUIN R.		S. LAHONTAN	
	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY	WATER & WASTE WATER	WATER ONLY
14														
▪ Ordinance SF	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2004-2020	2012-2020	2000-2020	2000-2020	2000-2020	2000-2020
▪ Ordinance MF	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2011-2020	2000-2020	2000-2020	2000-2020	2000-2020
▪ Direct SF	2000-2020	2002-2020	2000-2020	2000-2020	2000-2020	2000-2020	None	None	2015-2020	2019-2020	None	None	2001-2020	None
▪ Direct MF	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	2000-2020	None	None	2014-2020	2018-2020	2007-2020	None	2000-2020	2002-2020
▪ Rebate SF	2009-2020	2014-2020	2000-2020	2000-2020	2000-2013	2000-2008	None	None	None	None	None	None	None	None
▪ Rebate MF	2002-2020	2006-2020	2000-2020	2000-2020	2000-2020	2000-2017	None	None	None	None	None	None	None	None

* *It is assumed that the landscape budget called for in BMP 5 for dedicated-meter customers is cost-effective in all years in all regions.*

ECONOMIC SAVINGS

Tables 13 and 14 compare the annual "full MOU" and economic gross and net savings potential across all regions and BMPs for each year through 2020.[17] In both tables, the economic savings potential is shown assuming each of the three BMP 14 (ULFT retrofit) implementation approaches. The tables assume that, in each year for which a BMP is not cost-effective in a region, the water providers in that region would take advantage of the MOU exemption provision and not implement that BMP. The sole difference between the two tables is that Table 13 is based only on cost-effective contributions from water suppliers, while Table 14 also assumes contributions from wastewater utilities.

By comparing the two tables, it is obvious that the impact of wastewater contributions on increasing economic savings is fairly insignificant.[18] In 2007, the consideration of wastewater contributions increases cost-effective conservation by 7 acre-feet (1%). In 2020, the increase is 12 acre-feet (also about 1%).[19] Therefore, the remaining tables of economic savings are based on water utility contributions only. It should, however, be recalled that the estimate of wastewater savings is based on a crude average of statewide capital and operating costs. Sensitivity analysis of the results to these assumptions should be carried out, including some estimates of the environmental costs that are avoided as a result of reduced discharges.

17 Footnotes assume MOU renewal after year 2007.

18 This is not to say the magnitude of the contributions themselves is insignificant, only their impact on the level of cost-effective savings.

19 These estimates assume that BMP 14 is implemented as a simple rebate program.

Table 13

COMPARISON OF ANNUAL SAVINGS FROM ALL BMPS ACROSS ALL HYDROLOGIC REGIONS: FULL MOU IMPLEMENTATION VS. ECONOMIC POTENTIAL ASSUMING NO WASTEWATER UTILITY CONTRIBUTION (000 AF)

YR	FULL MOU IMPLEMENTATION		ECONOMIC POTENTIAL					
			ASSUMING BMP 14 ORDINANCE IMPLEMENTATION		ASSUMING BMP 14 DIRECT DISTRIBUTION IMPLEMENTATION		ASSUMING BMP 14 SIMPLE REBATE IMPLEMENTATION	
	GROSS	NET	GROSS	NET	GROSS	NET	GROSS	NET
1999	268	98	244	74	241	71	242	71
2000	371	181	315	125	310	121	311	121
2001	469	261	383	176	378	170	379	171
2002	562	338	450	225	444	219	445	220
2003	652	412	513	272	506	266	507	266
2004	739	482	573	317	566	310	567	311
2005	822	551	631	360	624	353	624	353
2006	902	618	686	402	679	394	679	395
2007	979	681	740	443	732	435	733	435
2008	1011	701	772	463	764	454	765	455
2009	1044	722	805	484	797	475	795	474
2010	1075	742	837	504	828	495	825	492
2011	1098	755	860	517	851	508	846	503
2012	1120	766	883	529	873	519	867	513
2013	1140	777	902	539	892	528	884	521
2014	1159	786	920	547	909	536	900	528
2015	1177	795	936	555	925	544	916	535
2016	1193	804	951	562	940	550	930	541
2017	1209	812	964	566	952	554	942	544
2018	1224	819	976	570	964	558	952	547
2019	1239	826	979	566	975	563	962	550
2020	1252	833	982	563	986	567	972	552

Table 14

COMPARISON OF ANNUAL SAVINGS FROM ALL BMPS ACROSS ALL HYDROLOGIC REGIONS: FULL MOU IMPLEMENTATION VS. ECONOMIC POTENTIAL ASSUMING MAXIMUM COST-EFFECTIVE CONTRIBUTION FROM WASTEWATER UTILITY (000 AF)

YR	FULL MOU IMPLEMENTATION		ECONOMIC POTENTIAL					
			ASSUMING BMP 14 ORDINANCE IMPLEMENTATION		ASSUMING BMP 14 DIRECT DISTRIBUTION IMPLEMENTATION		ASSUMING BMP 14 SIMPLE REBATE IMPLEMENTATION	
	GROSS	NET	GROSS	NET	GROSS	NET	GROSS	NET
1999	268	98	248	77	244	74	244	74
2000	371	181	321	131	316	127	316	127
2001	469	261	390	183	385	177	384	177
2002	562	338	457	232	450	225	450	225
2003	652	412	521	280	513	272	513	272
2004	739	482	582	326	573	317	573	317
2005	822	551	641	371	631	360	631	360
2006	902	618	698	414	687	402	687	402
2007	979	681	753	455	741	444	740	443
2008	1011	701	786	476	774	464	773	463
2009	1044	722	820	499	808	486	807	485
2010	1075	742	853	520	840	507	839	506
2011	1098	755	875	531	861	518	861	518
2012	1120	766	895	541	881	527	881	527
2013	1140	777	914	550	900	536	900	536
2014	1159	786	931	558	917	544	916	543
2015	1177	795	947	566	934	552	931	549
2016	1193	804	962	573	948	559	945	555
2017	1209	812	974	577	960	563	955	558
2018	1224	819	986	581	972	566	965	560
2019	1239	826	989	576	974	562	967	555
2020	1252	833	992	573	977	557	969	549

The impact of these economic exemptions for key years is summarized in Table 15.[20] About 75% of gross savings and 65% of net savings are estimated to be economic.

[20] Note that this and subsequent tables assume that implementation of BMP 14 is through a simple rebate.

Tables 16 and 17 break down the savings by BMP and by region respectively.

Table 15
IMPACT OF ECONOMIC EXEMPTIONS ON SAVINGS POTENTIAL

YEAR	GROSS SAVINGS		NET SAVINGS	
	FULL-MOU (000 AF)	ECONOMIC (000 AF)	FULL-MOU (000 AF)	ECONOMIC (000 AF)
2007	979	733 *(75%)*	681	435 *(64%)*
2020	1252	957 *(76%)*	833	538 *(65%)*

Table 16
COMPARISON OF SAVINGS BY BMP FOR ALL HYDROLOGIC REGIONS: FULL MOU IMPLEMENTATION VS. ECONOMIC POTENTIAL (000 AF)

BMP	2007				2020			
	FULL MOU		ECONOMIC POTENTIAL		FULL MOU		ECONOMIC POTENTIAL	
	GROSS	NET	GROSS	NET	GROSS	NET	GROSS	NET
1	11	11	0	0	16	16	0	0
2	82	3	80	1	95	1	95	0
3	168	168	144	144	195	195	195	195
4	87	87	0	0	120	120	0	0
5 (budget) *	83	83	83	83	95	95	95	95
5 (survey)	64	64	46	46	103	103	71	71
9	157	157	68	68	196	196	113	113
14	327	108	311	93	432	107	403	78
Total	**979**	**681**	**732**	**435**	**1,252**	**833**	**972**	**552**

* *It is assumed that the landscape budget called for in BMP 5 for dedicated-meter customers is cost-effective in all years in all regions.*

Table 17
COMPARISON OF SAVINGS BY HYDROLOGIC REGION FOR ALL BMPS: FULL MOU IMPLEMENTATION VS. ECONOMIC POTENTIAL (000 AF)

REGION	2007				2020			
	FULL MOU		ECONOMIC POTENTIAL		FULL MOU		ECONOMIC POTENTIAL	
	GROSS	NET	GROSS	NET	GROSS	NET	GROSS	NET
Central Coast	32	21	17	6	42	26	40	24
SF Bay	157	94	139	77	194	106	182	93
South Coast	500	326	466	291	626	380	581	335
Tulare Lake	102	87	36	22	140	120	48	27
Sacramento	103	80	31	9	133	101	62	30
San Joaquin	66	54	31	20	90	73	41	24
South Lahontan	19	19	12	12	28	28	18	18
Total	**979**	**681**	**732**	**437**	**1,253**	**834**	**972**	**551**

REQUIRED ECONOMIC CONTRIBUTIONS

For years in which a BMP in a particular region is cost-effective to the local agency, it is assumed that utilities in that region will implement that BMP to the level called for in the MOU with no additional outside funding. Note that the cost-effectiveness test assumes that the agency has made good-faith efforts to share costs with other benefited entities. In addition to wastewater agencies, this may include energy utilities, non-profit organizations, and other water utilities.

However, for those years in which a BMP in a particular region is not cost-effective despite such good-faith efforts, it is assumed that utilities will exempt themselves from implementation *unless they receive a financial contribution that would reduce the net cost to the utility at least to the present value of the benefits*. Table 18 breaks down these annual "break-even" contributions by BMP, while Table 19 breaks them down by hydrologic region.

The tables show that the economic shortfall is substantial. In constant year 2000 dollars, approximately $92 million is required this year. This dips to about $65 million annually in 2010 before increasing again to close to $85 million annually in 2020. Based on estimated wastewater utility avoided costs, wastewater agencies could cover about $10-$15 million of this annual requirement.

Table 18
Required Annual Contributions to Achieve Full MOU Implementation Savings Potential* by BMP ($millions)

BMP	2000		2005		2010		2015		2020	
	NET OF WATER & WASTE WATER	NET OF WATER ONLY	NET OF WATER & WASTE WATER	NET OF WATER ONLY	NET OF WATER & WASTE WATER	NET OF WATER ONLY	NET OF WATER & WASTE WATER	NET OF WATER ONLY	NET OF WATER & WASTE WATER	NET OF WATER ONLY
1	$23.4	$25.3	$23.7	$25.6	$27.7	$29.9	$27.7	$29.9	$27.7	$29.9
2	$1.1	$1.7	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
3	$2.2	$2.2	$1.0	$1.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
4	$48.6	$48.6	$46.6	$46.6	$11.7	$11.7	$12.1	$12.1	$12.2	$12.2
5 (budget)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
5 (survey)	$1.8	$1.8	$2.4	$2.4	$3.7	$3.7	$5.4	$5.4	$5.9	$5.9
9	$2.4	$8.0	$3.6	$8.1	$6.0	$10.5	$10.5	$15.2	$11.7	$16.4
SUBTOTAL	$79.6	$87.6	$77.3	$83.7	$49.2	$55.9	$55.7	$62.6	$57.4	$64.4
BMP 14 Ordinance	$0.1	$1.6	$0.0	$1.4	$0.0	$0.6	$0.0	$0.3	$0.0	$0.3
TOTAL	$79.6	$89.2	$77.3	$85.1	$49.2	$56.5	$55.7	$62.9	$57.4	$64.7
BMP 14 Direct	$2.7	$5.0	$2.5	$4.6	$1.6	$3.8	$0.6	$1.8	$0.6	$1.6
TOTAL	$82.3	$92.6	$79.8	$88.3	$50.8	$59.7	$56.3	$64.5	$58.1	$66.0
BMP 14 Rebate	$4.1	$5.6	$5.3	$6.8	$6.5	$9.3	$11.8	$16.7	$13.5	$19.5
TOTAL	$83.6	$93.2	$82.6	$90.5	$55.7	$65.2	$67.5	$79.3	$70.9	$83.8

