PACIFIC INSTITUTE

FOR STUDIES IN DEVELOPMENT, ENVIRONMENT, AND SECURITY

REVIEW OF THE CALFED WATER-USE EFFICIENCY COMPONENT TECHNICAL APPENDIX

Formal Comments Submitted to CALFED

Report to the United States Department of the Interior
Bureau of Reclamation
Grant No. 8-FG-20-16250

Principal Investigator: Dr. Peter H. Gleick
Research Associate: Dana Haasz

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Many people offered assistance in tracking down data, references, and sources of information for this analysis. CALFED staff members were open and helpful in explaining questions we raised, as were the analytical staff at the California Department of Water Resources. Several national and international experts in water-use efficiency questions also provided feedback and guidance. Members of environmental organizations and groups representing local communities or water agencies in California passed on comments related to water-use efficiency and water conservation. We thank them all. The United States Department of the Interior Bureau of Reclamation provided funding for this work.

Our focus of analysis here is the assumptions, methods, and data related to estimates of water-use efficiency potential in California. We have also provided some short comments on issues of water transfers, recycling, and implementation, but these areas deserve more analysis that was beyond the scope of this project. All errors are, of course, our own.

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EXECUTIVE SUMMARY

Much of the fresh water that is used by southern California cities and Central Valley farmers passes first through the Sacramento-San Joaquin Delta (the "Delta") system of California. Over the past 50 years, the health of this complex series of wetlands and ecosystems has declined substantially as more and more water has been shipped south. Concerns have also been raised about the reliability of future water supplies from this region because of changing demographics and demands. For several years the CALFED Bay-Delta Program ("CALFED") has been working to develop a comprehensive plan to address these concerns and to restore ecological health and improve water management in the Delta. Because of the comprehensive nature of CALFED and because decisions in this area affect water users throughout the state, the CALFED process has become central to all California water planning and management.

Phase II of CALFED has been devoted to analyzing and refining three alternative solutions to Delta problems with the goal of eventually identifying a preferred alternative. Common to all three alternatives are certain elements to ensure that California's water supplies are used efficiently. One of these is the Water Use Efficiency Component (WUEC). In March 1998, CALFED staff released a draft of the WUEC Technical Appendix, as part of the draft Programmatic EIS/EIR. At that time, the U.S. Bureau of Reclamation contracted with the Pacific Institute to perform an independent review of that Component to explore assumptions, data, and conclusions. A final draft of the review was to be completed by the end of the formal public comment period, initially scheduled for June 1, 1998 and subsequently extended to July 1.

Substantial efforts on the part of CALFED staff and California water stakeholders have gone into the CALFED program in an effort to reach agreement on how to move forward with the debate over California water policy and management. The comments in this review should be seen as an effort to further strengthen the CALFED effort and to improve the quality of the information that will ultimately go into any decision about a preferred alternative.

The Numbers Matter

Before describing our specific concerns with the WUEC, we wish to note that the "numbers matter." By this we mean that despite many existing uncertainties about the potential for demand management to both reduce anticipated future demands and to supply new water, the numbers used in the analysis directly affect outcomes, conclusions, and long-term California water plans. Reiterated throughout the CALFED document is the statement that the information and the analysis in the WUEC are not intended to be used as planning recommendations. CALFED staff have noted that CALFED's objective is to reduce the mismatch between future supply and demand and to focus on supply reliability rather than to quantify demand. This argument is used to downplay the importance of the actual estimates of potential for the conservation options. This casual approach toward the numbers biases the choice of a preferred alternative by not providing a full and accurate account of the potential for demand management to reduce the discrepancy between supply and demand or the relative benefits and costs of demand management compared to developing new supply. The numbers matter, and we urge

CALFED staff to continue their efforts to correct incorrect data, identify gaps in data, and refine estimates as new information is developed.

Major Findings

The concerns we raise about methods and specific data sets are important. Errors in methodology and data affect CALFED modeling efforts to evaluate impacts (the ongoing impact analyses) and they form the basis for the Economic Risk Model assumptions used to evaluate costs and benefits of various supply options.

Below we offer a summary of our more detailed comments, followed by specific recommendations for ways to improve the WUEC and improve the analysis of CALFED alternatives. In addition to the recommendations scattered throughout the assessment, some detailed recommended word changes are listed in Appendix A.

1. Methodological Problems

- There can be no single estimate of the potential for water-use efficiency improvements. Each CALFED alternative comes with a different set of assumptions, physical structures, and costs. These characteristics will determine which water-use efficiency components are most cost-effective, which are applicable in different regions, and ultimately, how much future demands for water in California can be reduced or modified. This point should be emphasized at the beginning of the WUEC.

- There is a misrepresentation in the CALFED WUEC about the definition and role of water-use efficiency improvements. In the WUEC, such improvements are incorrectly treated as supply options in the water balance, rather than as direct reductions in future demand. This leads to grossly inflated estimates of future water needs.

- Basic economic principles receive inadequate treatment and attention throughout the report. Both water demand and supply levels are projected independent of costs, prices, subsidy considerations, and market forces, and are therefore incomplete and unrealistic. In the one case where economic costs of demand management options are presented, the estimates are based on incorrect and incomplete data from DWR.

- The benefits of promoting water conservation in urban areas are understated and misinterpreted. A decrease in per-capita urban water demand due to water-use efficiency improvements will lead to direct reductions in the projections of future demand, will extend the supply available to meet future demand, and will have a wide range of other indirect water quality and ecosystem advantages. Total applied water reductions should be counted as reductions to future demand. A wide range of potential improvements that have been left out should be brought into the assessment.

- The benefits from improving water use in agriculture are understated and incorrectly described. These benefits include decreases in agricultural applied water needs, increased availability of water for other agricultural or non-agricultural uses, and improvements in instream flows and quality. Great uncertainties about total potential remain, but several methodological and data flaws should be corrected.

- Evaporation and transpiration from agriculture are treated as a single factor with a fixed value. They must be considered separately. Real savings from reductions in nonproductive evaporative losses are not evaluated in the WUEC, leading to an underestimate of the potential savings in agriculture. Insufficient consideration is given to ways of reducing transpiration.

- The WUEC incorrectly assumes that no landscape improvements down to 0.8 ETo are evaporative losses. The landscape conservation literature suggests that substantial reductions in consumptive losses are possible. The analysis also underestimates the fraction of residential landscape that can be reduced to 0.6 ETo, overestimating future outdoor landscape water needs.

2. Data and Information Gaps

- The greatest problem with the WUEC Technical Appendix is its reliance on the demand estimates and analysis of the California Department of Water Resources draft Bulletin 160-98. As noted here and elsewhere, the draft Bulletin 160-98 contains major methodological and data flaws. CALFED significantly improves on Bulletin 160-98 water-use efficiency estimates, but adopts some major flaws from that document. These flaws lead to overestimates of future water demand and underestimates of the potential for cost-effective water-use efficiency improvements by the year 2020 in both the urban and agricultural sectors. These errors are important: they drive the CALFED modeling efforts to evaluate impacts (the ongoing impact analyses) and they form the basis for the Economic Risk Model assumptions used to evaluate costs and benefits of various supply options.

- The baseline data on water use in California are adopted from the draft Bulletin 160-98. It now appears that this baseline significantly overestimates current demand for water. This overestimate, in turn, directly leads to a significant overestimate of future baseline demand for water and therefore an exaggeration of the gap between supply and demand. As noted above, the supply/demand numbers drive much of the rest of the impact and assessment work of CALFED.

- No satisfactory water balance of supply and demand is provided within each region. This makes it impossible to compute regional water reuse factors, total applied water, or consumptive versus non-consumptive uses.

- The potential for urban demand management appears to ignore a wide range of existing cost-effective technology and policies. Detailed residential end-use studies suggest that even the current generation of conservation options can reduce indoor and outdoor end use to well below the levels assumed by CALFED. The potential for new and developing technologies over the next 22 years is excluded entirely.

- The value and scope of improvements in irrigation technology are underestimated. More quantitative analysis is needed of decreases in evaporative losses, reduced energy and economic costs to farmers of overapplication, and improvements in water quality.

- The WUEC discussion of the "costs of conservation" options is inadequate; the data used are inaccurate and incomplete. The single measure used – cost per acre-foot – is inappropriate. Other measures, including benefit/cost ratios and simple payback periods are also important indicators of costs. The data used reflect the upper end of current estimates, but not the lower end, and they are based on an incomplete reading of the literature by DWR. Detailed recommendations are provided below.

In addition to the aforementioned problems, the following gaps in the data essentially make it impossible to analyze the CALFED document in proper detail. Many of these flaws are not the fault of CALFED – in many cases no good data actually exist. In order to make intelligent decisions, however, much of this information will have to be made available.

Residential landscape area is highly uncertain;
Residential landscape water use is poorly understood or measured;
Distribution of residential water-using appliances, by type and use, is not known;
Distribution of irrigation technology by type and crop, is not known;
Statewide and regional values for agricultural water-use efficiency are not measured or separated into its component parts: evaporation and transpiration;
Agricultural water-use efficiency, as a function of irrigation technology, is incompletely understood;
Economic costs of conservation options are poorly understood and quantified;
The water balance of major regions has not been adequately done;
The implications for water quality of conservation options has not been explored analytically.

Great uncertainties still remain about the potential for demand management and improvements in water-use efficiency in California. The magnitude of this potential depends on water prices, rate designs and structures, existing and developing technology, public opinion and preferences, and policies pursued by water agencies and managers. Despite these uncertainties, there is a very high likelihood that appropriately designed water-use efficiency programs will generate large, cost-effective improvements in water-supply reliability, water quality, and ecosystem health. The framework and implementation of these programs have yet to be adequately addressed by CALFED.

Many of the uncertainties associated with the water-use efficiency programs can be reduced with modest investments in data collection and analysis. Until proper comparisons are made between demand-management potential and new supply infrastructure, large investments in new water-supply systems should be delayed, since they may prove economically and environmental unjustifiable.

I INTRODUCTION

The CALFED Bay-Delta Program ("CALFED") is designed to develop a comprehensive plan to restore ecological health and improve water management in the Bay-Delta system of California. Because of the comprehensive nature of CALFED and because decisions in the Bay-Delta affect water users throughout the state, the CALFED process has become central to all California water planning and management. Phase II of CALFED has been analyzing and refining three alternative solutions with the goal of eventually identifying a preferred alternative. Common to all three alternatives are certain components to ensure that California's water supplies are used efficiently. One of these is the Water Use Efficiency Component (hereafter referred to as "WUEC"). In March 1998, CALFED staff released a draft of the WUEC Technical Appendix, as part of the draft Environmental Impact Statement/Environmental Impact Review. At the same time, the U.S. Department of the Interior Bureau of Reclamation contracted with the Pacific Institute to perform an independent review of that Appendix to explore assumptions, data, and conclusions. A final draft of the review was to be completed by the end of the formal public comment period, initially scheduled for June 1, 1998 and subsequently extended to July 1.

This report is broken into three major components:

- **Methodological Questions and Errors**
- **Data and Analysis: Omissions and Errors**
- **Implementation and Assurance Issues**

In addition, two Appendices are attached: Appendix A includes specific recommendations for wording changes; Appendix B offers a quantitative estimate of the potential water savings from horizontal-axis washing machines.

II METHODOLOGICAL QUESTIONS AND ERRORS

The CALFED Water Use Efficiency Appendix has some methodological flaws. Many of these result from reliance on basic assumptions used in the draft Bulletin 160-98 – the California Department of Water Resources long-term water planning document. A draft of this document was released in early 1998; a final is scheduled to be released in late 1998. Some of the flaws in the draft Bulletin 160-98 have been pointed out in public comments produced in spring 1998. By far the most important of these is an error in the application of the concepts of "applied" water, "new" water, and "real" water. Other problems with methodology include failure to integrate basic economic principles and concepts into the analysis, miscategorization of certain demand management options, and the incorrect description of water use categories in the agricultural sector. These issues are discussed below in more detail.

Another important methodological flaw results from the stated assumption that the water-use efficiency program of CALFED would be the same across the different supply-side alternatives. There can be no single estimate of the potential for water-use efficiency improvements. Each CALFED alternative comes with a different set of assumptions, physical structures, and costs. These characteristics will determine which water-use efficiency components are most cost-effective, which are applicable in different regions, and ultimately, how much future demands for water in California can be reduced or modified. While this is acknowledged in the WUEC (page 2-1), it is later ignored when water conservation potentials are calculated and presented.

II.1 Incorrect Application of Applied Water/Real Water/New Water Distinction

A fundamental CALFED assumption underlying water-use projections and the role of water-use efficiency improvements is that improvements in the efficiency of non-consumptive uses produce no "new" water and hence are of no water supply value other than unquantified improvements in water quality. This assumption comes initially from the draft Bulletin 160-98 and has enormous implications for total future water supply and demand. In this report, in formal comments submitted to the Department of Water Resources, and in a previous memo produced by the Pacific Institute, we describe a fundamental flaw in that assumption that leads to a large overestimate of total future California urban water demand.[1]

Bulletin 160-98 and the CALFED DEIS/DEIR draw a distinction between "applied water," "real water," and "new water."[2] This distinction has long been understood in agricultural water analysis and under certain circumstances it is very useful. In recent years it has been applied in Asia and Africa. Among other things, this

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[1] Gleick, P.H. May 20, 1998. "Application of Applied Water/Real Water/New Water Distinction in Bulletin 160-98 and CALFED DEIR/DEIS." Public Memo, Pacific Institute for Studies in Development, Environment, and Security, Oakland, California; Pacific Institute, April 2, 1998, "Comments on the Draft Bulletin 160-98," Pacific Institute for Studies in Development, Environment, and Security, Oakland, California.

[2] See, for example, page 1-4 in the CALFED WUEC.

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distinction can help identify where improvements in water-use efficiency may be most appropriate and valuable.[3] [Note: the term "real" water, however, is not used in the literature and is misleading. All water from conservation activities is "real." The appropriate distinction, however, is between water that can be reallocated ("new" water here) and water conservation savings that reduces future increases in demand and has other instream benefits ("applied water").]

This approach is based on the idea that in a region with limited water resources and 100 percent downstream reuse, any reductions in non-consumptive uses of water do not produce "new" water because any water saved is already committed for use by a downstream user. While imperfect, this line of reasoning is justified in certain regions with **fixed demand.** Bulletin 160-98 and CALFED adopted this approach in their analysis of potential improvements in water-use in all sectors. Problems arise because DWR and CALFED incorrectly apply this approach to inland urban water use in a situation of **growing demand**. In such a situation, improvements in water-use efficiency may not lead to "new" water being created, but they do lead to real reductions in the projected increases in demands. This is independent of whether that region returns water to a saline sink or downstream user.

This error leads DWR and CALFED to either completely ignore, or to underestimate, improvements in urban water-use efficiency in inland regions. This, in turn, leads to a significant overestimate of future urban demand for water. Even adopting conservative assumptions about the potential for demand management and recycling (discussed further in Sections II and III), this single error leads to an overestimate in future urban demand on the order of one million acre-feet.