* *Required contributions expressed in constant year 2000 dollars.*

Table 19

REQUIRED ANNUAL CONTRIBUTIONS TO ACHIEVE FULL MOU IMPLEMENTATION SAVINGS POTENTIAL* BY REGION ($MILLIONS)

REGION	2000		2005		2010		2015		2020	
	NET OF WATER & WASTE WATER	NET OF WATER ONLY	NET OF WATER & WASTE WATER	NET OF WATER ONLY	NET OF WATER & WASTE WATER	NET OF WATER ONLY	NET OF WATER & WASTE WATER	NET OF WATER ONLY	NET OF WATER & WASTE WATER	NET OF WATER ONLY
Central Coast	$1.8	$2.9	$1.7	$2.7	$1.1	$1.4	$0.7	$0.8	$0.7	$0.7
SF Bay	$5.7	$7.2	$4.8	$5.2	$5.0	$5.4	$4.6	$5.1	$4.5	$5.0
South Coast	$12.1	$13.4	$12.9	$14.1	$15.3	$17.9	$18.7	$23.5	$19.9	$25.8
Tulare Lake	$20.5	$22.7	$21.5	$23.7	$12.5	$15.1	$16.9	$19.4	$18.0	$20.5
Sacramento	$31.9	$33.7	$30.3	$32.0	$14.9	$16.8	$16.9	$18.8	$17.4	$19.3
San Joaquin	$10.8	$11.9	$11.2	$12.2	$6.7	$7.9	$8.8	$10.0	$9.3	$10.5
South Lahontan	$0.7	$1.5	$0.1	$0.6	$0.1	$0.7	$0.9	$1.7	$1.2	$2.0
TOTAL	**$83.6**	**$93.2**	**$82.6**	**$90.5**	**$55.7**	**$65.2**	**$67.5**	**$79.3**	**$70.9**	**$83.8**

* *Required contributions expressed in constant year 2000 dollars..*

Figures 3 and 4 illustrate how these contributions are split among BMPs and regions.[21] Figure 3 shows that, in early years, the largest contributions by far are associated with BMP 4, which requires individual metering of all accounts within a 10-year period. By 2010, this contribution falls off substantially as the existing unmetered accounts are assumed to be retrofitted by then. BMP 1 (residential surveys) also requires a large contribution throughout the period. BMPs 9 and 14 show increasing requirements through the period.

[21] Both of these charts show contributions in excess of the economic expenditure by water utilities only.

Figure 3.Required Contributions by BMP

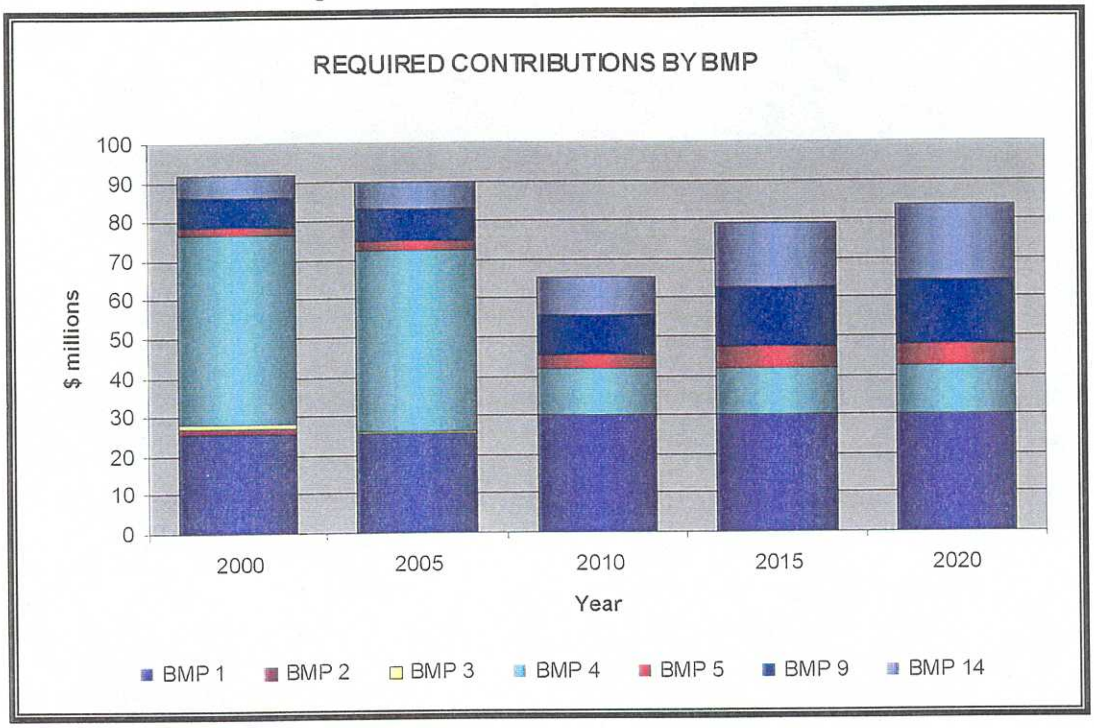
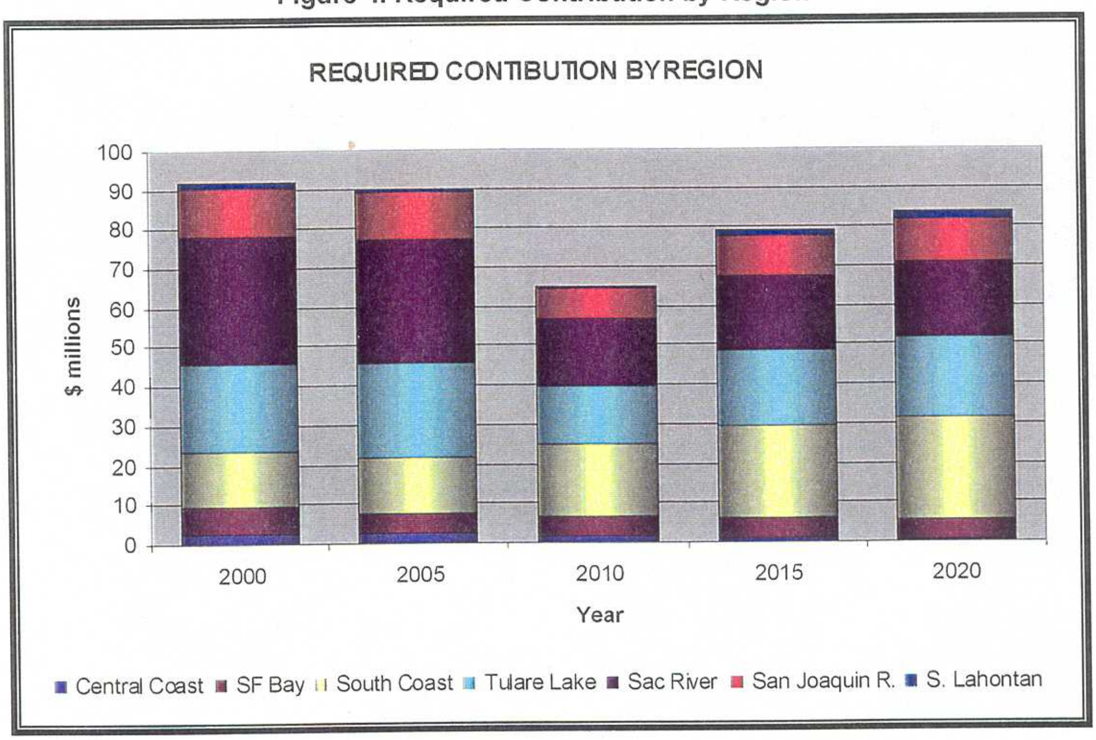


Figure 4. Required Contribution by Region



On a regional basis, Figure 4 shows the largest requirements are in the three regions (Sacramento River, San Joaquin River, and Tulare Lake) in which individual metering is an important issue. For a different reason, namely its large population, the South Coast region also requires large contributions.

UNIT COSTS OF REQUIRED CONTRIBUTIONS

State policymakers must compare the cost required per unit of conserved water for each BMP to supplement the cost-effective expenditures in each region. This is accomplished by examining a summary index known as the "unit cost". The unit cost is simply defined as follows: [22]

$$UnitCost = \frac{EconomicShortfall}{\Pr esentValueWaterSavings}$$

Figure 5 shows these real-dollar unit costs for year 2000, while Figure 6 shows them for year 2020. Where applicable, the charts distinguish between single-family and multi-family customers because of the potentially important differences between the unit BMP costs to these classes.

The chart indicates that BMP 1 (residential surveys) is, far and away, the most expensive per unit of water saved, with costs ranging in excess of $1,500 per acre-foot. This is followed by BMP 2 (residential plumbing retrofit) with unit costs for many regions in the $400-$600 range. Currently, BMPs 3, 4, 5, 9, and the multi-family portion of BMP 14 show unit costs less than $100 per acre-foot for virtually all regions, with BMP 14 single-family retrofits ranging up to $200.

Table 20 presents the unit cost information in a different fashion. For each BMP, the table shows the 2007 and 2020 savings for supplemental investments for ranges of unit costs. The table shows that the vast majority of savings can be achieved through supplemental investments in BMPs with unit costs under $200 per acre-foot.

[22] Although the present value of a non-monetary quantity such as water savings does not have meaning in and of itself, the derivation of this expression is actually based on the present value of the avoided water costs. It can be shown mathematically that such unit costs are a valid and useful way to compare the unit cost per unit of water savings or production for diverse resource alternatives. They are commonly used for that purpose.