Figure 1, modeled after similar DWR (Figures 4-1 and 4-2) and CALFED (Figures 4-6 and 4-7) figures, outlines in graphic form the Bulletin 160-98/CALFED error. In this representation, two cities take water, one after another, from a river with average renewable supply of 500 units. In time period 1 (assumed here to be 1995 "Base Case"), each city withdraws 100 units of water, "consumes" (through evapotranspiration or irrecoverable losses) 40 units of water, and returns to the river or groundwater ("non-consumptive use") 60 units for reuse by other users downstream.

At some time in the future (assumed by DWR/CALFED to be 2020), population and economic growth increase the demand for water. In order to estimate these future water needs, DWR projects future per-capita water demand and multiplies that demand by future population projections.[4] Although it is not clear from Bulletin 160-98, we assume here that DWR uses a value for per-capita demand that has been adjusted for 'full

[3] See, for example, Keller and Keller, 1995, "Effective efficiency: A water use efficiency concept for allocating freshwater resources," Center for Economic Policy Studies, Winrock International, Arlington, VA; Molden, 1997, "Accounting for water use and productivity," International Irrigation Management Institute (IIMI), Sri Lanka; and Seckler, 1996, "The new era of water resources management: From 'dry' to 'wet' water savings," Research Report 1, International Irrigation Management Institute (IIMI), Sri Lanka.

[4] The DWR and CALFED use population projections from the California Department of Finance (DoF). When the draft Bulletin 160-98 and WUEC reports were released, DoF's 2020 forecasts were 47.5 million Californians. There is now evidence to suggest that the DoF 2020 forecast will be reduced substantially – by perhaps 2 million people – before the end of 1998. When and if this occurs, all Bulletin 160-98 and CALFED future demand estimates will have to be redone, and model runs reconfigured.

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implementation" of the BMPs.[5] CALFED makes more aggressive assumptions about the potential for efficiency improvements but then assumes that in inland areas these improvements produces no new water, because that water is already committed to other downstream uses.

In a situation with growing demand for water what is needed is either "new" water or real reductions in demand. Efficiency improvements in inland areas may not generate "new" water, but they produce one-for-one reductions in anticipated demand for water. These reductions are independent of location (inland or coastal) – they all lead to reductions in anticipated future demand. In Figure 1, 2020 Base Demand for each city is assumed to rise 50 percent to account for population growth (from 100 units to 150 units). Thus each city would demand 150 units of water, consumptively use 60 units, and return 90 units to the river. Total basin demand would thus rise from 200 units to 300 units; total base consumptive use would rise from 80 units to 120 units, and downstream flows would drop from 420 to 380 units. Under this scenario, DWR argues that an increase in applied water supply of 100 units is needed (2020 base demand –1995 base demand).

Under a scenario with 20 percent potential urban conservation in non-consumptive uses (keeping the increase in consumptive uses the same – a conservative assumption), 2020 Conservation Demand in each city would drop to 132 units. In this scenario, final downstream flow still drops 40 units due to the assumed increase in consumptive uses, but total upstream demand drops from 300 to 264, a real reduction in demand of 36 units from the 2020 Base Demand scenario. If 1995 supply and demand are in balance, these conservation options would reduce the future gap between supply and demand from 100 units to 64 units. Because no "new" water is created, however, DWR ignores these savings while simultaneously failing to reduce projected demand.

These results are independent of location: it does not matter if a city is inland, with 100 percent downstream reuse. Demand reductions in non-consumptive uses still lead to reductions in overall demands, directly reducing the magnitude of new supply needed and reducing the impacts of growing populations.

In numerical terms, this error means that the distinction drawn in CALFED between the "applied water" and "depletion reduction" savings attributable to inland urban areas should be eliminated, and that all applied water savings potential should be counted as reductions in estimated future demand on a one-for-one basis. Thus, actual urban demand reductions expected for 2020 under CALFED Actions should be the full 3.06 to 3.37 million acre-feet (listed in Table 5.5, page 5-48). [Other factors that change the *magnitude* of these estimates are discussed later.]

There are other benefits of reductions in applied water, including improvements in human health, more reliable instream flows, ecosystem and habitat restoration, reductions in the cost of treating drinking water, less environmental contamination by agricultural chemicals, and reductions in the economic costs of multiple unnecessary withdrawals of

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[5] Bulletin 160-98 estimates that "full implementation" of the urban Best Management Practices (BMPs) will save 1.5 million acre-feet of water by 2020, though no information in the Draft is available to support this estimate. The Bulletin 160-98 Draft also does not make clear if and how this value is applied to the future demand projections because insufficient information is provided on how future urban demand is computed.

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water. Some of these additional benefits are mentioned in the WUEC, but they are not quantified or valued.

Recommendations

Several things would help eliminate this confusion:

- Acknowledgement of the ability of all urban conservation efforts to reduce projected increases in demand. The distinction between "applied water" savings and "depletion reductions" in the WUEC should clearly note that "applied water" savings directly reduce future growth in demand.
- The term "real" water should be changed to "new" water.
- Re-label "Real water" tables and reword "applied water" footnotes. Please see "Specific Wording Recommendations," Appendix A.

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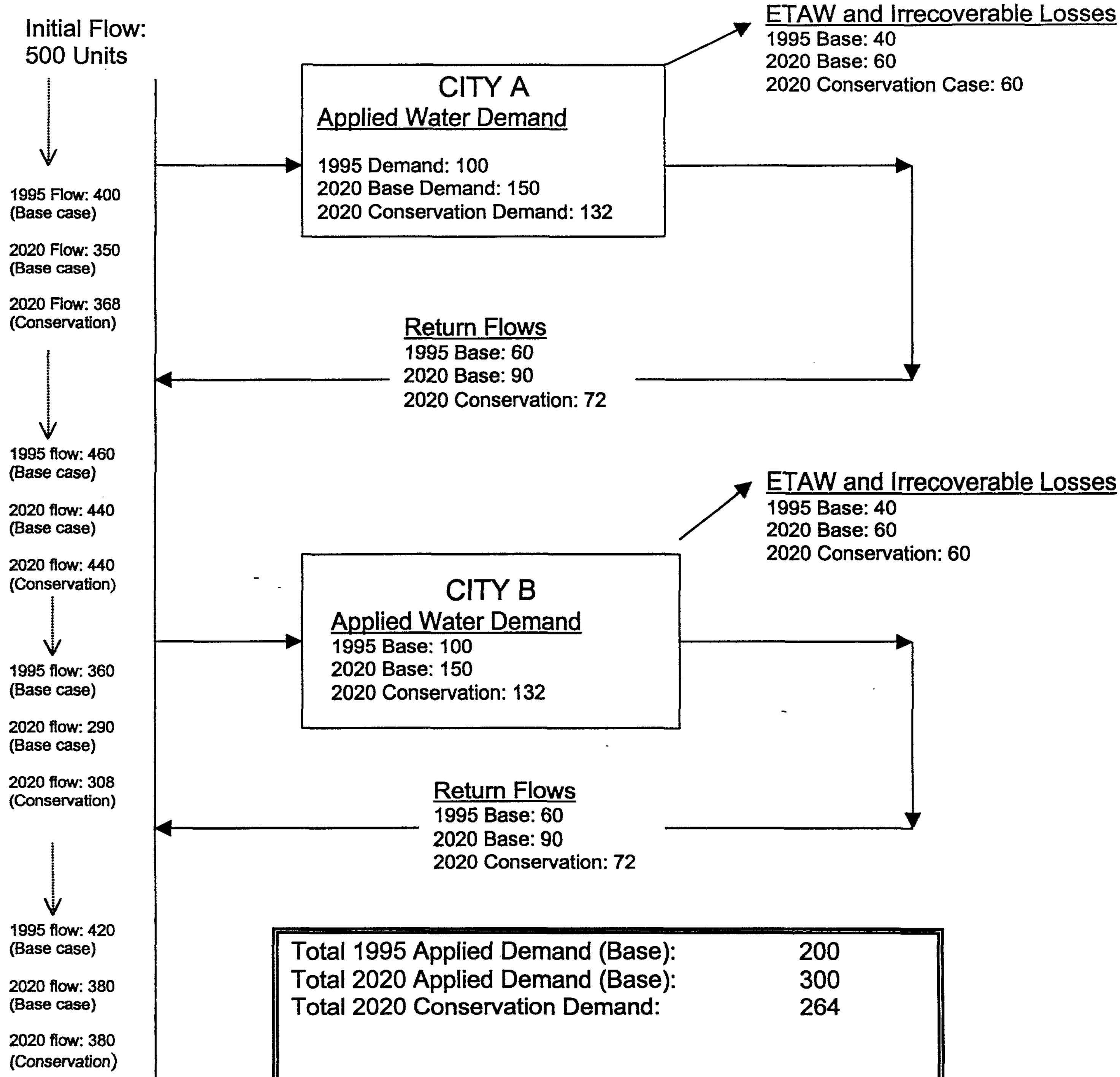
Figure 1
Urban Water Use Projections: No Conservation versus 20% Conservation



Total 1995 Applied Demand (Base):	200
Total 2020 Applied Demand (Base):	300
Total 2020 Conservation Demand:	264
Total 1995 Consumptive Use (Base):	80
Total 2020 Consumptive Use (Base):	120
Total 2020 Consumptive Use (Conservation):	120
Projected 2020 New Supply Needed	
Base Case (no conservation):	100
Conservation:	64
Real Demand Savings:	36 Units

II.2 Economic Considerations Are Not Factored into Future Agricultural Water Demand Estimates

The price of water, market prices of crops, and the presence or absence of subsidies greatly affects grower decisions about cropping patterns. The Broadview Water District, during the recent multi-year drought, implemented a rising block rate tariff structure, which was very effective at changing planting patterns and irrigation water use levels.[6] More and more irrigation districts are now beginning to apply some form of rising block rate structure,[7] but these changes are not reflected in CALFED's analysis. No data are provided on future agricultural water costs or prices used in planning models or on the elasticities assumed for those prices. Similarly, no data are provided by DWR on historical, present or assumed future subsidy rates or crop prices, making a comprehensive public review impossible. These gaps are also found in CALFED's analysis, which fails to include the potential for economic forces to change agricultural behavior.

<u>Recommendation</u>

- Publish assumed crop and water prices for present day and 2020. Publish econometric model assumptions.
- Submit models and assumptions to peer review by outside independent agricultural economists.

II.3 The WUEC Summary Misstates the Scope and Range of CALFED Water-Use Efficiency Estimates

The Technical Appendix states that "CALFED estimates of water use efficiency are intended to bracket the potential range of savings so that impacts can be identified and assessed."[8] This may have been the intent, but CALFED's analysis does not identify the maximum potential, which would be required in order to "bracket" the savings possibilities. In fact, CALFED tends to use the average savings value in its calculations of potential savings rather than the upper and lower limits. An upper limit of potential savings would evaluate all technically feasible savings.

<u>Recommendations</u>

- At a minimum, the wording in this section should be changed to acknowledge that these savings estimates do not encompass the actual range of potential savings.

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[6] Gleick, P.H. P. Loh, S.V. Gomez, J. Morrison. 1995. "California Water 2020: A Sustainable Vision." Pacific Institute for Studies in Development, Environment, and Security. Oakland, California.

[7] King, L. 1998. "Presentation by Laura King, Director of Strategic Planning, San Luis and Delta-Mendota Water Authority." Before the Bay Delta Advisory Council, June 18, 1998, Fresno, California. According to King, all San Luis and Delta-Mendota Water Authority "districts have implemented some form of tiered pricing programs."

[8] CALFED, WUEC, pp. 1-5.

II.4 Narrow Definition of "Irrigation Efficiency" Limits the Scope of Improvements of Agricultural Water Use

There are many ways to measure the efficiency of water use in agriculture. CALFED's dependence on irrigation efficiency (IE) and distribution uniformity (DU) as the sole measures of irrigation performance limits the kinds of improvements analyzed. Irrigation terminology is important because inherent to it are value judgments concerning whether the water is being used in a beneficial and reasonable manner. For example, crop evapotranspiration is included as one of the beneficial uses of water in the IE equation. However, as mentioned in a separate section, not all ET is beneficial or reasonable. This assumption thus has the potential to lead to a significant overestimation of the actual efficiency of irrigation water use.

CALFED concedes that IE is a gross measurement that is based on information that is often incomplete and can easily be misinterpreted. While it does have its uses, we recommend that CALFED expand the measures used so that the value judgments involved are more clearly distinguishable. One suggestion is to use the concept of fractions such as consumed fraction (CF), which would clearly identify the proportion of the water that is consumed in the production of plant material, reusable fraction, conveyed fraction, and so on.[9] Various other terms, such as irrigation sagacity, can also be used in combination with IE to provide a clearer measure of prudent water use.[10]

Recommendation

- Clarify the discussion and definition of irrigation efficiency to reflect the comments above.

II.5 The Potential for Agricultural Water-Efficiency Improvements is Mischaracterized. CALFED Must Distinguish between Evaporation and Transpiration in Agriculture

CALFED lumps evapotranspiration from agricultural production into a single figure: ET (or ETAW, depending on application). For the purposes of evaluating the potential for reducing agricultural water use, however, these two terms should be analyzed separately. They represent different processes; they are affected by different actions on the part of growers; and they have different implications for water policy and management.

The fundamental premise of the agricultural efficiency component of the CALFED WUEC is that the consumptive water demands of crops do not change. Figures 4.6 and 4.7 illustrate a regional water balance with and without on-farm efficiency improvements. The only result of the efficiency improvements is that water required for reuse

[9] Willardson, L.S., R.G. Allen, and H.D. Frederiksen. 1994. "Elimination of Irrigation Efficiencies" Irrigation Planning and Management Measures in Harmony with the Environment. 13th Technical Conference, USCID, Denver, Colorado.

[10] Burt, C.M., Clemmens, A.J., Strelkoff, K.H., Bliesner, R.D., Hardy, L.A., Howell, T.A., Members, ASCE, and D.E. Eisenhauer. 1997. "Irrigation Performance Measures: Efficiency and Uniformity." *Journal of Irrigation and Drainage Engineering*, 123(6):423-442.

downstream, which is water that was originally acquired from surface runoff and deep percolation, must now be obtained through increased groundwater pumping. This reasoning fails to consider evaporation and transpiration separately, or the possibility of reducing each component.

The problem with the aggregation of evapotranspiration into a simple fixed depletion value is that, in fact, it is made up of two distinct processes. Molden and others distinguish these types of depletions based on their beneficial use.[11] Process depletion is defined as that amount of water diverted and depleted to produce an intended good, such as water transpired by crops and incorporated into the plant tissue. Non-process depletion is when water is depleted, but not by the process that it was intended for, such as evaporation from soil and free water surfaces and evaporation of spray drift. In other words, evaporation and transpiration are distinguishable and separating ET into its component parts would shift the focus to beneficial uses of irrigation water by allowing the user to manipulate non-beneficial evaporative losses.