Figure 5. Unit Costs of BMPs: Year 2000

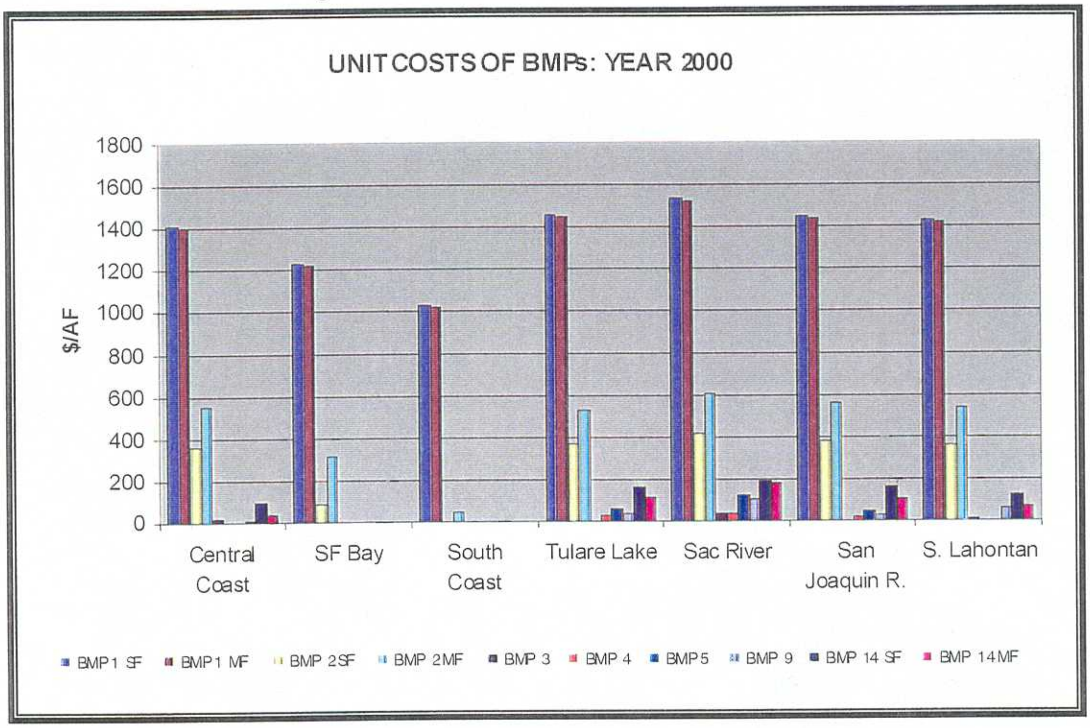


Figure 6. Unit Costs of BMPs: Year 2020

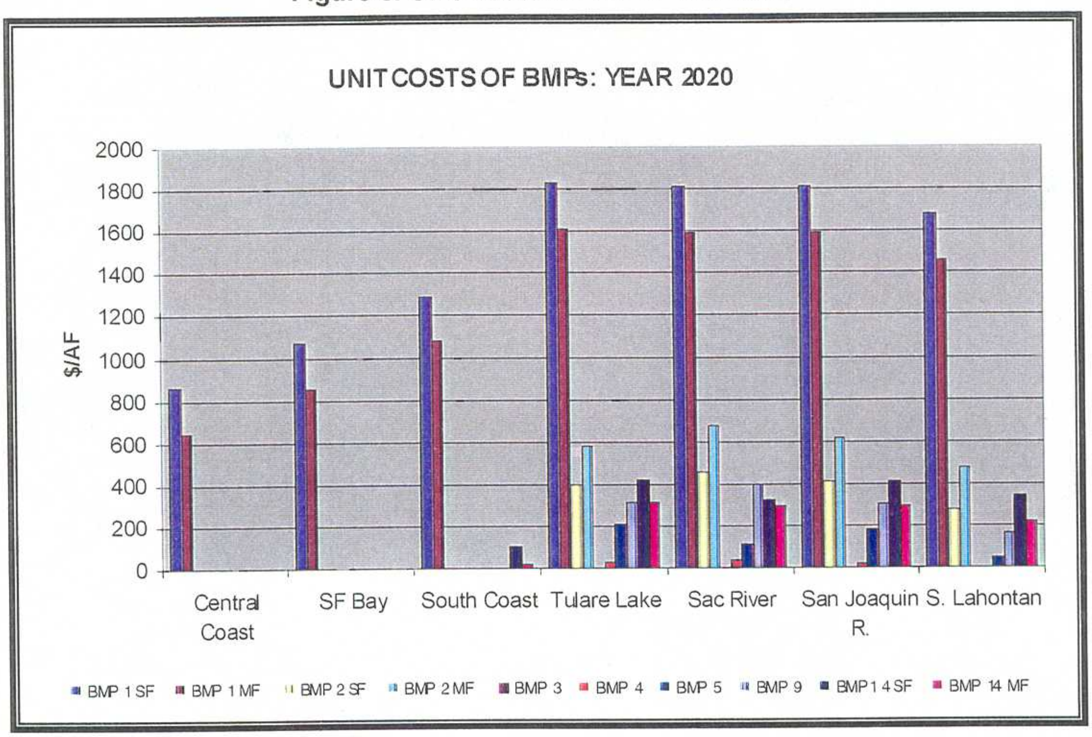


Table 20
CONSERVATION POTENTIAL ATTRIBUTABLE TO FINANCIAL CONTRIBUTIONS

	FINANCIAL CONTRIBUTION AND RESULTING 2007 & 2020 SAVINGS (AF)							
BMP	$0-$200		$200-$400		$400 +		TOTAL	
	2007	2020	2007	2020	2007	2020	2007	2020
1. Water Survey	0	0	0	0	11,000	16,000	11,000	16,000
2. Residential Plumbing Retrofit	1,000	0	1,000	0	2,000	1,000	4,000	1,000
3. Audits, Leak Detection and Repair	24,000	0	0	0	0	0	0	0
4. Metering	87,000	120,000	0	0	0	0	87,000	120,000
5. Landscape Conservation	17,000	32,000	0	0	0	0	17,000	32,000
9 Commercial, Industrial, and Institutional	88,000	83,000	0	0	0	0	39,000	52,000
14. ULFT Replacement	15,000	43,000	0	0	0	0	15,000	43,000
TOTAL	**232,000**	**278,000**	**1,000**	**0**	**13,000**	**17,000**	**246,000**	**295,000**

CONCLUSIONS

Subject to the caveats and limitations discussed in the Introduction, the key conclusions of the CUWA study of BMP savings potential are as follows:

- Year 2007 gross and net savings assuming full MOU implementation are estimated as **979,000** and **681,000** acre-feet respectively. Corresponding figures for 2020, assuming MOU renewal, are **1,252,000** and **802,000** acre-feet. If the MOU is not renewed, 2020 gross and net savings decline to **768,000** and **351,000** acre-feet respectively. Thus, in both years, about two-thirds of the potential savings from quantifiable BMPs are economic to local agencies.

- The year 2020 savings estimates are approximately 22% below the appropriately-adjusted DWR estimates for the same year.

- Year 2007 gross and net savings reflecting economic exemptions are estimated as **732,000** and **437,000** acre-feet respectively. Assuming MOU renewal, corresponding figures for 2020 are **972,000** and **552,000** acre-feet.

- Contributions from wastewater utilities increase the economically-achievable savings somewhat, but not substantially.

- The impacts of economics varies substantially from BMP to BMP and across hydrologic regions.

- Required contributions to achieve full-MOU coverage levels range from $92 million in year 2000 to $65 million in 2010 and $85 million in 2020. These amounts are all expressed in constant year 2000 dollars. The largest share of these contributions are in the Central Valley to pay for individual metering, as called for by BMP 4. BMP 1 (residential surveys) also requires a large contribution throughout the period. Of course, non-economic incentives (e.g. legislation, regulation) could potentially replace a portion of these economic contributions.)

- The return on these contributions varies substantially by BMP and region. BMPs 3, 4, 5, and 9 show the highest returns (i.e. lowest unit conservation costs). BMPs 1 and 2 show the lowest returns (i.e. highest unit costs). These variations can be used to guide future state investments in urban conservation.

APPENDICES

APPENDIX A
DESCRIPTION OF FULL-MOU SAVINGS MODELS

BMP 1

Savings potential is based on BMP 1's coverage requirement that 15% of single-family and 15% of multi-family residences receive a water use survey within 10 years from the date implementation to commence. Savings from home surveys potentially overlap with BMPs 2 and 14, creating a double counting problem. This issue is addressed through the assumption for savings per survey. The model below can calculate (1) annual savings assuming agencies stop distribution program after 15% coverage is reached and (2) annual savings assuming agencies continue distribution program after 15% coverage is reached. Model will be developed in Excel 97-98.

Key Model Assumptions: Savings per survey estimate needs to account for potential double-counting with other BMPs. We assume a constant annual survey rate. The rate at which savings from surveys decay over time has significant implications for total program savings. There is not much data to guide this assumption. The model is constructed to allow different decay rates to be tested. Calculating the coverage requirement depends on whether coverage is expressed as a percent of the beginning housing stock, ending housing stock, or some value in between. Since the MOU does not currently define the base year for calculating coverage, the model allows this assumption to be set by the user.

Indexes

Table A - 1. Index Definitions

INDEX NAME	DEFINITION
i	Year = 1991...2020
j	Region = the seven regions
sf	Single-family residence
mf	Multi-family residence

Variables

Table A - 2. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
$H_{sf,j}$	Stock of single-family houses in region j at start of implementation	Housing Census
$H_{mf,j}$	Stock of multi-family units in region j at start of implementation	Housing Census
$g_{sf,j}$	Growth rate of single-family houses in region j	Based on DOF population forecasts
$g_{mf,j}$	Growth rate of multi-family houses in region j	Based on DOF population forecasts
$COVERAGE_{sf,j}$	Percent of single family residences that must receive surveys within 10 years of date implementation to start	15% per MOU Exhibit 1
$COVERAGE_{mf,j}$	Percent of multi family residences that must receive surveys within 10 years of date implementation to start	15% per MOU Exhibit 1
α_{sf}	Percent of single-family coverage receiving a survey in any year	Model assumption. We assume 10% so that the coverage requirement is reached in 10 years, per MOU Exhibit 1
α_{mf}	Percent of multi-family coverage receiving a survey in any year	Model assumption. We assume 10% so that the coverage requirement is reached in 10 years, per MOU Exhibit 1
σ_{sf}	Average initial savings per survey for single-family houses	CUWCC Data
σ_{mf}	Average initial savings per survey for multi-family residences	Same as above
δ_{sf}	Annual rate of savings decay for single-family houses	Same as above
δ_{mf}	Annual rate of savings decay for multi-family houses	Same as above
$Savings_{sf,i,j}$	Single-family savings in year i, region j	Model formula
$Savings_{mf,i,j}$	Multi-family savings in year i, region j	Model formula

Formulas

Table A - 3. Model Specification:
Program Discontinued After Coverage Met / Coverage Based on Initial Stock of Housing

VARIABLE	IS EQUAL TO
$Coverage_{sf,j}$	$0.15 * H_{sf,j}$
$Coverage_{mf,j}$	$0.15 * H_{mf,j}$
$Savings_{sf,i,j}$	$\sigma_{sf} \cdot \alpha_{sf} \cdot COVERAGE_{sf,j} \cdot \sum_{t=1}^{i}(1-\delta_{sf})^{t-1}$ if $i \le 10$ $\sigma_{sf} \cdot \alpha_{sf} \cdot COVERAGE_{sf,j} \cdot \sum_{t=1}^{i}(1-\delta_{sf})^{(t-1)+(i-10)}$ if $i > 10$
$Savings_{mf,i,j}$	$\sigma_{mf} \cdot \alpha_{mf} \cdot COVERAGE_{mf,j} \cdot \sum_{t=1}^{i}(1-\delta_{mf})^{t-1}$ if $i \le 10$ $\sigma_{mf} \cdot \alpha_{mf} \cdot COVERAGE_{mf,j} \cdot \sum_{t=1}^{i}(1-\delta_{mf})^{(t-1)+(i-10)}$ if $i > 10$

Table A - 4. Model Specification:
Program Discontinued After Coverage Met / Coverage Based on Ending Stock of Housing

VARIABLE	IS EQUAL TO
$Coverage_{sf,j}$	$0.15 \cdot H_{sf,j} \cdot 1 + g_{sf,j}{}^{10}$
$Coverage_{mf,j}$	$0.15 \cdot H_{mf,j} \cdot 1 + g_{mf,j}{}^{10}$
$Savings_{sf,i,j}$	$\sigma_{sf} \cdot \alpha_{sf} \cdot COVERAGE_{sf,j} \cdot \sum_{t=1}^{i}(1-\delta_{sf})^{t-1}$ if $i \le 10$ $\sigma_{sf} \cdot \alpha_{sf} \cdot COVERAGE_{sf,j} \cdot \sum_{t=1}^{i}(1-\delta_{sf})^{(t-1)+(i-10)}$ if $i > 10$
$Savings_{mf,i,j}$	$\sigma_{mf} \cdot \alpha_{mf} \cdot COVERAGE_{mf,j} \cdot \sum_{t=1}^{i}(1-\delta_{mf})^{t-1}$ if $i \le 10$ $\sigma_{mf} \cdot \alpha_{mf} \cdot COVERAGE_{mf,j} \cdot \sum_{t=1}^{i}(1-\delta_{mf})^{(t-1)+(i-10)}$ if $i > 10$

Table A - 5. Model Specification:
Program Continued After Coverage Met / Coverage Based on Initial Stock of Housing

VARIABLE	IS EQUAL TO
$Coverage_{sf,j}$	$0.15 * H_{sf,j}$
$Coverage_{mf,j}$	$0.15 * H_{mf,j}$
$Savings_{sf,i,j}$	$\sigma_{sf} \cdot \alpha_{sf} \cdot COVERAGE_{sf,j} \cdot \sum_{t=1}^{i} (1-\delta_{sf})^{t-1}$
$Savings_{mf,i,j}$	$\sigma_{mf} \cdot \alpha_{mf} \cdot COVERAGE_{mf,j} \cdot \sum_{t=1}^{i} (1-\delta_{mf})^{t-1}$

Table A - 6. Model Specification:
Program Continued After Coverage Met / Coverage Based on Ending Stock Of Housing

VARIABLE	IS EQUAL TO
$Coverage_{sf,j}$	$0.15 \cdot H_{sf,j} \cdot 1 + g_{sf,j}{}^{10}$
$Coverage_{mf,j}$	$0.15 \cdot H_{mf,j} \cdot 1 + g_{mf,j}{}^{10}$
$Savings_{sf,i,j}$	$\sigma_{sf} \cdot \alpha_{sf} \cdot COVERAGE_{sf,j} \cdot \sum_{t=1}^{i} (1-\delta_{sf})^{t-1}$
$Savings_{mf,i,j}$	$\sigma_{mf} \cdot \alpha_{mf} \cdot COVERAGE_{mf,j} \cdot \sum_{t=1}^{i} (1-\delta_{mf})^{t-1}$

BMP 2

Savings potential is based on BMP 2's coverage requirement that 75% of single-family and 75% of multi-family residences constructed prior to 1992 are fitted with high-quality, low-flow showerheads. Agencies are to deliver high-quality, low-flow showerheads to 10% of pre-1992 houses each reporting period (every two years) until 75% saturation achieved. The model below can calculate (1) gross and net savings assuming agencies stop distribution program after 75% saturation is reached and (2) gross and net savings assuming agencies continue distribution program after 75% saturation is reached. Model will be developed in Excel 97-98.

Key Model Assumptions: The model assumes showerheads are distributed completely at random within regions (i.e., via non-targeted mass distribution programs). While this makes the problem of estimating the proportion of units retrofitted through active programs tractable, it also produces the lowest possible estimate of program cost-effectiveness, *all other things being the same*. The model accounts for natural replacement occurring between 1992 and 1997, but not showerheads distributed through active conservation programs. The effect is to underestimate the amount of active savings and to overestimate the amount of post-97 water savings that will result from low-flow showerhead programs. The water savings calculations do not account for device decay. To the extent this type of decay is a common occurrence, failure to account for this fact will cause the resulting calculations to over-estimate the amount of both active and passive savings attributable to low-flow showerhead retrofits.

Indexes

Table A - 7. Index Definitions

INDEX NAME	DEFINITION
i	Year = 1991...2020
j	Region = the seven regions
sf	Single-family residence
mf	Multi-family residence

Variables

Table A - 8. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
$N_{sf,j}$	Natural replacement rate for showerheads in single-family residences in region j	Model assumes average remaining life of 10 years for existing stock. This implies a 10% replacement rate.
$N_{mf,j}$	Natural replacement rate for showerheads in multi-family residences in region j	Model assumes average remaining life of 10 years for existing stock. This implies a 10% replacement rate.
$D_{sf,j}$	Showerhead distribution rate for single-family residences in region j	Assume 5% per year per MOU exhibit 1
$D_{mf,j}$	Showerhead distribution rate for multi-family residences in region j	Assume 5% per year per MOU exhibit 1
$H_{sf,j}$	Stock of pre-1992 single-family houses in region j	1990 Housing Census
$H_{mf,j}$	Stock of pre-1992 multi-family units in region j	1990 Housing Census
$SPH_{sf,j}$	Average number of showerheads per single-family residence in region j	Census data
$SPH_{mf,j}$	Average number of showerheads per multi-family residence in region j	Census data
Continued		

VARIABLE NAME	DEFINITION	DATA SOURCES
σ_{sf}	Average savings per showerhead for single-family houses	CUWCC Data
σ_{mf}	Average savings per showerhead for multi-family residences	CUWCC Data
$\alpha_{sf,j}$	Percent of pre-1992 single-family residences with high-flow showerheads receiving and installing low-flow showerhead from agency program	Models assumes 50% of distributed showerheads are installed.
$\alpha_{mf,j}$	Percent of pre-1992 multi-family residences with high-flow showerheads receiving and installing low-flow showerhead from agency program	Models assumes 50% of distributed showerheads are installed.
$NATRL_{sf,i,j}$	Number of pre-1992 single-family residences replacing showerheads in year i, region j	Model formula
$NATRL_{mf,i,j}$	Number of pre-1992 multi-family residences replacing showerheads in year i, region j	Model formula
$DISTR_{sf,i,j}$	Number of pre-1992 single-family households receiving showerheads from agency distribution program in year i, region j	Assumed to be 5% of pre-1992 sf connections each year per Exhibit 1 coverage requirement.
$DISTR_{mf,i,j}$	Number of pre-1992 single-family households receiving showerheads from agency distribution program in year i, region j	Same as above
$DISTR\_ALREADY\_RETROFITTED_{sf,i,j}$	Number of pre-1992 sf households with low-flow showerheads receiving showerheads from distribution program	Model formula
$DISTR\_ALREADY\_RETROFITTED_{mf,i,j}$	Number of pre-1992 mf households with low-flow showerheads receiving showerheads from distribution program	Model formula
$DISTR\_NOT\_ALREADY\_RETROFITTED_{sf,i,j}$	Number of pre-1992 sf households with high-flow showerheads receiving showerheads from distribution program	Model formula
$DISTR\_NOT\_ALREADY\_RETROFITTED_{mf,i,j}$	Number of pre-1992 mf households with high-flow showerheads receiving showerheads from distribution program	Model formula
$DISTR\_INSTALLED_{sf,i,j}$	Number of pre-1992 sf households with high-flow showerheads installing low-flow showerheads distributed by program	Model formula
$DISTR\_INSTALLED_{mf,i,j}$	Number of pre-1992 mf households with high-flow showerheads installing low-flow showerheads distributed by program	Model formula

Continued

VARIABLE NAME	DEFINITION	DATA SOURCES
$RS_{sf,i,j}$	Remaining stock of pre-1992 single-family residences with high-flow showerheads in year i, region j	Model formula
$RS_{mf,i,j}$	Remaining stock of pre-1992 multi-family residences with high-flow showerheads in year i, region j	Model formula
$RS\_NO\_DISTR_{sf,i,j}$	Remaining stock of pre-1992 single-family residences with high-flow showerheads in year i, region j assuming no showerhead distribution program in place	Model formula
$RS\_NO\_DISTR_{mf,i,j}$	Remaining stock of pre-1992 multi-family residences with high-flow showerheads in year i, region j assuming no showerhead distribution program in place	Model formula
$GROSS\_SAVINGS_{i,j}$	Gross savings (AFY) from natural replacement and showerhead distribution program in year i, region j	Model formula
$NET\_SAVINGS_{i,j}$	Net savings (AFY) attributable to showerhead distribution program in year i, region j	Model formula

Formulas

Table A - 9. Formulas

VARIABLE	IS EQUAL TO
$RS_{sf,i,j}$	$RS_{sf,i-1,j}$ - $DISTR\_INSTALLED_{sf,i,j}$ - $NATRL_{sf,i,j}$
$RS_{mf,i,j}$	$RS_{mf,i-1,j}$ - $DISTR\_INSTALLED_{mf,i,j}$ - $NATRL_{mf,i,j}$
$DISTR_{sf,i,j}$	$D_{sf,j} * H_{sf,j}$
$DISTR_{mf,i,j}$	$D_{mf,j} * H_{mf,j}$
$DISTR\_ALREADY\_RETROFITTED_{sf,i,j}$	$DISTR_{sf,i,j}$ - $DISTR\_NOT\_ALREADY\_RETROFITTED_{sf,i,j}$
$DISTR\_ALREADY\_RETROFITTED_{mf,i,j}$	$DISTR_{mf,i,j}$ - $DISTR\_NOT\_ALREADY\_RETROFITTED_{mf,i,j}$
$DISTR\_NOT\_ALREADY\_RETROFITTED_{sf,i,j}$	$(RS_{sf,i-1,j} \div H_{sf,j})*(1- N_{sf,j})* DISTR_{sf,i,j}$
$DISTR\_NOT\_ALREADY\_RETROFITTED_{mf,i,j}$	$(RS_{mf,i-1,j} \div H_{mf,j})*(1- N_{mf,j})* DISTR_{mf,i,j}$
$DISTR\_INSTALLED_{sf,i,j}$	$\alpha_{sf,j}$ * $DISTR\_NOT\_ALREADY\_RETROFITTED_{sf,i,j}$
$DISTR\_INSTALLED_{mf,i,j}$	$\alpha_{mf,j}$ * $DISTR\_NOT\_ALREADY\_RETROFITTED_{mf,i,j}$
$NATRL_{sf,i,j}$	$N_{sf,j} * RS_{sf,i-1,j}$
$NATRL_{mf,i,j}$	$N_{mf,j} * RS_{mf,i-1,j}$
$RS\_NO\_DISTR_{sf,i,j}$	$RS\_NO\_DISTR_{sf,i-1,j} * N_{sf,j}$
Continued	

VARIABLE	IS EQUAL TO
$RS\_NO\_DISTR_{mf,i,j}$	$RS\_NO\_DISTR_{mf,i-1,j} * N_{mf,j}$
$GROSS\_SAVINGS_{i,j}$	$(H_{sf,j} - RS_{sf,i,j})\ SPH_{sf,j}\ \sigma_{sf,j} + (H_{sf,j} - RS_{sf,i,j})\ SPH_{mf,j}\ \sigma_{mf,j}$
$NET\_SAVINGS_{i,j}$	$(RS\_NO\_DISTR_{sf,i,j} - RS_{sf,i,j})\ SPH_{sf,j}\ \sigma_{sf,j} +$ $(RS\_NO\_DISTR_{mf,i,j} - RS_{mf,i,j})\ SPH_{sf,j}\ \sigma_{mf,j}$

BMP 3

Savings potential is based on BMP 3's coverage requirement that agencies undertake a full-scale audit whenever unaccounted losses exceed 10% of water into the system. The model uses water system data from DWR/DHS to estimate the percent of total production coming from systems with losses exceeding 10%. Systems with losses exceeding 10% are further subcategorized by the magnitude of these losses. The loss categories are 10-12.5%, 12.5-15%, ..., 37.5-40%, greater than 40%.

Key Model Assumptions: For systems whose unaccounted for water exceeds 10% of total production, we assume 80% of this unaccounted water is lost to the system. The distribution of systems falling into each loss category was based on statewide data. Data limitations prevented us from estimating the distribution of losses by region.