Evaporation occurs in several ways, including water loss from soils, from soil surfaces, from crop and weed surfaces, and during irrigation water application as wind drift and direct evaporation. Some of this evaporation is unproductive: reducing it does not affect crop production, soil quality, or yields. Reductions in evaporation directly reduce both total applied water and the consumptive use of water.

Transpiration is the water used by crops during growth and depends on climate, crop type, and cropping patterns and extent. Reductions in transpiration also can reduce both total applied water and the consumptive use of water.

Both factors can be reduced with different technology, water policies, and agricultural practices. Reductions in evaporation can be achieved by reducing surface water exposure, evaporation from soils, and mis-application of irrigation water. Reductions in transpiration can result from changes in crop types, the introduction of more water-efficient varieties, land fallowing, and land retirement.

Discussions of crop switching, fallowing, and land retirement have traditionally been excluded from California water policy debates, even though changes in cropping patterns over time in California have had a great impact on total agricultural water demand, water quality, and consumptive use.

While we acknowledge the difficulty of having such a discussion within the CALFED process, issues related to reductions in both evaporation and transpiration are critical to estimating total future demands for water in the agricultural sector. A partial discussion already occurs implicitly in (1) the estimates of changing crop acreage by 2020, such as those estimates generated by the DWR for the Bulletin 160-98 process, (2) estimates of agricultural water use for 2020, and (3) agricultural pricing discussions. A more complete discussion of these issues is needed in the WUEC of CALFED.

Below we raise several of the more important aspects of this issue as they relate to CALFED's WUEC.

[11] Molden, M. 1997. "Accounting for Water Use and Productivity." System-Wide Initiative for Water Management. International Irrigation Management Institute. Sri Lanka.

II.5.1 Reducing Evaporation Losses

Nowhere in the WUEC is there discussion or analysis of the possibility of reducing evaporative losses in order to improve agricultural efficiency. It is widely understood that changing irrigation frequency, irrigation method, mulching, shading, and so forth can modify evaporation.[12] A significant fraction of the water evaporated without entering the plant is consumed non-productively and any irrigation method that minimizes evaporation (but not transpiration) will increase the water-use efficiency of the crop and decrease overall water consumption.

One of the components of evaporation from agricultural lands is soil evaporation. This reflects water that enters the vapor phase and is lost to direct productive use by crops. Some fraction of soil evaporation, however, must be considered a productive use, since it either directly or indirectly reduces crop transpiration requirements. Thus part of any reduction in evaporative soil losses may simply be accompanied by a comparable increase in transpiration. Despite the fact that these changes do not produce "new" water, they typically lead to increases in agricultural yields – thus they increase the overall crop productivity per unit water.[13] This benefit is not noted by the WUEC or accounted for in DWR cropping models. Some fraction of soil evaporation is unproductive loss, however. A reduction in this fraction leads to a reduction in applied water requirement and a reduction in ETAW – leading to "new" water supply.

There are a number of different ways to reduce evaporation. Efficient crop maintenance is important: a well-watered crop with dry soil and plant surfaces (full cover, no weeds) requires less water than a well watered crop with wet soil and plant surfaces and weeds in between plants. Another significant component to evaporation is wind loss immediately during and following field application. Changing irrigation technology has been shown to have a major effect on reducing wind evaporative losses, while maintaining or improving crop yields.

Irrigation methods that introduce water directly into the root zone, such as drip irrigation, without sprinkling the foliage or wetting the entire soil surface minimize deep percolation, surface runoff, and unproductive evaporative loss, while surface application induces depletion by evaporation. Drip irrigation (see Sidebar 1 for details and numbers) offers the additional benefit of keeping the soil surface between the rows of crop plants dry, discouraging the growth of weeds that compete with the crops for nutrients and moisture.[14] Evaporation can also be reduced by improving irrigation timing and

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[12] Burt, C.M., Clemmens, A.J., Strelkoff, K.H., Bliesner, R.D., Hardy, L.A., Howell, T.A., Members, ASCE, and D.E. Eisenhauer. 1997. "Irrigation Performance Measures: Efficiency and Uniformity." *Journal of Irrigation and Drainage Engineering*, 123(6):423-442.
Hillel, D. 1997. "Small-Scale Irrigation for Arid Zones; Principles and Options." FAO Development Series 2. Rome, Italy.
Molden, M. 1997. . "Accounting for Water Use and Productivity." System-Wide Initiative for Water Management. InternationalIrrigation Management Institute. Sri Lanka.
Gallardo, M., Snyder, R.L., Schulbach, K., and L.E. Jackson. 1996. "Crop Growth and Water Use Model for Lettuce." Journal of Irrigation and Drainage Engineering, 122(6).

[13] Robert Lascano, June 23, 1998, Texas A & M University, personal communication. Many examples of this effect can be found in the agricultural literature.

[14] Hillel, D. 1997. "Small-Scale Irrigation for Arid Zones; Principles and Options." FAO Development Series 2. Rome, Italy.

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providing the crops with water when they need it most. For example, there is a greater potential to reduce ET during the midday when transpiration is reduced and evaporation is at its highest. Improvements in irrigation technology and irrigation management can both decrease evaporative losses, and these methods need to be better addressed in the CALFED report.

Because of these advantages, much of the irrigation in the High Plains region is now shifting away from inefficient sprinkler technology toward low-energy precision application (LEPA) sprinker technology or drip systems. True LEPA systems are considered to be 95 percent efficient compared to furrow systems at 60 percent efficiency, with a significant fraction of the gain coming from reduction in immediate wind loss. Greater application of such efficient systems is also beginning to happen in California and will have a definite effect on reducing unproductive evaporation losses.[15]

II.5.1.1 Drip Irrigation as an Example of Technology Leading to Evaporation Savings

Precision irrigation systems, such as drip systems, offer the advantage of more precisely controlling the delivery of water to the plants. They improve irrigation efficiency by improving the ratio of water beneficially used by the plant to that of the water applied, acting to reduce applied water and to increase beneficial use of the applied water. Because they don't spread water over the soil surface, precision irrigation systems reduce evaporative losses from standing water – a savings in consumptive use – and reduce runoff and deep percolation losses. Drip delivery, for example, can provide high distribution uniformity, which minimizes the amount of water applied to adequately wet the field and reduces water lost to deep percolation. Drip systems can also improve crop yields. For example, sub-surface drip irrigation reduces water lost to evaporation and increases water available for transpiration, allowing for increased yields. The Irrigation Training and Research Center believes that crops grown with a well-managed drip irrigation system take up almost ten percent more water than crops grown under other irrigation systems (ET_{crop} increases by 10 percent), because the soil is never allowed to dry enough to stress plants. With improved yields, efficiency as a measure of yield/total evapotranspiration would increase even if there were little change in amount of water applied. Similarly, current yields could be maintained with a reduction in total water requirement.

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[15] Ken Carver, June 23, 1998, High Plains Underground Water District, personal communication.

Sidebar 1
Precision Irrigation: The Case of Drip Irrigation in California

Improved irrigation technology and reductions in evaporation can increase overall water-use efficiency or increase crop yields without increasing water demands. In this section, we describe a few examples of the rapidly expanding application of precision drip irrigation in California for high-value vegetable and fruit crops, and increasingly, for row and field crops traditionally considered unsuitable for drip.[16] This rapid expansion has been accompanied by reductions in applied water use, reductions in consumptive water use, and consistent increases in crop yields. **For the purposes of CALFED and the WUEC, some note must be taken of these potential improvements in the agricultural sector. Even if uncertainties remain about total reductions in consumptive water needs (reductions in ETAW), improvements in crop production should be incorporated into future estimates and modeling assumptions.**

- In Los Banos in Fresno County, Trecho Farms has been using subsurface drip irrigation to grow fresh market and processing tomatoes for the past eight years. Trecho Farms reports that it took at least a year to get the drip system working efficiently, but applied water use has been reduced by as much as 50 percent from previous furrow systems.

- At Hammond Ranch in Firebaugh, Fresno County, the owner has established subsurface drip irrigation on 560 acres of cotton, tomatoes, and asparagus. Hammond Ranch reports improvements in yields and reduced water use. Cotton on drip requires 20 percent less water than the region's average (2.1 acre-feet of water per acre, instead of 2.7 acre-feet per acre) and has produced yields approximately 15 percent above the region's average. Three-year old asparagus fields currently yield about 185 crates per acre, though the owner expects 300 creates per acre when the crop matures at five years. Such yields would be 50 percent higher than those typical produced using furrow or sprinkler irrigation.

- Turlock Fruit Company, also in Firebaugh, has subsurface drip systems serving 300 acres of asparagus, 150 acres of melons, and 150 acres of cotton. They began installing systems in 1993. The company reports that drip irrigation has increased yields on these fields by 30 to 40 percent and reduced water use by 20 to 30 percent, as well as eliminating drainage problems. Soil salinity is monitored, and they have seen no increase in soil salinity on drip irrigated fields.

- In the early 1990s, the California Energy Commission (CEC) granted low-interest loans to two California farmers to help cover the costs of converting bell pepper row crops to drip irrigation. In 1993, High Rise Farms near Gilroy installed buried drip irrigation equipment on forty acres, and Underwood Ranches near Oxnard installed buried drip irrigation on fifty acres. Technical assistance and monitoring were provided by the Irrigation Training and Research Center (ITRC) at Cal Poly San Luis Obispo. Both farms found that buried drip irrigation substantially increased pepper yields, decreased water consumption, and greatly improved profits. The average net revenue increase for High Rise Farms was $1,100 per acre per year; the average net revenue increase for Underwood Ranches was $1,900 per acre per year. Applied water use dropped between 16 and 25 percent at Underwood Ranches while yields went up between 10 and 50 percent. Applied water use at High Rise Farms dropped as much as 11 percent while yields went up as much as 56 percent. Initial installation and operation problems often experienced with new systems were successfully addressed and both farms have since expanded their drip irrigation systems with their own money.

All these cases reported additional savings from reduced fertilizer and a pesticide application.

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[16] These case studies come from M. Fidell, P.H. Gleick, and A. Wong, 1998. "Converting to Drip Irrigation:Underwood Ranches and High Rise Farms," Pacific Institute for Studies in Development, Environment, and Security, Oakland (in preparation September 1998), and from Cohen R. and Curtis J. 1998. "Agricultural solutions: Improving Water Quality in California Through Water Conservation and Pesticide Reduction." Natural Resources Defense Council, New York

To date, the portion of ET lost to evaporation has been poorly quantified. In a series of field-level water balances, Molden found that evaporation losses accounted for 17 percent of total depletion in wheat crops and 30 percent in cotton crops. Hillel estimates that, under flood irrigation, 20 to 30 percent of applied water is lost to evaporation from open water surfaces and transpiration by weeds. Another estimate is that 1-2 percent of applied water is lost to evaporation from the spaces in between the crops alone.[17] It is estimated that the proportion of ET lost to evaporation is not known to within 30 percent of its actual value.[18] It is reasonable to consider, however, that a large part of this loss is non-beneficial and avoidable. There is little doubt that, at least at the field level, evaporative losses can be reduced by a significant amount.[19] At the regional level, there are even a larger number of unknowns and the interaction between evaporation and transpiration requires further investigation. Even at this level, however, there are areas such as the Central Coast that are considered to have significant potential savings from reductions in evaporation due to their combination of climate type, wind, and high proportion of surface irrigation.[20]

Seemingly small reductions in the percentage of water being unnecessarily lost to evaporation can amount to large volumes of water being saved. A 1.5-percent reduction in current agricultural demand would result in a savings of 510,000 acre-feet of irrecoverable losses, larger than the amount that Bulletin 160-98 estimates can be saved by implementing the EWMPs. This kind of information and analysis is crucial if we are to more accurately estimate potential reductions in agricultural water use.

A part of evaporation from surrounding areas reduces transpiration because evaporation reduces available heat energy and increases humidity. Reducing evaporative losses will therefore be partly balanced by increasing transpiration (see next section). Lascano and Baumhardt note that in cotton production, using a moisture barrier can reduce soil evaporation by as much as 50 percent. This reduction was accompanied by an increase in crop transpiration and an increase in cotton yield. When these different effects were combined, the overall water-use efficiency (measured as the ratio of crop yield to total evapotranspiration) increased 37 percent.[21] Thus the decreases in soil evaporation and accompanying increases in transpiration are not necessarily additive.[22] According to Piper and Cappelluci, efficient irrigation systems tend to increase crop yield

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[17] U.S. Bureau of Reclamation, Penny Howard, personal communication, March 6, 1998.

[18] Burt, C.M. Professor and Director, Irrigation Training and Research Center, BioResource and Agricultural Engineering Dept. California Polytechnic State Univesity. Personal Communication June 23, 1998.

[19] Burt, C.M. Personal communication, June 23, 1998.

[20] Burt, C.M. Personal communication, June 23, 1998.

[21] Lascano, R.J. and R.L. Baumhardt. 1996. "Effects of Crop Residue on Soil and Plant Water Evaporation in a Dryland Cotton System." Theoretical and Applied Climatology, Vol. 54, pp. 69-84.

[22] Solomon, K.H. and C.M. Burt. 1997. "Irrigation Sagacity: A Performance Parameter for Reasonable and Beneficial Use. ASAE Paper No. 97-2181.

or decrease crop production inputs, an effect noted by many others as well.[23] Bernardo and Whittlesey reported that the potential for conserving water without greatly affecting producer income runs up to 35 percent for surface irrigation and up to 25 percent under center pivot irrigation.[24] These results suggest that total crop yields in California can be maintained with a smaller input of water; or conversely that crop yields can be significantly boosted with the water currently being used by the agricultural sector. Recent experience with precision irrigation systems in California supports this conclusion (see Sidebar 1 above).

The CALFED WUEC should recognize the need to separate evaporation from evapotranspiration and include in their analysis the potential savings that would result from minimizing the former. The effects of different irrigation technologies, irrigation scheduling, and other factors, must be evaluated in terms of their potential to reduce evaporative losses and thus increase the total potential for savings in agricultural water use. The economic and environmental implications of making these changes should also be evaluated. Although the numbers have not been well quantified to date, it is clear that evaporative losses can be reduced using some irrigation measures (such as drip systems, eliminating over-irrigation, limiting weed growth) compared with other methods. By ignoring the distinction between evaporation and transpiration, the CALFED document significantly underestimates the potential for reduction of consumptive losses in the agricultural sector.

Recommendations:

- Do separate assessments of the potential for reducing evaporation and transpiration. Report on this potential as a function of crop type and irrigation method. Compute separate evaporation savings potential as "new water."

- Evaluate the economic and environmental aspects of making changes in evaporation and transpiration components of agricultural water use.

II.5.2 Reducing Transpiration Losses

By separating evaporation and transpiration, different conservation options become more apparent. As described above, reductions in evaporation losses can be achieved through changes in irrigation technology, approaches for applying irrigation water, and other management techniques. Reductions in crop transpiration are also possible. These can result from changes in crop types, cropping patterns, and planting patterns. Traditionally, the agricultural community has argued that decisions about these changes should be left completely to the discretion of growers and irrigation districts, even though numerous federal, state, and local policies already in place play an important role in influencing these decisions. In particular, pricing policies for water, federal crop

[23] Piper, R.A. and A.J. Cappellucci. 1993. "Reductions of Deep Percolation and Drain Water." Journal of Irrigation and Drainage Engineering. Vol. 119, No. 3, pp. 568-576.