Indexes

Table A - 10. Index Definitions

INDEX NAME	DEFINITION
i	Program year
j	Region = the seven regions
k	System loss categories K=1, system losses equal 10 - 12.5% K=2, system losses equal 12.5 - 15% ... K=12, system losses equal 37.5 - 40% K=13, system losses equal to more than 40%. All losses in this category truncated to 40%

Variables

Table A - 11. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
Pct_k	The percent of total water system production from systems with losses in loss category k	DWR and DHS water system data. Based on annual survey of 300+ water systems in California
$Prod_j$	Total water system production in region j	DWR Bulletin 160-98
α	Percent of unaccounted water lost to the system	We assume 80% of unaccounted water is actually lost to the system
$Savings_j$	Estimated savings in region j from reducing system losses to 10% by end of BMP 3 implementation period	Model formula

Formulas

Table A - 12. Model Specification: Program Continued After Coverage Met

VARIABLE	IS EQUAL TO
$Savings_j$	$\alpha Prod_j \left[\sum_{k=1}^{12} \left(\frac{1}{2} \left[(0.1 + 0.025(k-1)) + (0.1 + 0.025k) \right] - 0.1 \right) \cdot Pct_k + 0.3 \cdot Pct_{13} \right]$

BMP 4

Savings potential is based on BMP 4's coverage requirement that 100% of unmetered connections are metered and billed by volume of use within 10 years from date implementation to commence.

Key Model Assumption: Savings per metered connection is assumed to be 15 percent, the low end of the range of estimated savings reported in the literature.

Indexes

Table A - 13. Index Definitions

INDEX NAME	DEFINITION
i	Program year
j	Region = the seven regions

Variables

Table A - 14. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
$UNMETERED_j$	Number of unmetered connections in region j at start of implementation	Unmetered agencies
USE_j	Total use by unmetered connections in region j at start of implementation	Unmetered agencies
AVG_USE_j	Average use per unmetered connection in region j at start of implementation j	Model formula
RETRO_RATE	Rate unmetered connections are retrofitted and billed by volume of use	Assume 10% per year to meet coverage requirement per MOU Exhibit 1
$RETROFITTED_{i,j}$	Number of unmetered connections in region j, year i retrofitted with a meter and billed by volume of use	Model formula
σ	Savings per retrofitted connection	Assumed to be 15%
$SAVINGS_{i,j}$	Savings (AFY) in year i, region j	Model formula

Formulas

Table A - 15. Formulas

VARIABLE	IS EQUAL TO
AVG_USE_j	$USE_j \div UNMETERED_j$
$RETROFITTED_{i,j}$	$RETRO\_RATE * UNMETERED_j$
$SAVINGS_{i,j}$	$i * RETROFITTED_{i,j} * AVG\_USE_j * \sigma$

BMP 5

Savings potential for landscape budgets based on coverage requirement that agencies provide budgets to not less than 90% of accounts with dedicated irrigation meters. The estimated share of urban water use served by dedicated irrigation meters is derived from the DWR/DHS data that show number of such accounts and deliveries by agency. Accounts are divided into several categories, including dedicated irrigation meter accounts. The estimate is based on the proportion of total urban water use for this sample of agencies that is delivered via dedicated irrigation meters. The BMP requires that the budgets for dedicated irrigation meters equal 100% of reference ETo. The assumed 15% reduction used to estimate water savings is based on a study in which water-based rate structures and penalty pricing provided a strong financial incentive to stay within budget. The study found average reductions of about 20%. We reduce estimated savings to 15% because the MOU does not strictly require agencies to couple rates with the budgets, though this option is available to any agency implementing budgets..

Savings potential for CII landscape surveys depends on average landscape acreage per surveyed account, average water use per landscaped acre, expected savings per survey, and expected savings decay rate. Separate models were developed to estimate savings from each requirement.

Model for Landscape Budgets

Indexes

Table A - 16. Index Definitions

INDEX NAME	DEFINITION
i	Year = 1991...2020
j	Region = the seven regions

Variables

Table A - 17. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
$TOTAL\_USE_{i,j}$	Total urban water use (net of losses) for year i, region j	DWR
PCT_IRR	Percent of total use used by accounts with dedicated irrigation meters	Estimated from DWR/DHS water system survey data
$\beta_{i,j}$	Percent of accounts with dedicated irrigation meters with budgets in year i, region j	Coverage requirement is 90%. The model will let the user change this value.
σ	Savings per irrigation account, expressed as percent of use	Note estimate is derived from studies of agencies with budget-based rates. Since BMP does not require coupling rates to budget, we reduce study estimate by about 25%.
$SAVINGS_{i,j}$	Savings (AFY) in year i, region j	Model formula

Formulas

Table A - 18. Formulas

VARIABLE	IS EQUAL TO
$SAVINGS_{i,j}$	$TOTAL\_USE_{i,j} * PCT\_IRR * \beta_{i,j} * \sigma$

Model for Landscape Surveys

Indexes

Table A - 19. Index Definitions

INDEX NAME	DEFINITION
i	Year = 1991...2020
j	Region = the seven regions

Variables

Table A - 20. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
CII_ACCTS_j	Number of CII accounts in region j	Estimate using CUWCC and DWR data.
g_j	Growth rate of CII accounts in region j	Estimate using CUWCC and DWR data
AVG_ACRES_j	Average number of acres for CII accounts receiving surveys in region j	Interviews with CUWA conservation coordinators
AVG_USE_j	Average use per acre for commercial landscape in region j	Interviews with CUWA conservation coordinators
$COVERAGE_j$	Percent of CII accounts that must receive surveys within 10 years of date implementation to start	15% per MOU Exhibit 1
α	Percent of coverage receiving a survey in any year	Model assumption. We assume 1.5% so that the coverage requirement is reached in 10 years, per MOU Exhibit 1
σ	Average initial savings per survey express as a % of use	CUWCC Data, interviews, BMP 5 Manual
δ	Annual rate of savings decay for survey	Same as above
$Savings_{i,j}$	Savings in year i, region j	Model formula

Formulas

Table A - 21. Model Specification:
Program Discontinued After Coverage Met / Coverage Based on Initial Number of CII Accounts

VARIABLE	IS EQUAL TO
$COVERAGE_j$	$0.15 * CII\_ACCTS_j$
$SAVINGS_{i,j}$	$\sigma \cdot AVG\_ACRES_j \cdot AVG\_USE_j \cdot \alpha \cdot COVERAGE_j \cdot \sum_{t=1}^{i}(1-\delta)^{t-1}$ if $i \le 10$ $\sigma \cdot AVG\_ACRES_j \cdot AVG\_USE_j \cdot \alpha \cdot COVERAGE_j \cdot \sum_{t=1}^{i}(1-\delta)^{(t-1)+(i-10)}$ if $i > 10$

Table A - 22. Model Specification: Program Discontinued After Coverage Met / Coverage Based on Ending Number of CII Accounts

VARIABLE	IS EQUAL TO
$COVERAGE_j$	$0.15 \cdot CII\_ACCTS_j(1+g_j)^{10}$
$SAVINGS_{i,j}$	$\sigma \cdot AVG\_ACRES_j \cdot AVG\_USE_j \cdot \alpha \cdot COVERAGE_j \cdot \sum_{t=1}^{i}(1-\delta)^{t-1}$ if $i \leq 10$ $\sigma \cdot AVG\_ACRES_j \cdot AVG\_USE_j \cdot \alpha \cdot COVERAGE_j \cdot \sum_{t=1}^{i}(1-\delta)^{(t-1)+(i-10)}$ if $i > 10$

Table A - 23. Model Specification: Program Continued After Coverage Met / Coverage Based on Initial Number of CII Accounts

VARIABLE	IS EQUAL TO
$COVERAGE_j$	$0.15 * CII\_ACCTS_j$
$SAVINGS_{i,j}$	$\sigma \cdot AVG\_ACRES_j \cdot AVG\_USE_j \cdot \alpha \cdot COVERAGE_j \cdot \sum_{t=1}^{i}(1-\delta)^{t-1}$

Table A - 24. Model Specification: Program Continued After Coverage Met / Coverage Based on Ending Number of CII Accounts

VARIABLE	IS EQUAL TO
$COVERAGE_j$	$0.15 \cdot CII\_ACCTS_j(1+g_j)^{10}$
$SAVINGS_{i,j}$	$\sigma \cdot AVG\_ACRES_j \cdot AVG\_USE_j \cdot \alpha \cdot COVERAGE_j \cdot \sum_{t=1}^{i}(1-\delta)^{t-1}$

BMP 9

Agencies can satisfy BMP 9 coverage requirements in two different ways: (1) reduce CII water use by an amount equal to 10% of 1989 use within 10 years of implementation start date or (2) complete surveys for 10% of CII accounts within 10 years of implementation start date. Savings from BMP 5 surveys count towards BMP 9 coverage requirements. Therefore, estimates will be net of landscape savings to avoid double counting.

Savings potential for CII surveys depend on average water use per surveyed account, expected savings per survey, and expected savings decay rate. Estimates of average savings per survey and average savings life are based on "Evaluation of the MWD CII Survey Database" prepared for Metropolitan Water District of Southern California by Hagler Bailly Services, Inc.

Separate models were developed to estimate savings for each alternative. The final estimate averages the results of the two models.

Model for CII Water Use Reduction

Indexes

Table A - 25. Index Definitions

INDEX NAME	DEFINITION
i	Year = 1991...2020
j	Region = the seven regions

Variables

Table A - 26. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
$TOTAL\_USE_{1989,j}$	Total CII use in 1989, region j	DWR
$SAVINGS_{i,j}$	Savings (AFY) in year i, region j, net of BMP 5 survey savings	Model formula

Formulas

Table A - 27. Formulas

VARIABLE	IS EQUAL TO
$SAVINGS_{i,j}$	$TOTAL\_USE_{1989,j}$ * 0.10 - Survey savings estimated for BMP 5

Model for CII Surveys

Indexes

Table A - 28. Index Definition

INDEX NAME	DEFINITION
i	Year = 1991...2020
j	Region = The Seven Regions

Variables

Table A - 29. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
CII_ACCTS_j	Number of CII accounts in region j	Estimate using CUWCC and DWR data
g_j	Growth rate of CII accounts in region j	Estimate using CUWCC and DWR data
$COVERAGE_j$	Percent of CII accounts that must receive surveys within 10 years of date implementation to start	10% per MOU Exhibit 1
α	Percent of coverage receiving a survey in any year	Model assumption. We assume 10% so that the coverage requirement is reached in 10 years, per MOU Exhibit 1
σ	Average initial savings (net of landscape) per survey	"Evaluation of the MWD CII Survey Database" prepared for Metropolitan Water District of Southern California by Hagler Bailly Services, Inc.
δ	Annual rate of savings decay for survey. This model does not use this parameter →	We estimated average savings life from the MWD survey data. From this analysis we assume savings last 12 years on average. This specification was adopted to maintain consistency with the MWD data and analysis.
$Savings_{i,j}$	Savings in year i, region j	Model formula

Formulas

Table A - 30. Model Specification:
Program Discontinued After Coverage Met / Coverage Based on Initial Number of CII Accounts

VARIABLE	IS EQUAL TO
$COVERAGE_j$	$0.15 * CII\_ACCTS_j$
$SAVINGS_{i,j}$	$i \cdot \sigma \cdot \alpha \cdot COVERAGE_j$ for $i \le 10$ $10 \cdot \sigma \cdot \alpha \cdot COVERAGE_j$ for $10 < i \le 12$ $[10 - (i - 12)] \cdot \sigma \cdot \alpha \cdot COVERAGE_j$ for $12 < i \le 22$

Table A - 31. Model Specification:
Program Continued After Coverage Met / Coverage Based on Initial Number of CII Accounts

VARIABLE	IS EQUAL TO
$COVERAGE_j$	$0.10 * CII\_ACCTS_j$ for $i \le 10$ $0.10*(1+ g_j)^{10}*CII\_ACCTS_j$ for $i > 10$
$SAVINGS_{i,j}$	$i \cdot \sigma \cdot \alpha \cdot COVERAGE_j$ for $i \le 10$ $\left[10 + (i - 10) \cdot (1 + g_j)^{10}\right] \cdot \sigma \cdot \alpha \cdot COVERAGE_j$ for $10 < i \le 12$ $\left[[10 - (i - 12)] + (i - 10) \cdot (1 + g_j)^{10}\right] \cdot \sigma \cdot \alpha \cdot COVERAGE_j$ for $12 < i \le 22$

BMP 14

Savings potential is based on BMP 14's coverage requirement that an agency implement a ULFT program that is at least as effective as implementing a retrofit on resale ordinance. Savings calculations are based on MOU Exhibit 6 methodology and household savings estimates. The model below can calculate (1) gross and net savings assuming agencies discontinue ULFT program after 10 year term of MOU and (2) gross and net savings assuming agencies continue ULFT program after 10 year term of MOU.

Indexes

Table A - 32. Index Definitions

INDEX NAME	DEFINITION
i	Year = 1991...2020
j	Region = the seven regions
sf	Single-family residence
mf	Multi-family residence

Variables

Table A - 33. Variable Definitions and Data Sources

VARIABLE NAME	DEFINITION	DATA SOURCES
$START\_YR_j$	Year retrofit-on-resale ordinance starts for region j	Assumption. MOU coverage requirement based on r-o-r starting in 1998.
$N_{sf,j}$	Natural replacement rate for toilets in single-family residences in region j	Assumption. Exhibit 6 assumes 4%, giving existing high-flow toilets an average remaining life of about 25 years.
$N_{mf,j}$	Natural replacement rate for toilets in multi-family residences in region j	Same as above
$R_{sf,j}$	Average resale rate for single-family residences in region j	5-10 year average. Estimated from resale data purchased from Dataquick.
$R_{mf,j}$	Average resale rate for multi-family residences in region j	5-10 year average. Estimated from resale data purchased from Dataquick.
$H_{sf,j}$	Stock of pre-1991 single-family houses in region j	1990 Housing Census
$H_{mf,j}$	Stock of pre-1991 multi-family units in region j	1990 Housing Census. We'll have to approximate the number of units using census data.
$PPH_{sf,j}$	Average number of persons per single-family residence in region j	Census data
$PPH_{mf,j}$	Average number of persons per multi-family residence in region j	Census data
$TPH_{sf,j}$	Average number of toilets per single-family residence in region j	Census data
$TPH_{mf,j}$	Average number of toilets per multi-family residence in region j	Same as above
$PRE80_{sf,j}$	Percent of $H_{sf,j}$ constructed prior to 1980	1980 and 1990 Housing Census
Continued		

VARIABLE NAME	DEFINITION	DATA SOURCES
$PRE80_{mf,j}$	Percent of $H_{mf,j}$ constructed prior to 1980	Same as above
$\bar{\sigma}_{sf,j}$	Average savings per single-family household for given $PPH_{sf,j}$ and $TPH_{sf,j}$ as listed in MOU Exhibit 6	Exhibit 6
$\bar{\sigma}_{mf,j}$	Average savings per multi-family household for given $PPH_{sf,j}$ and $TPH_{sf,j}$ as listed in MOU Exhibit 6	Exhibit 6
$\sigma_{sf,j}$	Average savings per single-family household for given $PPH_{sf,j}$ and $TPH_{sf,j}$, adjusted for percent of pre/post 1980 construction	Exhibit 6 formula
$\sigma_{mf,j}$	Average savings per multi-family household for given $PPH_{mf,j}$ and $TPH_{mf,j}$, adjusted for percent of pre/post 1980 construction	Exhibit 6 formula
$Sold_{sf,j}$	Number of pre-1991 single-family residences sold in any year i, region j	Model formula
$Sold_{mf,j}$	Number of pre-1991 multi-family units sold in any year i, region j	Model formula
$Unsold_{sf,j}$	Number of pre-1991 single-family residences not sold in any year i, region j	Model formula
$Unsold_{mf,j}$	Number of pre-1991 multi-family unitis not sold in any year i, region j	Model formula
$ROR_{sf,i,j}$	Number of pre-1991 single-family residences sold AND retrofitted with ULFTs in year i, region j	Model formula
$ROR_{mf,i,j}$	Number of pre-1991 multi-family units sold AND retrofited with ULFTs in year i, region j	Model formula
$NATRL_{sf,i,j}$	Number of pre-1991 single-family residences unsold AND retrofitted with ULFTs in year i, region j	Model formula
$NATRL_{mf,i,j}$	Number of pre-1991 multi-family residences unsold AND retrofitted with ULFTs in year i, region j	Model formula
$RS_{sf,i,j}$	Remaining stock of pre-1991 single-family residences with high-flow toilets in year i, region j	Model formula
$RS_{mf,i,j}$	Remaining stock of pre-1991 multi-family residences with high-flow toilets in year i, region j	Model formula
$RS\_NO\_ROR_{sf,i,j}$	Remaining stock of pre-1991 single-family residences with high-flow toilets in year i, region j assuming no retrofit-on-resale ordinance in place	Model formula

Continued

VARIABLE NAME	DEFINITION	DATA SOURCES
$RS\_NO\_ROR_{mf,i,j}$	Remaining stock of pre-1991 multi-family residences with high-flow toilets in year i, region j assuming no retrofit-on-resale ordinance in place	Model formula
$GROSS\_SAVINGS_{i,j}$	Gross savings (AFY) from natural replacement and retrofit-on-resale requirement in year i, region j	Model formula
$NET\_SAVINGS_{i,j}$	Net savings (AFY) attributable to retrofit-on-resale requirement in year i, region j	Model formula

Formulas

Table A - 34. Formulas

VARIABLE	IS EQUAL TO
$\sigma_{sf,j}$	$\bar{\sigma}_{sf,j}$ [1.015 PRE80sf,j + 0.812(1- PRE80sf,j)] From MOU Exhibit 6
$\sigma_{mf,j}$	$\bar{\sigma}_{mf,j}$ [1.0255 PRE80sf,j + 0.8205(1- PRE80sf,j)] From MOU Exhibit 6
$Sold_{sf,j}$	$R_{sf,j}\ H_{sf,j}$
$Sold_{mf,j}$	$R_{mf,j}\ H_{mf,j}$
$Unsold_{sf,j}$	$H_{sf,j} - Sold_{sf,j}$
$Unsold_{mf,j}$	$H_{mf,j} - Sold_{mf,j}$
$ROR_{sf,i,j}$	$Sold_{sf,j}\ (RS_{sf,i-1,j} \div H_{sf,j})$
$ROR_{mf,i,j}$	$Sold_{mf,j}\ (RS_{mf,i-1,j} \div H_{mf,j})$
$NATRL_{sf,i,j}$	$Unsold_{sf,j}\ (RS_{sf,i-1,j} \div H_{sf,j})\ N_{sf,j}$
$NATRL_{mf,i,j}$	$Unsold_{mf,j}\ (RS_{mf,i-1,j} \div H_{mf,j})\ N_{mf,j}$
$RS_{sf,i,j}$	$RS_{sf,i-1,j} - ROR_{sf,i,j} - NATRL_{sf,i,j}$
$RS_{mf,i,j}$	$RS_{mf,i-1,j} - ROR_{mf,i,j} - NATRL_{mf,i,j}$
$RS\_NO\_ROR_{sf,i,j}$	$RS\_NO\_ROR_{sf,i-1,j}\ (1 - N_{sf,j})$
$RS\_NO\_ROR_{mf,i,j}$	$RS\_NO\_ROR_{mf,i-1,j}\ (1 - N_{mf,j})$
$GROSS\_SAVINGS_{i,j}$	$(H_{sf,j} - RS_{sf,i,j})\ \sigma_{sf,j} + (H_{sf,j} - RS_{sf,i,j})\ \sigma_{mf,j}$
$NET\_SAVINGS_{i,j}$	$(RS\_NO\_ROR_{sf,i,j} - RS_{sf,i,j})\ \sigma_{sf,j} + (RS\_NO\_ROR_{mf,i,j} - RS_{mf,i,j})\ \sigma_{mf,j}$

APPENDIX B
PROJECT ADVISORY COMMITTEE MEMBERS

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APPENDIX C
ESTIMATION OF MARGINAL SUPPLY COSTS

The following discussion of the avoided cost estimation process is divided into three parts, which are described below:

- The first section describes in more detail the approach used to estimate avoided costs associated with the major export projects, the Central Valley Project (CVP) and the State Water Project (SWP);

- The second section summarizes particular concerns with and limitations of these approaches; and

- The third section documents in more detail how this approach was implemented for each region.

AVOIDED COSTS OF THE MAJOR EXPORT PROJECTS

The areas we are investigating obtain water from the Delta, largely through the CVP or SWP. To determine the appropriate avoided cost, it is necessary to develop both the short-run and the long-run avoided costs, and the time when the long-run avoided cost is appropriate. When implementation of a program can potentially defer or remove the need for an investment in new facilities, the avoided cost used should reflect the fixed costs associated with those facilities in addition to the variable costs of supplies (long-run avoided costs). The basis for the short-run and long-run avoided costs associated with the water supply projects are discussed below.

Short Run Avoided Costs: State Water Project

The fixed costs for the SWP are allocated according to contractor entitlement, and do not vary according to the amount of water delivered. Thus these costs were ignored for the estimate of short-run avoided costs. Variable operating and net power costs are allocated to the contracting agencies according to the amount of water to be delivered. These variable costs are avoidable in the short-run, and so were used for the initial estimate of avoided costs. Current charges and estimates of future variable costs are reported for each contracting agency in Table B 18 of the Department of Water Resources' *Bulletin 132.*[23]

[23] *Management of the California State Water Project*, Bulletin 132-97 of the California Department of Water Resources.

In addition to these costs, off-aqueduct power supply costs are allocated on the basis of power supply used, which is a function of water delivered and delivery location. Thus, although these off-aqueduct costs include the fixed costs associated with power plants and pumps, their allocation to each agency can be changed according to the amount of water purchased. Of course, if all agencies reduced their water use by the same amount, the allocations would be unchanged. This complication was ignored in our analysis, and off-aqueduct power supply costs were included in the avoided cost estimates. Current and future estimates of these charges to each contracting agency are reported in Table B 16-b of *Bulletin 132*. These were added to the variable costs of Table B 18.

The assumed deliveries to each contracting agency used as a basis for these estimates are reported in Table B 5-b of *Bulletin 132*. These deliveries were used in conjunction with the two variable costs described above to develop an estimate of current and future variable costs per acre-foot. Over time the off-aqueduct power costs will be reduced as the bonds associated with the facilities are repaid. As a result, the variable costs of the SWP are shown to be decreasing in the future.

Short Run Avoided Costs: Central Valley Project

The CVP water rates are currently being renegotiated, making forecasts of future costs highly uncertain. In its *1999 Municipal and Industrial Water Rates,* the U.S. Bureau of Reclamation (Bureau) reports the following information that is pertinent to our analysis: the M&I surcharge, the Restoration Fee required under the Central Valley Project Improvement Act (CVPIA), and the Cost of Service rate. This latter is expected to be the basis for the future contracts. In Schedule A-2A the Cost of Service rate is broken into the M&I Capital Rate (the amount estimated to cover the fixed costs), the O&M rate (estimated to cover variable costs), and the Deficit Rate (estimated to recover previous undercollections). If water deliveries to a contractor are reduced, the reduction in collections of the M&I capital rate plus interest are added to the accumulated deficit in future years. Thus only the O&M rate, the M&I surcharge and the Restoration Fee are variable costs.

Under the terms of the CVPIA the Bureau must institute tiered rates, so that the top 20 percent of entitlements will be billed at higher rates. These charges are based on the M&I Capital Rate, but calculated using a higher interest rate. Although this is based on the fixed cost calculations, the difference between it and the full cost amount could be considered a variable cost to the member agencies because the money collected will go into the Restoration Fund and not be used to reduce past or future capital deficits. However, the application of the tiered rate requirement remains unclear.