[24] Bernardo, D.J. and N.K. Whittlesey. 1989. "Factor Demand in Irrigated Agriculture Under Conditions of Restricted Water Supplies." Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture, Technical Bulletin No. 1765. Washington, D.C.

subsidies and land policies, local land-use regulations, and other public policy actions already affect decisions by growers. Changes in these policies will continue to affect cropping decisions based on real and perceived public policy benefits.

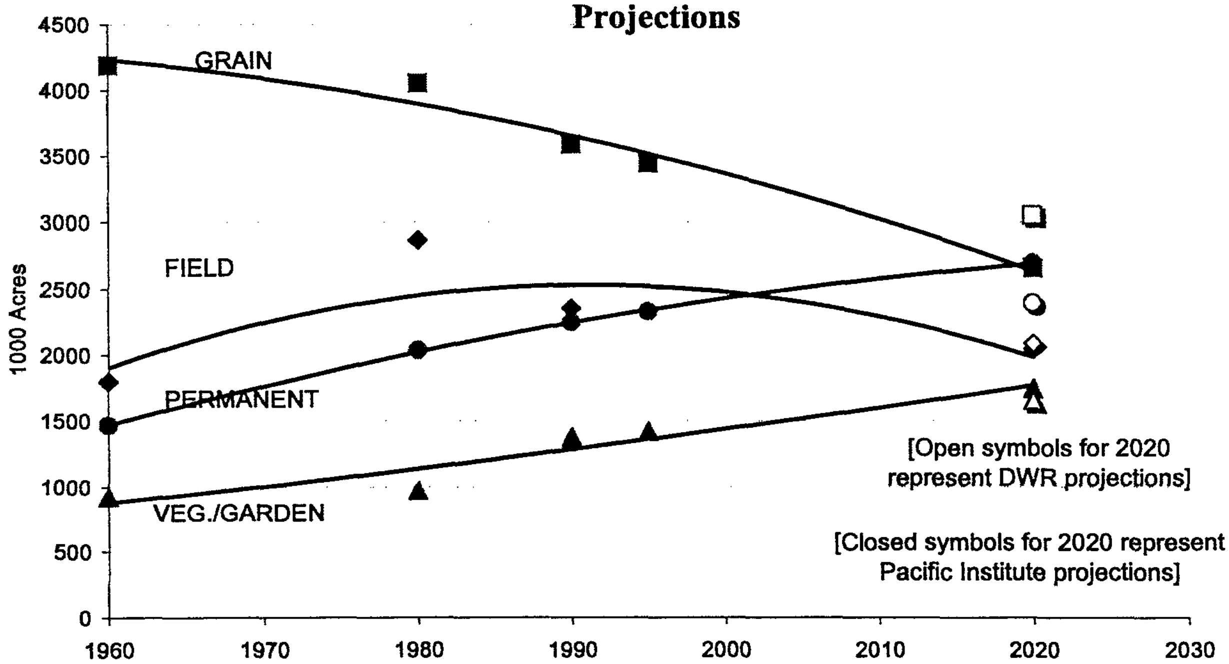
In the long run, California and federal water policymakers will have to determine the extent to which policy should be used to influence cropping decisions. It should be acknowledged in the WUEC, however, that such decisions have a direct and immediate impact on water demands and consumption. We believe that policies aimed at reducing transpiration losses could have very large long-term benefits for the California water balance without adversely affecting farm income.

II.5.2.1 Crop Shifting should be Explored More Fully

Cropping patterns change over time, and these changes are tentatively acknowledged by DWR's Bulletin 160-98 in their estimates of future crop acreage. Projections of future crop acreage are extremely uncertain. Nevertheless, there has been a clear trend over the past 40 years in California away from grain and field crops toward more profitable vegetable, truck, and orchard crops. There is no reason to believe that this trend will stop, and many reasons to believe it will continue or even accelerate. These include:

- growing pressures on water availability, which will encourage growers to plant crops with lower water demands or permanent crops likely to be given higher water priority during droughts;

Figure 2
California Crop Trends: Pacific Institute and DWR 2020 Projections



- higher profit for food crops, which can be grown productively on California farmland;

- the ability to better control evaporative losses using precision irrigation, which is more suited to orchards, vineyards, and row crops than low-valued field and grain crops.

Figure 2 shows the historical trends in California crops. Extending these trends into the future suggests greater shifts in cropping patterns than suggested by DWR Bulletin 160-98, with greater reductions in overall agricultural water use and improvements in farm income.[25] Similar trends away from grain and field crops and toward permanent or vegetable crops can be seen in regional or district data. Figure 3 shows similar time series data for the Westlands Water District. Far more rapid changes in cropping patterns appear to be happening than estimated by DWR in their base case scenarios, adopted by the WUEC.

Even without changes in the actual crop types planted in California, we expect to see the introduction of new varieties of crops that are more water-efficient. Traditional crop genetics and efforts to develop new crop varieties with advanced genetic engineering are likely to permit increasing crop yields with either similar or lower water requirements in the future. While we know of no accurate estimates of the potential for such changes, the WUEC should acknowledge the possibilities, and research into this issue included in the final draft.

Recommendation

- Just as CALFED offers a No Action/CALFED Action set of alternatives for urban water use, different scenarios and assumptions are needed for the conservation potential from plausible changes in factors that lead to reductions in transpiration, including cropping patterns and the introduction of new genetic varieties.

- CALFED should explore and analyze the implications of changing cropping patterns over time in California to a greater extent than covered in Bulletin 160-98.

II.6 The Potential Water Savings of Changes in Irrigation Methods are Underestimated by the WUEC

There has been a substantial change in irrigation type in California, permitting increased yields, increased water-use efficiency, and reduced water applied per acre for many crops. This trend is likely to continue and could be further accelerated by appropriate policies. CALFED excludes any significant changes in irrigation methods between now and 2020.

[25] Gleick, P.H. P. Loh, S.V. Gomez, J. Morrison. 1995. "California Water 2020: A Sustainable Vision." Pacific Institute for Studies in Development, Environment, and Security. Oakland, California.

Figure 3
Westlands Irrigation District Crop Trends

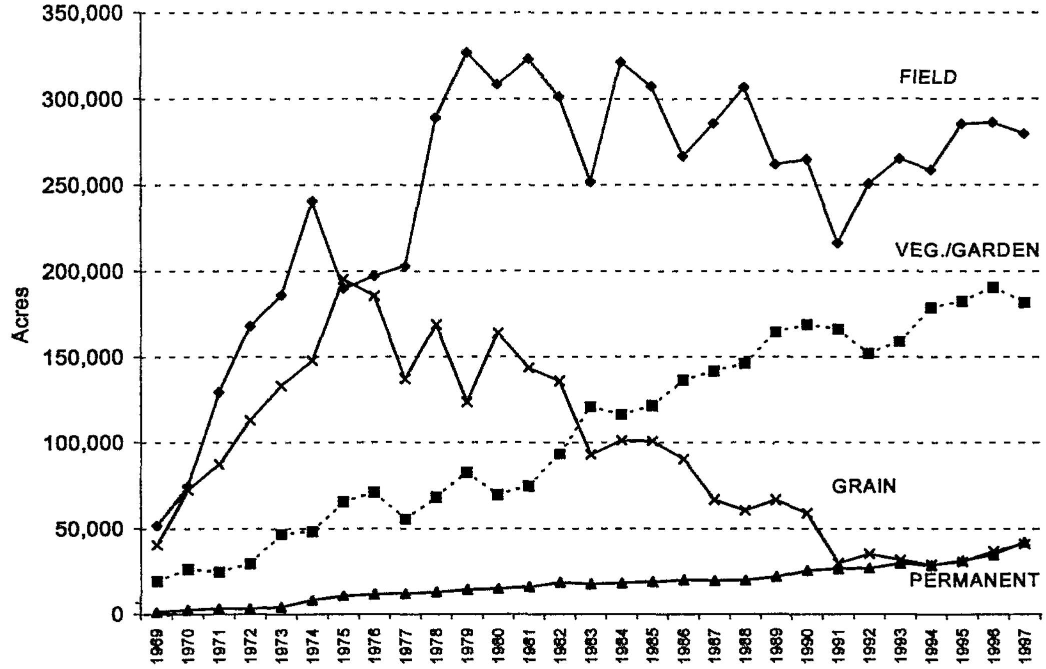


Table 1 shows an estimate of the changes in irrigation method between 1972 and 1991 in California.[26] This survey, conducted with the assistance of the DWR, shows that drip irrigation overall has been increasing at an average of 0.45 percent per year, and over 2 percent per year for vineyards. At the same time, surface and furrow irrigation has been decreasing at 0.73 percent per year, and over one percent annually for orchards and vineyards. Yet more than half of all vineyards were still not using drip irrigation in 1991; more than 80 percent of orchards have yet to implement drip. The same 1991 survey showed that 30 percent of orchards and 45 percent of vineyards were still using flood irrigation (see Figure 4). Thus, while California agriculture has begun to make progress in this area, enormous potential remains. Changing irrigation method leads to both applied and new water savings by reducing evaporative losses.

Recommendations

- Report on historical trends in irrigation technology by crop.
- Continue historical trends, assuming continued replacement of surface irrigation with sprinkler and drip irrigation.
- Re-evaluate potential reductions in future demand projections by 2020 due to irrigation technology changes.

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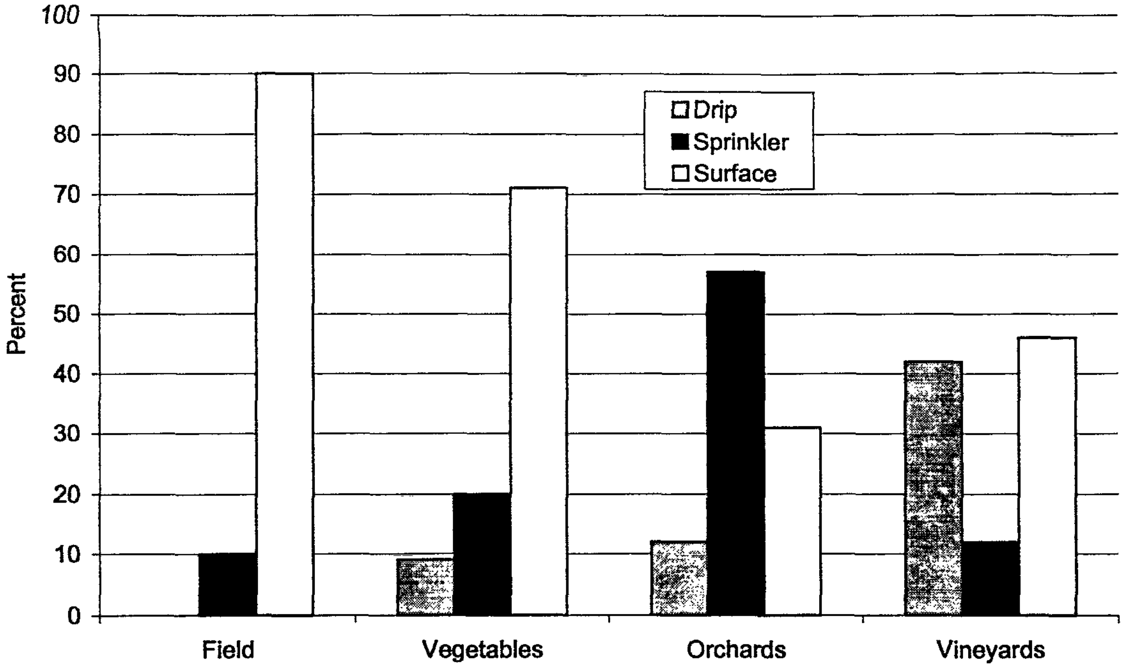
[26] Snyder,R.L., M.A. Plas, and J.I. Grieshop. 1996. "Irrigation Methods used in California: Grower Survey." Journal of Irrigation and Drainage Engineering, Vol. 122, July/August, pp. 259-262.

Table 1
Changes in Irrigation Method in California: 1972 to early 1990s [27]

Crop Type	Irrigation Method	Change per year (%)
All Crops	Surface	-0.73
	Sprinkler	0.30
	Drip	0.45
Field Crops	Surface	0.27
	Sprinkler	-0.25
	Drip	0.01
Vegetable Crops	Surface	-0.63
	Sprinkler	0.16
	Drip	0.50
Orchards	Surface	-1.49
	Sprinkler	0.98
	Drip	0.50
Vineyards	Surface	-2.05
	Sprinkler	-0.19
	Drip	2.08

[27] See previous footnote.

Figure 4
Survey of California Irrigation Technology, 1991



II.7 Outdoor Residential Landscape Potential is Incorrectly Characterized and Evaluated

CALFED notes correctly (page 5-15) that reductions in outdoor residential landscape water use from 1.2 to 0.8 ETo can be achieved through changing inappropriate irrigation practices, including timing of irrigation, accuracy of water application, and preventing overwatering. These reductions, however, are then treated as 100 percent recoverable, non-consumptive losses – it is assumed they run off to storm sewers. This is incorrect. In some locations up to 100 percent of this kind of urban overwatering wets impermeable surfaces and eventually evaporates. While there is uncertainty over the ratio of consumptive/non-consumptive losses for improvements down to 0.8 ETo, the ratio is not zero. Thus the WUEC should consider a substantial fraction of all reductions in ETo from residential landscapes to be evaporative losses and hence, "new water."

Recommendation

- Some allowance must be made in the WUEC for the fraction of improvement in landscape irrigation down to 0.8 ETo that is evaporative loss, and hence recoverable and available for reallocation. We recommend assuming that 50 percent of the improvement in this category be considered evaporation reduction.

II.8 Baseline Demand Estimates Appear to be Incorrect

The baseline data on water use in California are adopted from Bulletin 160-98. It now appears that this baseline significantly overestimated current demand for water in the future, which in turn directly leads to a significant overestimate of future baseline demand for water and an exaggerated gap between future supply and demand.[28]

CALFED makes an effort to avoid problems with this baseline by shifting the discussion away from the "gap" between a paper projections of demand and supply estimates, but several major pieces of the WUEC analysis (and the broader impact analysis and Economic Risk assessments) depend on it. For example, efforts to ensure reliability of supply are based on explicit and implicit assumptions about the magnitude of the future "gap." As noted elsewhere, serious questions have been raised about DWR's use of current data and their projections of current use into the future. These data appear to be far too high based on current trends, available technology, and widespread experience already available in California and elsewhere.[29] More and better information from DWR may clarify the apparent problems with this baseline estimate.

Table 2 lists examples of actual per-capita water use in California compared to Bulletin 160-98 assumptions. By using inflated estimates of actual urban use, DWR also gets inflated estimates of future use since 2020 projections are derived from the base 1995 numbers. Using more accurate data, actual base case urban demand could be more than one million acre-feet lower than estimated in Bulletin 160-98, even without **any** conservation efforts.