The law states that the rate based on the higher interest rate should be charged for the top 10 percent of an agency's entitlement, and a blended rate (an average of the full cost and the high interest fee) should be charged for the second highest 10 percent. However, under currently expected conditions the M&I users will only obtain full deliveries of their entitlement in wet years, and will likely use this water for storage purposes. Therefore its appropriateness as an avoided cost to be used in comparison to water conservation is unclear. The Bureau is also proposing to implement tiered rates so that "entitlement" is taken to mean "entitlement delivery", which has been defined as a rolling average of the previous five years' deliveries. If this interpretation is upheld, reducing consumption in a given year will save the cost of the high-tiered rate in that year, but will decrease the amount of water that can be purchased at the lower-cost tier in all subsequent years. Thus it appears that under this interpretation the higher-tier charges are not an avoidable cost, but can merely be postponed for a few years. For a definitive determination of whether these tiers can be considered avoidable, we will need to wait until the final implementation of the rate requirements of the CVPIA and analyze how water agencies will be affected.

For this current analysis we have used the variable portion of the cost of service rate, plus the Restoration Charge and the M&I surcharge as the basis for the avoided cost. These are reported for 1999 for each agency.[24] Since this is comprised largely of O&M and electricity, we have increased it at a rate of only 0.5 percent above inflation.

Long-Run Avoided Costs

For both SWP and CVP contractors, it is assumed that new supplies will be needed by the CALFED-specified date of 2020. Some agencies may need supplies before then, but the cost responsibility and timing of those supplies will depend at least in part on the interpretation and implementation of the CVPIA yield augmentation provisions. It appears that little to no progress has been made on the determination of these issues.

Because these new facilities are only needed in the long run, those costs that are normally thought of as fixed will be considered variable – that is, a new supply facility that is not needed for twenty years could potentially be avoided altogether by investments in conservation.

CALFED has conducted an economic evaluation of water management alternatives in 2020.[25] This study ranks potential water supply alternatives by cost and by geographic region for a number of future supply scenarios. Of the scenarios shown in the report, our analysis is based on the unconstrained analysis without the isolated facility because this most closely matches CALFED's Preferred Alternative. The CALFED report separates the ranked water supply alternatives into two groups: those that will likely be needed even with full implementation of the conservation BMPs; and those that would not be needed under that scenario.[26] For the long-run avoided supply cost for each region, we chose the marginal unit cost at the treatment plant

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24 *1999 Municipal and Industrial Water Rates, Central Valley Project, California,* Department of the Interior, Bureau of Reclamation, Mid Pacific Region, Sacramento, California

25 *The Economic Analysis of Water Management Alternatives*, prepared for CALFED Bay-Delta Program, October 1999.

26 See, for example, Table 2 in Appendix A of the CALFED report.

for the option reported as being immediately to the right of the demand curve with BMP implementation. Thus we selected the cost of the cheapest option that the CALFED analysis estimated would not be required because of conservation. This approach to long-run avoided cost means that our analysis shows that all agencies requiring additional imported supplies have the same avoided cost by the year 2020.

Treatment Costs

It is also possible that some local distribution and treatment costs may be avoidable by targeted conservation programs. For example, if a local treatment plant is nearing capacity, conservation programs targeted to the area served by that plant could defer the need for plant expansion. Few agencies have investigated these options, so the effects of such cost savings are included only in a general way. However, CALFED has assumed that increased treatment costs will be necessary by the year 2020 for those agencies obtaining water from the Delta. These increased costs are based on an expected requirement for reverse osmosis of a proportion of delivered water to reduce the impact of disinfectant byproducts. These capital and O&M costs were included as avoided costs.

CALFED's analyses have been based solely on the year 2020, and so we have no more precise statement of when this additional treatment would be necessary. We have assumed that the need for investment in these facilities will vary from agency to agency, and would most likely be phased in over time. This phase-in is assumed to occur in the decade between 2010 and 2020. The numbers reported here show a smooth percentage growth in avoided treatment costs from 2010 through 2020, commencing from the forecast of the specific agency's avoidable cost in the year 2010, and culminating in the CALFED estimate of fixed plus variable treatment costs required by 2020. The use of a smooth percentage growth means that smaller absolute increases in avoided cost occur in the early years of the decade, and larger absolute increases are concentrated in the later years of the decade. This modification is not included for agencies such as Sacramento, which diverts water from locations above the Delta, nor in cases such as Mojave, where the SWP water is used to recharge groundwater aquifers. While this smoothed approach to adding treatment capital costs is obviously not realistic, it appears to give the best estimate available at this time.

CONCERNS WITH AND LIMITATIONS OF THIS APPROACH

The analysis of avoided cost was limited by the amount of information the water agencies have developed and released. In most cases, we have a good estimate of current avoided costs. Most agencies have developed an estimate of whether they expect to need additional supplies by some future year, usually year 2020. In some cases, it is obvious that supplies will be needed before that time. Where no analysis is available to specify when those new supplies will be needed, we have made an arbitrary decision to include a need for additional supplies according to our understanding of the agency supply situation.

Some of the agency data on which we rely is outdated, and needs to be revised. For example, the recent CPVIA EIR provided an analysis of proposed CVP operations that would result in reduced supplies to M&I contractors, with shortages ranging up to 50 percent of entitlements rather than the previous expectation of no more than 25 percent shortages to M&I.[27] The M&I contractors are still attempting to have these operational plans revised, and no agency supply plans have been updated to reflect these new proposals. In addition, the effect on avoided costs of CVP yield enhancement and tiered rates are still undetermined.

The effect of the restructuring of California's electric utility industry on SWP pumping costs has not been included in this analysis. By pumping water off-peak and selling recaptured power on peak, the SWP can use the California Aqueduct as a pump-storage generating station. In its short life to date, the new state power exchange and the independent system operator have provided high payments for peak power and additional payments for ancillary services that can be provided by hydroelectric facilities. Thus, so long as the DWR is willing to release water out of San Luis into the California aqueduct on short notice to respond to transitory or more serious imbalances in the electric system, DWR can gain payments for potential generation, rather than actual generation. When water is released on peak, DWR can gain the benefit of high peak prices. In the first six months of the restructured industry operations, DWR is estimated to have made a "profit" (sales of recaptured electricity net of pumping costs) of over $40 million.

These higher prices potentially reflect in part more appropriate pricing of ancillary services, and possibly temporarily higher than average peak prices because of capacity constraints. It is likely that added capacity proposed for the near future could reduce the peak payments, but the ancillary payments are likely to remain high. It is also possible that as DWR operators gain experience in selling to the power exchange, it may be able to conform its operations to maximize the profits from power sales. This will lead to a reduction in the short-run variable costs for the SWP. In fact, if the current profitable situation continues, the short-run avoidable cost for the SWP could be negative.

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[27] *Central Valley Project Improvement Act, Final Programmatic Environmental Impact Statement,* U.S. Department of the Interior, Bureau of Reclamation, and U.S. Fish and Wildlife Service, October, 1999.

REGIONAL ANALYSES OF AVOIDED COSTS

The table at the end of this section provides the forecast of avoided costs at the level of the agencies implementing conservation. The details of the development of each of these regional estimates are provided below.

Bay Area Region

Water supplies in the Bay Area present a complicated picture, because there are many agencies that differ in the responsibilities they have assumed for implementation of conservation programs. Because of the complex nature of this region, further details are provided in an appendix. The following agencies were included in the analysis of Bay Area regional avoided costs:

- Alameda County Water District
- Contra Costa Water District
- East Bay Municipal Utility District
- San Francisco Public Utilities Commission
- San Francisco Water Department
- Santa Clara Valley Water District

The SFPUC and the San Francisco Water Department (SFWD) are treated separately because the BAWUA agencies that take supplies from the SFPUC are assumed to require new supply facilities in the year 2006. In contrast, because the SFWD supplies an area that is largely built-out, it is assumed to have no need of new supplies. The cost of new facilities to the BAWUA agencies is projected to be approximately $800 per AF. In 2020, the avoided costs for the BAWUA agencies are assumed to converge to the CALFED assumed cost of new supplies to the Bay Area. This analysis does not include the two agencies served through the North Bay Aqueduct, because they provide water to a small proportion of the bay area urban agencies' water supplies.

Water supplies in the Bay Area present a complicated picture:

1. There are a number of agencies which import water into the region and then sell the water at retail. These integrated agencies include East Bay Municipal Utility District (EBMUD) and the City of San Francisco Water Department (SFWD).
2. There are two wholesale agencies that import water into the region and sell the water to other agencies which then sell the water at retail. The wholesale agencies are the

Santa Clara Valley Water District (SCVWD) and the San Francisco Public Utilities Commission (SFPUC). Each of these wholesale agencies must be treated differently, because they take different approaches to conservation programs by their member agencies. SCVWD funds and operates the conservation programs within its service territory, seeing this as part of its responsibility to manage the county's water supplies. For this analysis, SCVWD is treated as an integrated agency because it is making the conservation decisions, not its member agencies. In contrast, SFPUC sees itself as the operator of the wholesale pipeline and storage system; conservation is seen as the responsibility of the individual member agencies. In the case of the SFPUC's retail agencies, there is no clear determination of who should plan for future supplies. The Bay Area Water Users' Association (BAWUA, the association of retail agencies purchasing water from SFPUC) is conducting joint studies with the SFPUC to determine this responsibility. The SFPUC is treated as a wholesale-only agency, and is treated separately from the SFWD.

3. There are two combination agencies. Contra Costa Water District (CCWD) is an integrated agency that also makes a small proportion of wholesale sales. For this analysis, CCWD is treated as an integrated agency. Alameda County Water District (ACWD) purchases some of its water from the SFPUC, and sells it at retail. It also imports some water independently, via the SWP. Finally, it also sells some water at wholesale. For purposes of this analysis, ACWD is treated as an integrated agency.

4. Finally, there are two agencies served through the North Bay Aqueduct. These agencies are the Napa County Flood Control and Water Conservation District, and the Solano County Water Agencies. These agencies provide water to a small proportion of the bay area urban agencies' water supplies, and so were ignored in this analysis.

The following sections provide the assumptions used for each of these agencies. Where percentage growth rates are identified, these are for nominal increases, including the 3 percent assumed inflation rate.

1. Contra Costa Water District

The short run avoided cost analysis includes three components:

- The short run avoided cost is the direct pumping cost from the Delta, plus the cost of pumping a proportion of the water into Los Vaqueros;

- Treatment costs, which are estimated to be $89.

- Costs for dry year transfers, which are expected to be needed in one year out of seven. In 1997 these were expected to cost $300 per AF.[28] CCWD forecast that for the next ten years, their current water supplies would be adequate in most years. However, in an estimated one year out of seven dry conditions would require the purchase of a dry-year transfer. For this period, the expected avoided costs was therefore derived by using a weighted average of the variable Central Valley Project (CVP, weighted by 6/7) and the cost of a dry-year transfer (weighted by 1/7).

After 2010, CCWD has assumed that its supplies of CVP water will be decreased, and that it would require a core or permanent water supply transfer to supplement these supplies. The cost for these transfers was set equal to those available under the drought water bank, or $175 per AF in 1995 dollars. The costs reported in this analysis are those developed by CCWD, with the following exceptions; CCWD based the growth of transfer prices on an expected inflation rate of 4 percent, and assumed that these prices would grow at 6.5 percent, or 2.5 percent above inflation. Instead, we have assumed 3 percent inflation, with 5.5 percent cost increases.