Table 2
Comparing Bulletin 160-98 and Actual Urban Water Use Estimates
(gallons per person per day (gpcd))

Water Supplier	B160 (1990)*	Actual Use: Utility estimate	Population (for year of Actual Use)
LADWP	180	155 (1994)[1]	3,620,000
EBMUD	196	171 (1996)[2]	1,200,000
SDCWA	196	184 (1994)[3]	2,700,000
Sacramento	290	271 (1995)[4]	384,757
MMWD	153	131 (1995)[5]	170,000
Fresno	285	258 (1995)[6]	452,033
Santa Barbara	177	130 (1997)[7]	93,746

* These data come from Bulletin 160-98, page 4-24, Table 4-7.
[1]Urban Water Management Plan for the City of Los Angeles, November 1995.
[2]Richard Bennett, EBMUD. Pers. communication, March 1998.
[3]Bob Yamota, SDCWA. Pers. Communication, March 1998.
[4]Liz Brenner, SWD. Pers. Communication, March 1998.
[5]Libby Pischel, MMWD. Pers. Communication, March 1998
[6]Diem Tonnu, FWD. Pers. Communication, April 1998
[7]Alison Whitney, SBWD, Pers. Communication, April 1998

[28] Pacific Institute. 1998. "Comments on Bulletin 160-98." Pacific Institute for Studies in Development, Environment, and Security. Oakland, California.

D. O'Conner. June 1998. "How Does DWR Forecast Urban Water Demand?" California Research Bureau, California State Library, Sacramento, California.

[29] See previous footnote.

While the CALFED WUEC attempts to minimize the problems associated with using potentially flawed baseline data from DWR, the projected gap and DWR's baseline data are used both explicitly and implicitly in the WUEC (see, for example, footnote 2 in Table 1.1 and page A-11). Most importantly, it is acknowledged in the WUEC that DWR and CALFED both use these estimates of future demand to drive the Economic Risk Model (ERM) to "meet unmet demands of a hypothetical need through various supply options." In addition, CALFED is using these incorrect demand estimates to drive the CALFED impact analyses, as noted in the WUEC, page A-7.

Recommendations

- Where CALFED adopts the baseline data on future water use from Bulletin 160-98, new language should be inserted noting the unreliability of these estimates.

- Better supporting data from DWR should be required. As the "base case" is recalculated, the "base" case for future urban demand will also have to be redone.

- All modeling estimates, including the ERM and the CALFED impact analyses, that use the baseline data or the estimated 2020 demand must be redone using the corrected future demand estimates.

III DATA AND ANALYSIS: OMISSIONS AND ERRORS

III.1 Basic Assumptions are Hidden

CALFED's WUEC relies on Bulletin 160-98, making substantive public review difficult or impossible for a number of crucial elements. Adequate public review requires that the document be clear, easy to read, and contain sufficient data and information to permit readers to understand the assumptions and conclusions. This is particularly true since the public is likely to be asked to pay a significant fraction of the costs of meeting future needs. To give just a few examples, no or insufficient information is available on:

- Regional or statewide water balances;
- actual detail on indoor and outdoor residential water use (both current and 2020);
- actual on-farm irrigation efficiencies;
- trends in irrigation efficiency over time;
- the distribution of irrigation methods by crop type;
- the separation of the transpiration component from evaporation in agriculture;
- the potential for reducing evaporation losses of the ET component;
- water reuse factors for different regions (i.e., applied water:actual water ratios);
- water saving and cost estimates from individual demand management practices;
- a quantitative and qualitative description of what is meant by "full implementation of the BMPs";
- actual average evapotranspiration for residential and commercial landscape;
- description of economic modeling, including assumptions used concerning prices, subsidies, and their effect on land use; and
- the methodology for how the 1995 base case per capita urban demand numbers were developed.

Recommendation

- Make available to the public the basic assumptions, data, and models used to generate the Bulletin 160-98 and CALFED WUEC drafts.

III.2 Improvements in Water Quality and Ecosystem Quality from Reductions in Applied Water Use are Inadequately Analyzed and Discussed

CALFED briefly notes the important links between reductions in applied water use and improvements in water quality and ecosystem quality, but fails to offer any quantification or detailed discussion of these benefits (WUEC, page 2-1). Without some effort to evaluate the actual economic, environmental, and social value of such benefits, policymakers cannot get a clear picture of any of the alternatives CALFED hopes to propose.

III.3 A Detailed Water Balance is Necessary

No satisfactory water balance of supply and demand is provided within each region. This makes it impossible to compute regional water reuse factors, total applied water, or consumptive versus non-consumptive uses. The lack of a detailed water balance has implications for many different parts of this assessment. Some of these are noted in other parts of this document.

III.4 "New Water" Estimates Ignore Water Reuse Factors

CALFED notes, correctly, that there is already substantial reuse of water in California; thus "applied" water used in a given basin is often larger than actual water available. Some estimates indicate that the "reuse" factor in some regions may be 2 or higher, suggesting that each acre-foot of water is used twice before being discharged to a saline sink or the ocean. No good estimate of the actual reuse factor has ever been done for California. If, however, certain demand management options produce "new" water, such as reductions in evaporation or other consumptive uses, the actual amount of "new" water created is the savings times the reuse factor. Thus, a thousand acre-feet of "new water" may actually produce two thousand acre-feet of potential use, if the reuse factor is 2.0. This issue has not been adequately analyzed, but has the potential to play a big role in California water planning.

Recommendation

- Calculate reuse factors by region. Apply that factor to all "new water" savings from demand management options. This would require a detailed water balance, as described and recommended elsewhere in these comments.

III.5 The Potential for Urban Demand Management Improvements is Underestimated and Excludes Technically and Economically Feasible Practices

The base assumption in Bulletin 160-98, adopted by CALFED, is that urban agencies will achieve "full implementation of the 'best management practices'" (BMPs) by 2020, nearly two decades after scheduled implementation. Yet "full implementation" leads to only modest savings – far below the potential and likely savings – because only a small fraction of the BMPs actually lead to water savings and because many potential savings are not included in the BMPs.[30] The CALFED WUEC should note explicitly that the current BMPs exclude a wide range of cost-effective conservation options and that many water agencies have not adopted the BMPs for planning and management. Even for those that have, entire categories of potential cost-effective improvements are ignored, discounted, or inaccurately evaluated.

CALFED then extends this base case to a "No Action" alternative and an "additional conservation" estimate. Even this latter category for urban demand management potential excludes a wide range of practices that are technically feasible and economically attractive, ignoring experience of existing water agencies, scientific reviews of technical potential, economic costs of demand management alternatives, and

[30] DWR staff, as of the date of this report, has not been able to provide further information on the quantification of BMP savings. The CALFED Water-Use Efficiency Appendix also does not make clear how BMP savings are accounted for in each region.

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information available at DWR. These cases thus substantially underestimate the potential for urban demand management in California and contribute to the inflated "paper demand" and shortage estimates for the year 2020.

Only those BMPs that were quantified in the original Memorandum of Understanding (MOU) and associated with a potential water saving were included in the calculation of demand reduction.[31] Of the fourteen BMPs, the following six fall into this category:

BMP #1: Residential Audit
BMP #2: Residential Plumbing Retrofit.
BMP #4: Metering with Commodity Rates.
BMP #5: Large Landscape Conservation Programs and Incentives
BMP #9: Conservation Programs for CII Accounts
BMP #14: Residential ULFT Replacement Programs

BMP #1: Residential Audit

Full implementation of this BMP only requires that 20 percent of residential users be approached with offers of water audits each reporting period and that 15 percent of them, or only three percent of total residential customers, accept audits. Implementing the recommendations is not required. Thus, "full implementation" means that approximately 97 percent of residential, governmental, and institutional users may not actually receive audits, and no formal implementation of recommendations – or actual saving of water – is guaranteed.

BMP #2: Residential plumbing retrofit.

Full implementation of this BMP only requires that 75 percent of residences be retrofitted with low-flow fixtures. This still leaves out a full 25 percent of residences. The remaining residences still have cost-effective water conservation potential in this area.[32]

BMP #3: Distribution System Water Audits, Leak Detection, and Repair

Full implementation of this BMP requires that 100 percent of utilities participate in audits according to AWWA standards. No definite savings are required, though a standard of 10 percent unaccounted for water is assumed. Substantial "unaccounted for" water is likely to remain, in audited and unaudited utilities. Assume reduction in actual "unaccounted for" water reaches 5 percent by 2020. These levels are achievable, according to DWR studies. Compute reduced water demand and subtract from total urban demand.

BMP # 4: Metering with Commodity Rates.

[31] The quantitative savings potential of efficient washing machines are available here in Appendix B. Additional estimates will shortly be available from CUWCC. CALFED and DWR should include these in their final reports.

[32] CUWCC. 1997. "Memorandum of Understanding Regarding Urban Water Conservation in California. Best Management Practices." Summary Report Fiscal Year 1995/96.

Full implementation requires that 100 percent of existing unmetered accounts be metered within 10 years. Meter retrofits are assumed to result in a 20-percent reduction in applied water demand by retrofitted accounts. DWR does not appear to have included this reduction for Sacramento or other regions that remain largely unmetered at present.

BMP #5: Large Landscape Conservation Programs and Incentives

Full implementation requires developing ETo-based water budgets for 90 percent of CII accounts with dedicated irrigation meters. For CII accounts with mixed-use meters, complete irrigation water-use surveys must be accomplished for 15 percent of accounts within 10 years. These surveys are assumed to reduce landscape water demands by 15 percent. Thus, full implementation can be achieved without the other 85 percent of CII mixed-use meter users receiving surveys or saving any water, leaving an enormous amount of potential cost-effective savings.

BMP # 9: Conservation Programs for CII Accounts

Full implementation requires that 10 percent of CII customers accept a water-use survey, and that total CII water use be reduced by 10 percent of baseline (use in 1989) within 10 years. Thus, 90 percent of CII customers may not have had a water-use survey or reduced water use at all. Moreover, the other 10 percent may still have cost-effective savings above and beyond the 10 percent savings called for by this BMP. Recent studies in the MWD service area have shown that the overall potential for savings in CII is between 23 and 29 percent and could be substantially higher in particular industries.[33]

The MWD findings are consistent with a recent DWR analysis, apparently ignored by Bulletin 160-98, in which investigators concluded that: "Commercial water-use volume may be cost-effectively reduced by approximately 22 percent."[34] Potential water savings, defined to include most institutional uses, ranges to about 50 percent, with results ranging from 20-25 percent in the analysis.[35]

BMP #14: Residential ULFT Replacement Programs

Full implementation programs should, at least, require the replacement of high-water-using toilets with ULFTs (1.6 gallons or less) upon resale of a home. This BMP is to be in effect for 10 years from the date of implementation. The official MOU makes a variety of assumptions (in Exhibit 6) for replacement of inefficient toilets.[36] Full implementation may still leave inefficient toilets in place, but DWR does not provide sufficient data to determine this.

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[33] Sweeten, J. and B. Chaput, 1997. "Identifying the Conservation Opportunities in the Commercial, Industrial, and Institutional Sector." Paper delivered to American Water Works Association, Denver, CO. p.8.

[34] U.S. Environmental Protection Agency. 1997. "Study of Potential Water Efficiency Improvements in Commercial Businesses. Final Report." U.S. EPA and the State of California DWR. (April).

[35] Pike, C.W. 1997. "Study of Potential Water Efficiency Improvements in Commercial Businesses." Final Report, U.S. Environmental Protection Agency / California Department of Water Resources, April, statement of conclusion and range of 0-50 percent from p. 28, range of 20-25.6 percent from p.11.

[36] CUWCC. 1997. Final Exhibit 1 Attachment to the Memorandum of Understanding (MOU).

The remaining BMPs have neither been quantified, nor assigned a coverage requirement and therefore are not included in the demand reduction estimates adopted by the CALFED WUEC. Furthermore, many practices that can potentially reduce water demand are not addressed in the current MOU at all. Excluding these practices results in further overestimates of future water demand in the urban sector.

III.6 The Potential for Indoor Residential Water-Use Improvements is Underestimated

It has been noted elsewhere that Bulletin 160-98's estimates of future indoor residential water use in California are far too high. Bulletin 160-98 suggests that this use will average 75 gallons per capita per day (gpcd) in 2020 (page 6-11), after "full implementation of the BMPs." A recent comprehensive residential end-use study sponsored by the American Water Works Association Research Foundation (AWWARF) was recently completed. This study included detailed water-use surveys of more than 5,500 homes, analyses of historic billing data from 1,000 homes, and comprehensive end-use monitoring at 12 sites in North America.[37] Altogether data on nearly 2 million separate water-use events were collected. The data shows that current indoor water use in a typical single-family home is *already far below* the 75 gpcd estimated by DWR for 2020. This study also showed that indoor use can be reduced to under 45 gpcd with only five *existing* conservation measures (ULFTs, low-flow showerheads, efficient washers, faucet aerators, and leak repair) (for details on this analysis see Table 3 and Figure 5 and the AWWA web page at www.waterwiser.org/wateruse/indoor.html). These estimates are even lower than the estimates made three years ago by the Pacific Institute in ***California Water 2020*** (51 gpcd indoor water use). It appears that the DWR has begun to acknowledge this. In a formal comment on the draft Bulletin 160-98 from the Water Conservation Office of DWR, the WCO office recommends dropping the readily achievable targets to 55 gpcd, noting that some California communities will reach this level in 2020 entirely through implementation of existing BMPs.[38]

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[37] Mayer, P.W., W.B. DeOreo, J.O. Nelson, E.M. Opitz. 1998. "Residential End Uses of Water: Project Update, Year Two." Presented at the June 1998 American Water Works Association Annual Meeting, Dallas, Texas. Text in this paper indicates average indoor water use is around 69 gpd; Table 1 shows this use at 61.8 gpd. Initial data on the website listed above shows existing indoor water use at just under 65 gpd.

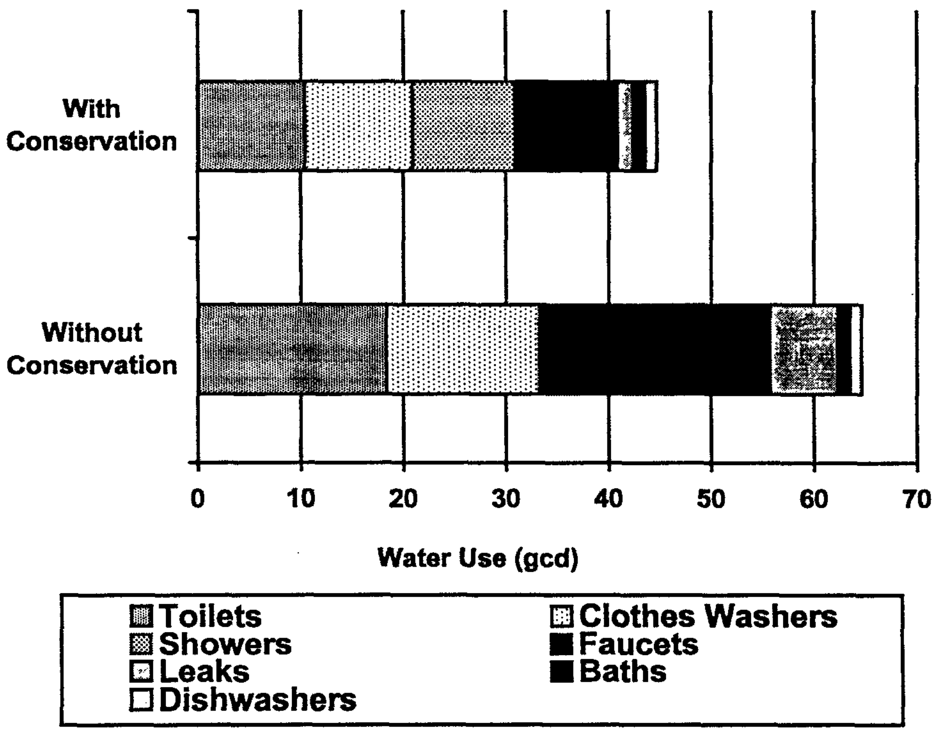
[38] Craddock, E. April 13, 1998. "Bulletin 160-98 Comments." Memo from the DWR Water Conservation Office to Jeanine Jones, Department of Water Resources, Sacramento, California.

Table 3
Per-Capita Savings of Selected Conservation Measures

Conservation Measure	Savings (gpcd)
ULFTs	8.0
Horizontal-Axis Washers	4.5
Low flow showerheads	2.2
Faucet aerators	0.2
Leak repair	5.0
Total for All Measures	19.9

*gpcd: gallons per capita per day
Source: Based on measured uses in 800 homes in six North American cities. See www.waterwiser.org/wateruse/tables.html

Figure 5. Household Indoor Use of Water With and Without Conservation [39]



Recommendations

- CALFED should reduce the No Action indoor residential use in 2020 to 45 gpcd. As the AWWA study shows, this change can be accomplished with existing technology

[39] American Water Works Association. 1998. Survey of Indoor Residential Water End Use." Available at www.waterwiser.org/wateruse/indoor.html

and conservation approaches and would reduce urban applied water demand by more than an additional one million acre-feet statewide below the WUEC's current No Action estimate and 530,000 acre-feet below the CALFED Program estimate.

III.7 The Water-Savings Potential of New Residential Appliances is Excluded

As shown in the recent AWWA Residential Water Conservation field studies, existing residential conservation technology and programs have the potential to reduce indoor water use to 45 gallons per capita per day. This is considerably below the minimum levels assumed by CALFED – 55 gpcd (WUEC page 5-10), and excludes the potential of a wide range of residential conservation alternatives now coming on the market or under rapid development.

Other than horizontal-axis washing machines (discussed below and in Appendix B), no other potential technological improvements are included, such as more efficient dishwashers, new models of high-efficiency toilets or showerheads, or hot water demand units.[40] Between now and 2020 the potential of such appliances to reduce per capita demand may be substantial, and remains unquantified by CALFED. For example, the Department of Energy's Federal Energy Management Program7 recommends 2.2 gallon per minute (gpm) showerheads and lists 1.5 gpm showerheads as the "best available" technology, instead of the national standard of 2.5 gpm. The 1.5 gpm "Universal Spa" version has already been installed at the MGM Grand, Bally's Resort, and dozens of other major hotels around the world.[41] Australia produces reliable dual-flush 1.6/0.8 gallons per flush (gpf) toilets, as do many other countries around the world, where dual-flush systems are standard design. This design uses 60 percent of the water used by today's 1.6 gpf toilets

The only new appliance CALFED analyzes (using DWR Bulletin 160 as the basis) as affecting urban water demand over the next 22 years is horizontal-axis washing machines, but it excludes the potential savings from these new appliances in the calculation of potential demand reductions. The California Urban Water Conservation Council, the Pacific Institute, the Department of Energy, and a wide range of independent testing laboratories have all recently produced estimates of the savings likely to accrue from replacing top-loading machines in use today with the front-loading machines currently available.[42] These studies estimate water savings of between 4,600 and 5,200

[40] For example, hot water demand units could reduce total residential hot water use by as much as 10 gpcd according to the U.S. EPA (see next footnote).

[41] S. Chaplin and R. Pinkham. 1998. "Comments on the U.S. EPA SDWA Draft Conservation Guidelines." Rocky Mountain Institute, Snowmass, Colorado.

[42] CEE. 1995. "High Efficiency Clothes Washer Initiative: Program Description." Consortium for Energy Efficiency, Boston, Massachusetts.
Mitchell, D. March 6, 1998. "Ad Hoc H-Axis Committee Interim Savings Recommendations." Memo to Steering Committee, H-Axis Committee of the California Urban Water Conservation Council.
Steding, A., J. Morrison, and P. Gleick. 1996. "Analysis of the Hydrologic Impact of Replacing Vertical-Axis Clothes Washers with the Frigidaire Alliance Horizontal-Axis Model in Three Western U.S. Metropolitan Areas." Pacific Institute for Studies in Development, Environment, and Security, Oakland, California.

gallons per year per retrofit. Horizontal-axis washing machines thus offer substantial annual water savings at the household level. These savings represent approximately 35 to 40 percent of household laundry water use and 5 to 10 percent of total household water use. Replacing a vertical-axis washer with a horizontal-axis washer offers approximately two-thirds the water savings realized by replacing conventional toilets with NEPA-compliant ULFT.[43] CALFED, using DWR assumptions, underestimates this potential savings at 25 to 30 percent, and does not explicitly include even this potential in the final analysis.

Applying California Department of Finance population and housing statistics, U.S. census data on household size and makeup, and estimates of washing machine use suggests that the gradual complete replacement by 2020 of the current population of vertical-axis machines with machines no more efficient than the horizontal-axis machines already on the market would lead to a reduction in total residential water demand between 170,000 and 200,000 acre-feet per year statewide. Lower replacement levels would produce proportionately lower levels of savings.

All of these estimates, moreover, assume only existing technology and no further technological improvements in washers, even through the year 2020. While a safe, conservative assumption, it is almost certainly incorrect. More background for the quantitative estimate of demand reductions available from horizontal-axis washing machines can be found in the June 1998 memo from the Pacific Institute, and attached as Appendix B here.[44]

Recommendations

- Increase the water-savings potential for front-loading washing machines to between 35 and 40 percent of current residential water used for laundry. Assume various scenarios for market penetration, up to 75 percent by the year 2020. Compute decreases in residential per-capita demand and apply those savings to all regions as reductions in future demands.

- Add a new estimate of the potential water savings from new water-efficient appliances (dual-flush toilets, hot-water demand heaters, 1.5 gpm showerheads, efficient dishwashers) using numbers from industry sources. Assume various

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U.S. DoE. 1996. "Energy Conservation Program for Consumer Products: Test Procedure for Clothes Washers and Reporting Requirements for Clothes Washers, Clothes Dryers, and Dishwashers." 61 Federal Register 17589. U.S. Department of Energy. Washington, DC.

[43] CEE. 1995. "High Efficiency Clothes Washer Initiative: Program Description." Consortium for Energy Efficiency, Boston, Massachusetts.
Steding, A., J. Morrison, and P. Gleick. 1996. "Analysis of the Hydrologic Impact of Replacing Vertical-Axis Clothes Washers with the Frigidaire Alliance Horizontal-Axis Model in Three Western U.S. Metropolitan Areas." Pacific Institute for Studies in Development, Environment, and Security, Oakland, California.

[44] Gleick, P.H. 1998. "Projected Statewide Water Savings from Conversion to Water-Efficient Horizontal Axis Washing Machines." Memo, June 1998, Pacific Institute for Studies in Development, Environment, and Security, Oakland, California.

scenarios for market penetration, up to 75 percent by the year 2020. Compute decreases in residential per-capita demand and apply those savings to all regions.

III.8 Outdoor Landscape Water Use Savings are Underestimated and Mis-Categorized

The CALFED WUEC underestimates the potential for outdoor residential water savings based on existing California experience. In addition, some of the consumptive use savings are described as non-consumptive use, leading to an underestimate of water that could be reallocated to other uses. The costs of achieving those savings appear to be overestimated.

The CALFED base estimates are derived from the Bulletin 160-98 draft. DWR estimates that by 2020 landscape statewide will be irrigated on average at about 1.0 ETo, and this could be further reduced to an average of 0.8 ETo with more intensive conservation measures. Bulletin 160-98, however, does not provide sufficient supporting data to show actual current level of landscape water use or extent, thus making it difficult to gauge the figures that they provide.

III.9 The Fraction of Residential Landscape that can be Reduced to 0.6 ETo is Underestimated

The CALFED WUEC notes that improvements below 0.8 ETo can readily be achieved, but places very little of the 2020 landscape acreage into the 0.6 ETo and below categories. According to Pittenger[45] et al. (1992), a wide range of common landscape groundcovers can consistently maintain acceptable aesthetic appearance when seasonal irrigation plus rainfall totals 33 percent of ETo or less. While this may be an optimistic level for a statewide average, the entire Irvine Ranch Irrigation District has **already** achieved average outdoor commercial irrigation efficiencies of between 0.6 and 0.65 ETo through progressive pricing structures and incentives.[46] It thus seems plausible and conservative to assume 0.6 ETo is should be the goal for all **new** landscape, and that a larger fraction actually achieves this goal than currently assumed in the WUEC Appendix C calculations.

According to the U.S. EPA Water Conservation Plan guidelines, installing an irrigation timer can save 10 gpcd alone; low water-use plants can save 7.5 percent of outdoor water use; lawn watering guidelines can reduce outdoor water use by 15 to 20 percent.[47] This same assessment indicates that simple outdoor residential water use

[45] Pittenger D.R., D.R. Hodel, D.A. Shaw, and D.B. Holt. 1992. Determination of Minimum Irrigation of Needs Non-Turf Groundcovers in the Landscape. University of California Water Resources Center.

[46] Tom Ashe, Irvine Ranch Irrigation District, personal communication, April 1998.

[47] U.S. EPA. 1998. "Water Conservation Plan Guidelines Pursuant to Section 1455 of the 1996 Safe Drinking Water Act." March draft, Table A-3, Washington, DC. [The EPA report is a draft; numbers may change in the final.]

audits can reduce end use by five to 10 percent. CUWCC estimates that landscape audits can yield water savings of 10 percent. Actual savings will, of course, depend upon behavior, but the WUEC should acknowledge these potential efficiency improvements and determine more plausible ranges for savings.

More advanced measures include the potential for graywater to replace potable water use in outdoor gardens. The U.S. EPA estimates that graywater use can save 20 to 30 gpcd.[48] CALFED should note this option as a potential alternative for 2020.

Recommendation

- CALFED should increase the fraction of new and existing landscape acreage that achieves 0.6 ETo by 2020. We recommend 50 percent as a target for new landscape area and 25 to 50 percent for existing landscape acreage.

- The WUEC should note the potential for meeting some residential landscape needs with non-potable water, including reclaimed water and graywater. These would lead to a reduction in applied water needs and would also result in "new," reallocable water.

III.10 Assessment of the Potential for Improving Agricultural Irrigation Efficiency Appears Low

CALFED assumes, using the incorrect DWR methodology, that reductions in "non-consumptive" uses in regions with growing demands are of no benefit other than contributing to CALFED objectives such as improving water quality. In regions with growing demand, however, reductions in non-consumptive uses lead to direct reductions in the estimates of future demands made by DWR Bulletin 160-98. We agree that such improvements do not necessarily lead to "new water" that can be reallocated, but they do have the potential to make a sizeable difference in future increases in demand projections.

The CALFED WUEC assumes seasonal application irrigation efficiency in 1995 were 73 percent statewide; DWR Bulletin 160-98 assumed that on-farm seasonal application efficiencies will average 73 percent in 2020. DWR note that 80 percent is readily achievable with existing technology. CALFED notes that 85 percent is a plausible target (WUEC p. 4-10). The technical literature shows that "potential attainable application efficiencies" for sprinkler and drip systems are between 80 and 90 percent.[49] Every one percent increase in irrigation efficiency will save on the order of 300,000 acre-feet of water. If efficiencies reach an average of 80 percent by 2020, a total additional water savings of more than 2 million acre-feet would result, even with existing crop acreage. Much of this water could serve to reduce future demand increases; some fraction of it would actually serve as "new" water that could be reallocated to other agricultural or non-agricultural uses.

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[48] U.S. EPA. 1998. Table A-3. See previous footnote.

[49] R.A. Piper and A.J. Cappellucci. 1993. "Reduction of Deep Percolation and Drain Water." Journal of Irrigation and Drainage Engineering, Vol. 119, No. 3, May/June, pp. 568-576.

Recommendations

- Note the potential for all water savings (applied water) to reduce future projected demand increases. Even using CALFED/Bulletin 160-98 estimates, this amounts to a total reduction in demand of 1.8 to 2.8 million acre-feet in the total 2020 demand projections of Bulletin 160-98.

- Recompute "new" water savings by including an estimate of the fraction of ET that is non-productive evaporation.

- Better describe the instream benefits of improvements in agricultural irrigation efficiencies.

III.11 Discussion of the Cost of Conservation Options should be Improved and Expanded. The Base Data Used are Incomplete and Inaccurate.

The cost of implementing options to reduce demand or increase the efficiency of water use will vary. These costs are fundamental to any decisions about alternative supply and demand options. No realistic estimates of prices of alternatives are offered in CALFED – instead a small data set collected by DWR is presented, despite the acknowledgement by DWR staff that they are not complete or meant to represent the true range of costs. This data set overestimates the cost of implementing demand management alternatives – for example the simplest outdoor residential water-use improvements are estimated at $750 per acre-foot, while some improvements can be implemented at zero or very low cost. Experience at Irvine Ranch clearly shows the potential that can be achieved, at low cost, with proper pricing structures, education, and strong agency efforts.[50]

DWR estimates that the cost of replacing toilets with ULFTs will be between $300 and 500 per acre-foot, while experience of the LADWP suggests retrofits cost well under $300 per acre-foot.[51] DWR assumes the cost of CII improvements will be $500 to $750 per acre-foot, while LADWP has shown that the water savings can be achieved for under $200 per acre-foot.[52]

The marginal cost of implementation of many conservation options in new construction is zero or negligible as old technologies are depreciated and replaced in the course of normal operations. The marginal cost of installing a ULFT or other efficient fixture instead of an inefficient toilet in a new house is zero. The marginal costs of replacing an existing toilet with a ULFT are lower than the full cost of the new toilet. The marginal cost of changing plants in a garden is zero, if old plants are naturally replaced by homeowners over time and if the new plants cost the same as the old ones – a reasonable assumption according to the landscape industry. The marginal cost of a

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[50] Tom Ashe, Irvine Ranch Irrigation District, personal communication, May 1998.

[51] Los Angeles Department of Water and Power. 1995. "Urban Water Management Plan for the City of Los Angeles. LADWP, Los Angeles.

[52] See previous footnote.

horizontal-axis washing machine at the time of replacement of a broken model is not the full cost of such machines but the marginal difference between models.