2. East Bay Municipal Utility District

The incremental cost to treat water at EBMUD averages $30 per AF. This includes labor to operate, chemicals, power, laboratory services and solids disposal. Maintenance costs are not included. This cost estimate is used for the short run avoided costs, and is escalated at 4.5 percent. This is assumed to be the avoided cost from the present to 2005. At that time, it is assumed that the avoided cost become the cost of Folsom South Canal, as estimated in EBMUD's *Water Supply Management Program, Final EIR*. The cost analysis is based on estimates for the Folsom South Canal. Capital costs were escalated to 2000 dollars, and unit costs calculated using EBMUD's assumptions of 6 percent capital recovery factor of 50 years. In 2020, the avoided costs were changed to reflect the CALFED estimates of supply costs to the bay area.

3. San Francisco Public Utilities Commission

The cost of avoided supplies at the retail level reflects the rates charged by the SFPUC for the Hetch Hetchy project. The Bay Area Water Users Association provided information on the cost of Hetch Hetchy supplies for the years 1998-2003. These data were adjusted to account for other power and compliance costs as specified in the Alameda County Water District's 1995 IRP Study. For these years the societal avoided costs of supply are the minimal pumping and filtration costs imposed by the Hetch Hetchy Project, and are the same as the avoided costs for the SFWD. These costs are assumed to rise at 4.5 percent.

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[28] Contra Costa Water District, *Contra Costa Future Water Supply Study* (1997), Technical Appendix F: Economic Analysis, Attachment 1, Service Area C, pages 1 and 2.

In year 2006 the cost of facilities to increase supply to these consumers is projected to be approximately $800 per AF, based on information provided by staff at the SFPUC Water Supply Master Plan Project. At this time, it is not clear whether this will be paid for by the SFPUC or by the retail customers. Because it is expected that the retail customers will gain the benefit from this new supply, and because the City of San Francisco appears unwilling or unable to finance new supply, we have assumed that the retail agencies (through some sort of Joint Powers Agency) will fund this investment. In 2020, the avoided costs are assumed to converge to the CALFED assumed cost of new supplies to the Bay Area, including water treatment costs.

4. San Francisco Water Department

The cost of avoided supplies to the SFWD are the incremental pumping and filtration costs of the Hetch Hetchy project. These are forecast to increase at 4.5 percent per year. This increase above the rate of inflation in part reflects the expectation that increased water treatment investments will be required in future. Because San Francisco is largely built out, demands within the city are not expected to increase significantly, and so no additional supply facilities are assumed.

5. Santa Clara Valley Water District

Avoided cost estimates reflect the following factors:

- Variable treatment costs are assumed to be the cost for ozonation, estimated at $35 per AF. These costs are assumed to increase at 4.5 percent per year.
- In normal years, the incremental costs are those associated with the CVP variable costs. Based on the CVP's 1999 *Municipal And Industrial Water Rates*, these are $56.96 per AF, and are assumed to escalate at 4.5 percent per year.
- In dry years a water transfer is assumed. This cost is based on the cost of water under proposed transfer agreements currently under negotiation. These proposals include a $10 per AF reservation fee that is paid in non-shortage years to reserve the water for use in shortage years, and a charge of $250 per AF in years in which the water is needed. These costs are estimated to increase at 4.5 percent per year. This water is assumed delivered through the SWP facilities at the variable costs estimated from Bulletin 132-97.

To develop a probability-weighted expected cost of water, the cost of dry-year supplies was weighted by the proportion of shortage years, and the incremental cost of CVP supplies were weighted by the proportion of non-shortage years expected. The probability of dry years is estimated to be zero in the year 2000, and increase to 25 percent probability in 2019. In 2020, the avoided cost is estimated to be the CALFED cost for new supplies to the bay area. The capital cost of water treatment is phased in over the years 2010-2010.

Central Coast Region

The only part of the Central Coast that relies on water imported from the Delta is in Santa Barbara County. The city of Santa Maria is 100 percent dependent on state water and is by far the largest entitlement holder. The cost per AF for State water varies depending on the location of each participant along the pipeline. Costs for participants in the northern part of the county are less than for those on the south coast, where deliveries require pumping up to Cachuma Reservoir. The avoided costs are the sum of the variable costs from the SWP as obtained from *Bulletin 132-97* plus the variable costs of in-county delivery by the Central Coast Water Authority. The variable costs charged by the CCWA vary from $18 per AF for Santa Maria (in the north county) to $107 per AF for the City of Carpinteria (in the south county). Currently there are no deliveries of SWP water to the City of Santa Barbara, so no variable cost estimates are available. Because the costs are related almost entirely to geographic location, the cost estimates for the City of Carpinteria were used for the City of Santa Barbara.

The avoided costs are increased in the year 2020 to reflect the CALFED estimate of new treated water supplies for the Central Coast region.

Sacramento Valley Region

The City of Sacramento is not a CVP contractor, but has reached an agreement to pay the Bureau for storage water held within the CVP. This is reported to be about $22 per AF in the CVP rate book. Including treatment, the total variable costs are estimated to be approximately $40, including chemicals, electricity, and the payment to the Bureau. Because of the City's location, there is assumed to be no need for additional facilities. The variable cost of water is largely related to chemicals and power, the avoided cost is assumed to escalate at 3.5 percent in nominal terms, or 0.5 percent above the rate of inflation.

Sacramento is currently in hearings for permits to divert additional supplies from the Sacramento and American Rivers. These diversions will perfect existing water rights, and the agency expects to proceed with construction on these diversion points in the near future. Thus it is unlikely that any conservation program undertaken in the future will be able to delay or avoid these costs. When these diversions are in place, Sacramento expects to have sufficient supplies through 2030. At that time, the CALFED assumption for the cost of new supplies is used as a proxy for the cost of this unspecified supply increment.

San Joaquin Region

The cities of Stockton and Modesto were used to represent this region. Stockton obtains water from the SEWD, which is a CVP contractor. The SEWD is also exploring options for new supplies, and recently purchased a water transfer of 30 TAF per year from Oakdale/South San Joaquin. As the CVP contractor, SEWD is ultimately responsible for conservation programs in the area. For year 2000, the estimated variable costs if SEWD supplies is $50 per AF for power and chemicals. For the forecast period, this cost is expected to increase at a nominal rate of 3.5 percent, or 0.5 percent above the assumed rate of inflation. In 2020 the assumed cost is based on the next costly supply option identified for the San Joaquin region by CALFED. To this is added the escalated cost of treatment as estimated for 2019.

The City of Modesto obtains half of its water through groundwater pumping, and half through the Modesto Irrigation District's treatment plant. Their avoidable costs are related to chemicals and power at the treatment plant, and are estimated at $27 per AF. In the long term, they are not looking for additional supplies out of the CALFED process. Their major concern today is with arsenic contamination of groundwater. Depending on the regulation for arsenic adopted by the EPA, new water supplies could be required for blending or additional treatment facilities could be needed. This could cause the variable costs of water supply to increase significantly, but the extent of that increase is not known.

For the forecast of long-term avoided cost, these costs were escalated at 5 percent in nominal terms. This is 2 percent above the general rate of inflation. This higher rate was chosen to reflect the need for some level of increased treatment and/or blending that will be required because of the arsenic standard.

South Coast Region

The South Coast Region is served by MWD, which imports water into the region from the SWP and from the Colorado River over the Colorado River Aqueduct (CRA). The SWP is the marginal supply, both because it is more expensive than the CRA supplies, and because MWD has made the decision to minimize its used of the SWP to protect the Delta and associated habitat. MWD has estimated its short-term avoided costs to be $154 dollars. The basis for this estimate is said to be $104 for pumping on the SWP, and $50 for treatment costs. This amount is the incentive MWD offers for conservation programs, but these estimates are out of date. The current estimate of SWP pumping costs as provided in *Bulletin 132-97* is $76 per AF.

In addition to the MWD incentive, some additional agencies also supply financial incentives to encourage their member agencies to institute conservation programs. The coverage of these incentives varies across the region. For example, the San Diego County Water Authority provides its member agencies with an incentive. In contrast, the Los Angeles Department of Water and Power obtains supplies directly and retails that water to the consumer. Therefore in this case there is no intervening agency (other than MWD) to supply an incentive. For this analysis, we have used a simplifying assumption of $154 as the total incentive payment. This will be too high in those cases where MWD is supplying less than the maximum incentive and no other agency is supplying an incentive. It will be too low in cases where MWD is supplying an incentive at or near the maximum value, and other agencies are also providing an incentive.

The retail avoided cost estimate is developed in three steps. First, MWD's current forecast for wholesale rates is used for the period 2000 through 2008. This is forecast to grow throughout the rest of the period at a nominal rate of 4.5 percent, or 1.5 percent above the assumed rate of inflation. Metropolitan's future wholesale rates will be tempered by the repayment of SWP and related bonds. Fixed charges from the SWP currently contribute approximately $200 per AF (or about one third) to MWD's rates. This is expected to drop to less than $50 per AF by the year 2040.

The forecast of MWD's retail rates also assumes that current rate designs will be continued. These rate structures are currently under review. If the rate structure changes so that an increased proportion of MWD's costs are recovered through fixed charges, the cost-effectiveness of conservation will decline.

To this amount is added the $154 of MWD's conservation incentive. This incentive is assumed not to change in nominal terms throughout the time of the study.

South Lahontan Region

The avoided costs for the City of Barstow were used to represent this region. Current variable water supply costs are $53 per AF for energy, chlorine and an administrative/biological assessment imposed by the Mojave Water Agency (MWA), which manages the adjudicated groundwater basin. Because of significant overdraft within the region, the adjudicated water rights will ramp down until the sustainable yield is reached. When the city produces more than its allowance, the incremental supply cost will rise to will include a replenishment assessment. Current raw water rate estimates from MWA are $191 per AF. We have assumed that the City will incur these replenishment charges from 2004 onwards. These rates are escalated at a nominal rate of 3.5 percent, which is 0.5 percent above the assumed inflation rate of 3 percent. A similar escalation rate was used to forecast treatment costs.

The MWA has a contract with the SWP to supply water to recharge the basin. This will be purchased with revenues from the replenishment assessment. There is plenty of room in the basin because of the severe overdraft. MWA should therefore be able to make use of active conjunctive use opportunities to extend its supply.

Tulare Region

The cities of Fresno and Bakersfield were used to represent this region. Fresno's current source of water is groundwater, which is being used at twice the rate of replenishment. Imported water is used to maintain the groundwater basin. Entitlements from converted agricultural land are viewed as the city's best source for new supplies. However, the variable costs for these are small, so the variable portion of the city's contract with the CVP is used as the basis for its avoided costs. The variable portion of the cost of service rate is currently $11.16 per AF. To this must be added the M&I and Restoration Fund charges. These were estimated to escalate at 2.5 percent in nominal dollars, or 0.5percent above the assumed rate of inflation. Because the city has growing supplies from retired agricultural acreage, we have assumed that there will be no requirement for new facilities as part of the CALFED solution.

Bakersfield's water supplies are from groundwater and Kern County Water Agency. Water rights are held in the SWP, but water is obtained through exchange with irrigation districts on the Kings River. Water at that source appears plentiful. The Kern County water is not the incremental supply; rather, this water serves the north of town, and groundwater serves the rest. Eighty percent of the water used is from groundwater production, so this was used as the basis for avoided costs. The variable costs of this supply are the costs of pumping and chemicals for treatment. This is estimated to be $130 per AF. There is no problem foreseen with future water supply. Because the variable costs are limited to pumping and some treatment, the costs were assumed to escalate at a nominal rate of 3.5 percent per year, or 0.5 percent above the assumed rate of inflation.