A critical component of the WUEC should be a discussion of the varying costs of implementing water-use efficiency improvements. In many cases, no (or inadequate) data on these costs exists. This should be explicitly pointed out. But data *are* available from many sources: water districts, industry, academic assessments, state agencies. The three tables provided in the WUEC, developed from data from a DWR internal memo, are inadequate and incorrect (WUEC, Tables 5-8, 5-9, 5-10). In many circumstances, the cost of implementing water-use efficiency improvements is zero – no capital cost and no annual operating and maintenance cost. There are two primary reasons for this:

(1) Improvements that save water with no new technology can be done during routine maintenance or system operation; and

(2) New or modified technology can be installed at the normal end of lifetime of existing technology. If the marginal cost of the new technology is comparable to the marginal cost of the old system, water conservation improvements are obtained at zero cost.

To offer one concrete example, the Department of Water and Power of the City of Los Angeles initiated a major industrial and commercial water survey program. The results of those surveys were published in 1991 in a series of "water conservation reports" that summarize the recommended conservation actions, their capital and operation and maintenance costs, the expected water saving, the expected economic savings, and the simple payback period.[53] Several of the actions had zero capital costs, zero annual costs, and an immediate payback period. Many other options, not listed below, had simple payback periods of less than one year, a phenomenally productive economic investment by any standards. Table 4 lists some of the recommended actions with zero costs or extremely short paybacks.

A wide range of other actions can lead to improvements in water-use efficiency at zero costs. Among the most common are new and replacement residential construction and building remodels, which lead to replacement of inefficient technology with more water-efficient systems, including toilets, showers, faucets, and dishwashers. Similarly, a consumer who replaces appliances at the natural end of their lifetime may do so with a new appliance that is more water efficient than the previous model. The "cost" of the efficiency improvement in these cases is zero – no additional marginal cost is accrued to the efficiency benefit.

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[53] LADWP. 1991a. Water Conservation Reports, Industrial/Commercial Customer Water Survey Program. Los Angeles, California.

LADWP. 1991b. "Water Conservation Survey: Hotel/Hospitals/Restaurants Customer Category." Brown and Caldwell Consultants, Report 5514/cac. Los Angeles, California.

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Table 4
Examples of Zero- or Low-Cost Water Efficiency Improvements (LADWP Service Area) [54]

Location	Action	Capital Cost ($)	Annual O&M Cost ($)	Annual Water Savings (gal/yr)	Simple Payback Period (years)
Hospitals	Dishwasher flow reduction	0	0	175,000	Immediate
	Dishwasher: adjust valves	0	0	230,000	Immediate
	Manual control: x-ray system	0	0	4,570,000	Immediate
	Landscape water reduction	0	0	730,000	Immediate
	Cooling tower flow reduction	0	0	1,530,000	Immediate
	Garbage disposal shut off	50	0	175,000	0.1
	Sterilizers, Autoclaves	2,000	0	2,300,000	0.3
Restaurants	Hand sprayer control	$400	0	733,650	0.2
	Flow restriction	150	0	308,430	0.2
	Repair leaks and drips	150	0	69,000	0.7
	Reduce prewash time	0	0	142,350	Immediate
Hotel	Water efficient valves: bathrooms	3000	0	2,700,000	0.4
	Shower retrofit	30,500	0	21,500,000	0.3
Health Club	Showerhead replacement	525	0	5,750,000	0.02
	Toilet replacement	37,000	0	1,730,000	0.15
	Urinal retrofit	95 each	0	500,000	0.08

Note: These estimates come from detailed audits conducted in specific locations and industries. Similar audits elsewhere will produce different lists of conservation options, costs, and benefits.

III.12 The Measures of Cost Effectiveness Used in the Discussion of Conservation Costs should be Elaborated

Various measures of cost effectiveness can be applied to water-use efficiency improvements. These include the anticipated payback period, the benefit-cost ratio, and relative cost measures. In the very limited discussion on cost effectiveness in the WUEC, CALFED only present a single table of data on the cost per acre-foot saved of the measures, without any comparison of the cost of water, the variation in cost/AF with location, or a measure of the economic benefits associated with a given strategy or technology. As a result, these data are of extremely limited use in making decisions

[54] See previous footnote.

among options. Below, some other data are presented in a different format. These data should offer some additional insight into the relative costs of water-use efficiency actions.

III.12.1 Payback Period and Benefit/Cost Ratios

One of the most effective measures of the actual cost and value of conservation options is the "payback" period – the period of time it takes until an investment is returned. The simplest estimate is something called "simple payback," which is the cost of implementing the option divided by the annual savings. There are differences in expectations for paybacks among consumers: homeowners typically prefer payback periods of up to three years, businesses often accept payback periods of up to seven years, and utilities often make investments with paybacks of 15 to 20 years.[55]

Another measure commonly used is the benefit/cost ratio. A typical form is the value of the benefit provided, including the cost of conserved water, ecosystem values, and other more difficult to quantify benefits, divided by the cost of implementing that option. In order to avoid subsidizing inefficient projects, the benefit/cost ratio should be greater than 1. Tables 5, 6, and 7 list benefit/cost ratios measured in various regions of California for various water-use efficiency improvements. These ratios are often far above 1, which suggests that very cost-effective implementation options are available. As conservation options are implemented, additional units of conservation will be more difficult or expensive to achieve. Ultimately, a true cost of conserved water curve will have to be developed on a regional or utility basis to determine appropriate levels of investment in conservation versus new supply. CALFED's text should reflect these issues more clearly and completely.

[55] Rocky Mountain Institute (RMI). 1991. Water Efficiency: A Resource for Utility Managers, Community Planners, and other Decisionmakers. Rocky Mountain Institute, Snowmass, Colorado.

Table 5

EBMUD Benefit/Cost Ratio for Conservation Options [56]

Hardware	Benefit/Cost
Single Family Toilets	5.11
Multi-Family Toilets	20.27
Single-Family Showerheads	31.27
Multi-Family Showerheads	40.56
Single-Family Aerators	18.62
Multi-Family Aerators	24.25

Table 6

EBMUD Additional Benefit/Cost Ratios for Water Conservation Options [57]

Element	Community Benefit/Cost
Residential Water Audits	3.81
Non-Residential Water Audits	5.26
ULFT Replacement	4.08
Irrigation Upgrades	2.7
Irrigation Audits	8.92
Landscape Standards	10.93

[56] EBMUD. 1994. "Water Conservation Master Plan." Exhibit 5-13, Final Report, East Bay Municipal Utilities District, Oakland, California.

[57] EBMUD. 1994. "Water Conservation Master Plan." Exhibit 5-20, Final Report, East Bay Municipal Utilities District, Oakland, California.

Table 7

Additional Estimates of Benefit/Cost Ratios for California Water Conservation Actions [58]

Element	Benefit/Cost Ratio
Toilet Replacement	
ULFT, Single Family Homes	3.12 - 9.09
ULFT, Multi-Family Homes	4.87 - 14.28
Toilet Tank Devices	
Displacement dams retail	22.78
Displacement Dams wholesale	45.55
Flappers	5.31
Leak Detection	2.11 - 12.65
Faucet Washers	11.76
Residential Clothes Washers	
Horizontal-axis vs. new vertical-axis	2.84
Hose control	2.3
Subsurface Drip	1.37
Irrigation Scheduling	21.91
Large Landscapes	
Drip irrigation vs. auto sprinklers	1.43
Drip vs. manual watering	3.58
Rain sensors	8.22
Irrigation scheduling	8.86
Commercial ULFT	6.64
Commercial ULF urinals	3.4
Commercial air chillers (vs. water)	18.46

[58] Fiske, G.S. and R.A. Weiner. 1994. "A Guide to Customer Incentives for Water Conservation." California Urban Water Agencies, California Urban Water Conservation Council, U.S. Environmental Protection Agency. Barakat and Chamberlin, Inc. Oakland, California.

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III.13 Strengthen Water Transfer Protections for Third-Parties

CALFED notes in Chapter 7 that one of the most important issues raised in the BDAC Water Transfer Work Group was protection of third-parties: "Among all the water transfer issues identified, providing adequate assurance of the avoidance or mitigation of impacts on groundwater resources and third parties will be the most critical issue for CALFED to resolve" (WUEC, p. 7-6).

As the WUEC notes, the economic impacts of transfers are not clearly regulated, though it is "generally recognized that certain types of transfers can have adverse impacts on local economic conditions" (WUEC, p. 7-11). Precisely because these impacts are poorly or incompletely monitored and regulated, we encourage CALFED to strengthen the "solution options" in the following manner:

- Explicitly involve local communities in decisions about transfers

The public disclosure and education programs proposed by CALFED (p. 7-14) are good, but do not explicitly require local community participation in decisionmaking. The "solutions options" should be expanded to require "Participation of local communities in decisions to approve transfers and to mitigate local economic impacts."

- CALFED should seek greater public involvement in several aspects of water transfers.

Because DWR, CALFED, and other water agencies are making water transfers a cornerstone of future plans, these organizations should seek greater public involvement in: (1) the development of statewide and regional water transfers policies; (2) the negotiation and approval of water transfers; and (3) the development of criteria to regulate and assess the impacts on agricultural communities.[59]

- Require analysis of the cumulative impacts of individual transfers.

Because large volumes of water may ultimately be involved in transfers, the combined impact of transfers may be different, and larger, than the impacts of individual transfers. The "Clearinghouse" may be an appropriate mechanism for this analysis.

III.14 Redo the Water Transfers Modeling Analysis Using Corrected 2020 Demand Estimates

Supplement A notes that CALFED modeling studies use projected 2020-level conditions for all CALFED impact analysis (WUEC, p. A-7). Given the errors in DWR's 2020 demand levels described extensively above, these CALFED modeling runs must all be redone with lower 2020 demands. This same comment applies to the use of the Economic Risk Model, used as a tool for meeting anticipated future demands.

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[59] Loh, P. and S.V. Gomez. 1996. "Water Transfers in California: A Framework for Sustainability and Justice." Pacific Institute for Studies in Development, Environment, and Security, Oakland, California.

IV IMPLEMENTATION AND ASSURANCE ISSUES

A new water policy emphasis on water efficiency rather than new supply is well founded in California law. The California Constitution prohibits "waste or unreasonable use" of water and excludes from water rights any water that is not reasonably required for beneficial use (Article X, Section 2). The prohibitions on waste and unreasonable use are also found in Sections 100 and 101 of the California Water Code. Responsibility for determining reasonable use lies with the State Water Resources Control Board (SWRCB), which can place water conservation conditions on water rights permits that it approves.

The California Water Code requires all urban water suppliers to give first consideration to demand management measures that offer lower marginal costs than new supplies (Water Code Section 10610 *et seq*). State and federal projects also include requirements that water-use efficiency be considered a higher priority: the Central Valley Project Improvement Act (CVPIA) calls for water conservation criteria to be developed to promote "the highest level of water use efficiency reasonably achievable" by beneficiaries of the water developed by the project. Similar provisions in some State Water Project contracts and SWRCB decisions require conservation efforts.

In recent years, however, efforts to promote water-use efficiency programs by State agencies with the authority to require them have given way to efforts at voluntary programs for urban and agricultural agencies. These voluntary programs – the urban and agricultural "best management practices" (BMPs) – have been implemented in an effort to forestall, and perhaps eliminate, more formal requirements.

The California public has expressed strong support for water-use efficiency actions. CALFED held a series of public meetings in the spring of 1996, where repeated calls were heard for improving efficiency and shifting away from building costly new supply facilities. We urge CALFED continue to explore ways that the implementation of water-use efficiency and water conservation improvements will be considered a fundamental component of local and regional water plans and will be required prior to reallocation of "new" water supplies or water transfers.

CALFED assumes that "implementation of efficiency measures will occur mostly at the local and regional level by local agencies, not by State and federal CALFED agencies" (WUEC p.2-2, 2-4, 2-9, and elsewhere). To the extent that this is true, CALFED should develop guidelines and standards for local and regional organizations to assist implementation of water-use efficiency programs and to help State agencies monitor performance and achievement.

While we agree that local and regional agencies and organizations will play a vital role in implementing water-use efficiency and conservation programs, there remains an extensive role and responsibility for State and Federal agencies as well. Large implementation potential results from the ability of State and Federal agencies to modify pricing structures under their control, implement state or national technology standards or environmental standards, affect technological development rates, or change the rules governing the water systems they own and operate. By ignoring these implementation avenues, CALFED underestimates not just the potential, but the likelihood, for implementation of efficiency measures.

Further, CALFED notes that they adopted implementation objectives established by the Water Use Efficiency Work Group (WUEC, p. 2-3). One of these is to emphasize incentive-based actions over regulatory actions. Yet extensive studies show that certain government roles cannot be devolved to local or private organizations, and that certain regulatory actions are valuable in pushing new technological development, in accelerating cost reductions of technology and policy options, and in advancing the rate of implementation. As just one example, the U.S. National Energy Policy Act of 1992 eliminated widely divergent and conflicting water-efficiency standards for appliances and set clear standards at the national level, at the request of consumers, industry, and state regulators. These simple national standards are expected to save more than 6.5 billion gallons per day by 2025 without affecting lifestyle or even requiring retrofit of old inefficient systems.[60] The standards are also leading to other economic and environmental benefits in terms of avoided energy, chemical, and waste-water treatement costs. Vickers estimates that the national cost savings from implementing these national standards will total hundreds of millions of dollars.[61] Other effective State or Federal actions include certification and labeling programs, reductions in subsidies for inefficient water use from government owned or operated facilities, and national monitoring programs for water quality. Limiting actions to those based on incentives alone thus reduces the potential for implementation of a wide range of water-use efficiency options, reduces the effectiveness of the ones described, fragments policymaking, and rules out Federal and State actions that are valuable, effective, and more efficient than comparable local actions.

Moreover, the extensive supply options described by CALFED are assumed to require State and Federal intervention, action, and funding. Assuming that demand management options will only be implemented through local and regional efforts is thus inconsistent with the supply-side assumptions made elsewhere in the draft document. We strongly urge CALFED to change this emphasis.

IV.1 General Comments on General Assurances

CALFED and CALFED agencies propose three general policies to provide assurance of efficient water use. Demonstration that appropriate water management and planning is being carried out and that cost-effective efficiency measures are being implemented will be necessary in order for a water agency to:

- Receive any "new" water made available by a Bay-Delta solution;
- Participate in any water transfer that requires approval by a CALFED agency or use of facilities operated by a CALFED agency; and
- Receive water through the DWR Drought Water Bank.

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[60] Vickers, A. 1996. "Implementing the U.S. Energy Policy Act." Journal of the American Water Works Association." Vol. 88, No. 1. Pp. 18-.

[61] See Table 2 and the accompanying text in Vickers, A. 1996. "Implementing the U.S. Energy Policy Act." Journal of the American Water Works Association." Vol. 88, No. 1. Pp. 18-.

These policies, however, ensure that no agency can lose existing water, even if they fail to demonstrate appropriate water-use efficiency actions. In addition, review of the voluntary implementation approaches already in place, particularly the BMPs, has noted that there is a serious lack of consistency and standardization across the different agencies trying to implement the BMPs.[62] Urban conservation standards more aggressive than the current generation of BMPs must be adopted. CALFED assurances for urban water management and conservation, which rely on current standards (see p. 2-17) are thus ineffectual – higher standards must evolve over time.

With no standard evaluation criteria, effective implementation is very difficult. General assurances that efficient water use will occur thus requires that appropriate management and planning guidelines be developed by CALFED or the appropriate agencies.

Recommendations

CALFED should proposed that standard evaluation and performance criteria for water-use efficiency improvements be developed and put in place to help local agencies develop consistent and effective plans.

CALFED and CALFED agencies should propose that failure to demonstrate appropriate management, planning, and implementation of water-use efficiency improvements will result in hearings on beneficial use before the SWRCB.

Failure to meet water-use efficiency criteria should result in actions to re-evaluate water rights being formally submitted to the SWRCB for their consideration.

[62] Mitchell, D.L. and W. Illingworth. 1997. "California Urban Water Agencies BMP Performance Evaluation" Final Report, M-Cubed, Oakland, California.

APPENDIX A

RECOMMENDATIONS FOR SPECIFIC WORDING CHANGES

Below we offer some specific wording changes to the Water Use Efficiency Component Technical Appendix (WUEC). Some of these relate to specific comments made elsewhere in the Pacific Institute formal analysis requested by the Department of the Interior Bureau of Reclamation. Other comments made in that analysis also need to be addressed, but we have not offered specific wording here. Additional specific wording suggestions related to our formal comments (submitted July 1, 1998) will be offered during July and August, as requested by CALFED staff.

Page 1-4, paragraph 4:

- Sentence 4: "Applied water reductions always have the potential to provide water quality and ecosystem benefits" include as well as to reduce the magnitude of anticipated demand.
- Sentences 5 and 6: Delete.
- Sentence 7: "...if water used by a city is discharged back into a river where it is used to meet downstream need, conservation does not mean there is new water in the river" include however, in a region of increasing population, it does mean that there will be more water available to meet the growing demand with fewer or no new storage facilities required.
- Sentence 8: Replace "It does mean" with It also means.
- Sentence 9: omit the word "conversely".

Page 1-5, Paragraph 3, Last sentence.

- The CALFED estimates of water-use efficiency do not "bracket" the potential range of savings. This sentence should be deleted or modified. See full comment in Section II.

- Page 1-6, Tables 1.1, 1.2, and 1.3
- Recalculate conservation estimates to include all estimated reductions in applied water. For example, Bulletin 160-98 urban baseline conservation should change to 1.5 maf. Note that all applied water savings reduce estimates of future demand.

- Footnote 1 to Table 1.1 should include "Reductions in applied water will reduce projections of future demand."

- In Tables 1.2 and 1.3, change column headings from "Real Water Savings" to "New Water." Include Applied Water estimates for Colorado River region.

- Change footnote 2 in Tables 1.2 and 1.3 to note that Applied Water Reduction in Colorado River Region can reduce future demand projections. This can reduce the amount of water needed in connected regions, which can affect the Bay/Delta.

Page 2-1, paragraph 1.

- Delete the word "local" in the CALFED definition of efficiency: "efficient water use is characterized by the implementation of water management actions that increase the achievement of CALFED goals and objectives."

Page 3-2, paragraph 2.

- "...conservation of lost water typically can only occur where water flows to salt sinks or unusable bodies of groundwater" include <u>or when water is lost to unproductive evaporation</u>.

Page 3-4, paragraph 3.

- Replace "Other regions may not truly save water" with <u>Conservation in other regions may not create a new supply of water but the conserved water can be used to meet projected increases in demands and</u> "reduce the cost of <u>building new structures</u>, treatment and distribution and have secondary benefits to the environment".

Page 4-1,last bullet.

- Rewrite last sentence of this bullet: "This category of loss reduction does not result in water that can be reallocated to other beneficial water supply uses, but can reduce future demand projections."

Page 4-2, Figure 4-2.

- Rewrite caption to this figure. "The reductions do not constitute a reallocable water supply but reduce future projections of demand."

Page 4-5, bullet 3.

- Rewrite first sentence: "Water conservation actions that reduce recoverable losses can potentially be credited with ecosystem or water quality benefits and reduce the magnitude of future demand in a region, but they may not result in "new" water that can be reallocated."

Page 4-15, paragraph 3.

- Replace "typically based solely" with <u>based largely</u> (because irrecoverable losses made up of evaporative losses as well, and these are unrelated to water quality).

Page 4-15, paragraph 4.

- Sentence 6: "To reduce these losses would deplete such supplies with no net gain in the total water supply" include <u>unless the loss reduction was experienced throughout the basin and then the reduction would constitute a supply either available to meet growing demands or instream flow requirements</u>.

- Sentence 7: Replace "They do, however" with <u>They also</u>.

Page 4-17, First sentence.

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- This is not necessarily correct. Different efficiency measures can be applied for each category of losses. Rewrite this sentence (or leave it out).

Pages 4-18, 4-19, Figures 4-6, 4-7.

- These figures should be redone, or expanded to include: (1) urban areas integrated into the basin; (2) growing overall demand, and the potential for applied water reductions to reduce that demand.
- These figures should also show the potential to reduce total water demand, and consumptive water demand by reducing unproductive evaporative losses. This requires separating ET into its component parts.
- The accompanying text on the following several pages should be rewritten to describe the new figures. Only a few suggestions are made below.

Page 4-20, bullet 1.

- Replace with <u>Crop evapotranspiration can be reduced by reducing nonproductive evaporative losses</u>.

Page 4-21, paragraph 1.

- Replace "Crop demands do not change" with <u>Crop water demands can be affected by changes in irrigation technology and management and by other factors</u>.

Page 4-23, paragraph 3.

- Rewrite the last sentence in this paragraph: "Estimated applied water reductions do not generate a reallocable supply but directly reduce the projected increases in demand in a region and provide other benefits desired by the CALFED program."

- Recalculate reductions in applied water resulting from water-use efficiency improvements. See specific comments submitted by the Pacific Institute.

Page 4-23, last paragraph.

- Include reductions in the Colorado basin because of their potential to reduce overall water demands, and hence provide water for other regions that might otherwise require water from the Bay/Delta system.

Pages 4-24 on: For ALL Regional AG estimates.

- In the sections on "Estimated Applied Water Reduction for Multiple Benefits" rewrite each section to note that "estimated reductions in applied water as a result of on-farm efficiency improvements that reduce recoverable losses have the ability to reduce projected increases in regional demand, benefit water quality, flow timing, and the ecosystem."

Page 4-44, Table 4.2 and Paragraph 1.

- Rewrite the third sentence of paragraph 1, and the footnote to Table 4.2, to read "The estimated reductions reduce the magnitude of anticipated demand, and have water quality, timing, and ecosystem benefits."

Page 5-1, paragraph 2.

- "…reductions in per-capita water use can" insert help meet the projected increases in demand, reduce the need for new development, "result in benefits to water quality….".

Page 5-2/3, paragraph 2.

- Replace "customer cost to reduce water use ranges from $300 to $600 per acre-foot annually" with $0 to $600 per acre-foot annually.

Page 5-3, paragraph 2.

- Replace "$400 to $1,600" with $0 to $1,600.

Page 5-4, last bullet.

- Replace "49 million" with 47.5 million by 2020.

Page 5-5, bullet 1.

- Add sentence before last as follows: However, while the reduction of urban non-consumptive use does not generate a new supply, this conserved water can be used to help meet the projected growth in demand.

Page 5-5, Bullet 2.

- "…can potentially be credited with" add helping to meet growing demand needs and thus reducing the need for new development, "ecosystem, water quality,…"

Page 5-9, Table 5.2.

- Per-capita water use estimates are high and should be reevaluated if possible.

Page 5-9, paragraph 1

- Replace "…1 million acre-feet of real water" with 1.5 million acre-feet of applied water.

Page 5-10, paragraph 5.

- Sentence 1: Replace "reduce indoor use to as low as 50 to 60 gpcd" with reduce indoor use to as low as 45 gpcd. Recalculate applied and "new" water savings.

- Sentence 2: after "…and use of water softeners," add "and will result in reductions in future demand statewide.

Page 5-11, first full paragraph.

- Replace the second sentence with: "This value will result in reductions in future demand statewide."

Page 5-11, paragraph 2.

- Replace "50 to 60 gpcd" with 45 gpcd. Replace "real water savings" with "new water"

Page 5-14/15, Last bullet.

- Add sentence: "Some fraction of this reduction represents evaporative losses."

Pages 4-1, 4-5, 4-14, 5-4, 5-16.

- Delete this sentence (and similar sentences). These estimates are supposed to be used for planning purposes.

Page 5-21, paragraph 1.

Replace "The CALFED incremental savings would result in another 10 percent reduction" with 15 percent reduction (15 percent would provide the upper limit of the 30 percent potential and since it is CALFED's stated intention to bracket this potential, the upper limit calculation should also be presented).

Page 5-24, paragraph 2.

- Add sentence before last as follows: However, while the reduction of urban non-consumptive use does not generate a new supply, this conserved water can be used to help meet the projected growth in demand.

Page 5-25, paragraph 2, last sentence.

- Replace "Estimated applied water reductions do not generate a reallocable supply" with Estimated applied water reductions generate a supply that can be used to meet the increasing demand, as well as "provide other benefits..."

Page 5-25, paragraph 3.

- Sentence 1: Replace "Potential applied water reductions" with Potential water reductions.
- Sentences 2 and 3 replace with Reductions in the Colorado River region as well as in other zones that import water from the Bay-Delta but are not tributary to the Delta, can provide ecosystem benefit through reductions in diversions or modified diversion timing. These reductions in water diversions can also be used to meet an increasing demand.

Pages 5-26 to 5-46. All "Applied Water" and "Real Water" Tables for Regions

- All footnotes that discuss "real"/"applied" water figures should be rewritten to note the reduction in total demand projections from all applied water savings.
- The last column in each "real water" table should not read "Total Conservation Potential." Rename it "Total New Water" or "Reallocable Water."
- Re-evaluate the ratios "New Water/Applied Water" for each region. Offer justification for values used.

- Recalculate water savings with the assumption that 50 percent of the water saved in reducing landscape use to 0.8 ETo is a reduction in irrecoverable losses, and that 50 percent of new landscapes will be at 0.6 ETo.

- Recalculate water savings with CII use reduced by 15 percent beyond the No Action alternative.

Page 5-47,48, tables 5.4 and 5.5.

- Include the Colorado River Region in these estimates.

- Rename last column of Table 5.4 "Total New Water Generated."

- Delete "and should not be used for planning purposes" in the text above Table 5.4

- On page 5-48, third sentence: rewrite to read "The savings, though, will reduce the size of future demands and can have water quality, flow timing, ..."

- Correct the numbers based on re-calculations.

Page 5-51, Table 5.8.

- This entire section needs to be redone. Please see Pacific Institute's detailed comments on the cost of conservation options. Change the lower bound of the cost estimates to $0 and recalculate cost per acre-foot of savings accordingly.

Page 5-52, Table 5.9.

- Change lower bound of cost estimate to $0 and change "irrecoverable loss identified" values to those of <u>total applied loss identified</u> and recalculate cost per acre-foot of applied loss saved per year.

APPENDIX B

WATER-SAVINGS POTENTIAL FOR HORIZONTAL-AXIS WASHING MACHINES

Projected Statewide Water Savings from Conversion to Water-Efficient Horizontal Axis Washing Machines

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Summary

A wide range of new technologies for using water more efficiently in residential, commercial, industrial, and agricultural activities are becoming available on the market, and more are under development. As these options reach consumers, changes in water use will occur. In order to project total future demand for water by California consumers more accurately, water planners must begin to incorporate estimates of how adoption of these technologies will affect both per-capita and total water demands.

One of these technologies, recently brought to commercial markets in the United States, is the residential horizontal-axis washing machine. Such machines have long been used in commercial settings, and are widely preferred in European residential markets because of their energy and water savings. Until recently, however, more than 98% of all residential washing machines sold in the United States have been vertical-axis units.

Several detailed field and laboratory surveys evaluating water savings from the use of horizontal-axis machines have been completed in the past couple of years (CEE 1995; Steding et al. 1996; THELMA 1998, U.S. DoE 1996). These studies permit the first detailed assessments to be made of the potential for water savings in California. Below, we offer such an assessment for the residential sector, with explicit discussion of our assumptions and data. As new or better data are developed, such estimates can be refined.

Our studies suggest that replacing the existing average vertical-axis washing machine with currently available horizontal-axis models will save between 4,600 and 5,200 gallons per year per household. This range reflects differences in household usage and model design. Full penetration of the current generation of horizontal-axis machines into California's residential market by the year 2020 thus has the potential to reduce future residential demand for water by between 171,000 and 194,000 acre-feet per year.

This estimate is based on current best estimates of future population, household size and distribution in 2020 and the distribution of washing machines per household. Several factors are likely to increase the potential savings: (1) growing State and personal income are likely to increase the fraction of households with washing machines; (2) further improvements in washing-machine technology over the next 22 years are likely to reducing water use per machine beyond that of the current generation of high-efficiency machines; (3) this estimate excludes any improvement in the water-use efficiency of commercial washing machines.

Some factors could reduce overall savings, but the most important of these would be counterbalanced by other changes that would tend to keep water-use lower than currently projected. These include: (1) less than full penetration of horizontal-axis machines, though further improvements in the efficiency of vertical-axis machines are also occurring, which would also lead to savings; (2) slower overall population growth rates, which would separately reduce total water demands;[1] and (3) larger household size, which would reduce the total number of machines in use, but which would probably lead to higher use rates per household, keeping savings high.

On balance, we believe that the estimate below is a conservative estimate of potential savings. Projections, however, are not predictions, and this calculation should be considered as a current best guess. Actual savings will depend on future technology, demographic trends, market forces, and California water policies.

Savings Potential for Full Penetration of Horizontal-Axis Washing Machines in California's Residential Sector by 2020

Savings per Washing Machine

Horizontal-axis washing machines are estimated to reduce water use by 30 to 40 percent compared with the average vertical-axis machine. Several different estimates have been made of the annual savings per household expected from replacing vertical-axis machines with horizontal axis machines (CEE 1995, DoE 1996, Steding et al. 1996, THELMA 1998). These estimates have been developed from both extensive field tests and surveys and from laboratory studies. The results depend on assumptions of the average water use in existing machines and estimates of usage patterns. For this assessment, we adopt the formal U.S. Department of Energy guidelines for estimating savings, and compare them with the recent THELMA/EPRI field studies of households across the U.S. Both approaches produce savings of between 4,600 and 5,200 gallons per household per year, despite different estimates of the loads washed per year and the savings per load. In addition, we looked at the savings likely to result from replacing the average vertical-axis machines ***currently in use***, and the savings from the average vertical-axis machine produced in 1995 (Table 1). These savings are slightly different, reflecting ongoing efficiency improvements of vertical-axis units over time.

Table 1
Water Use for Vertical- and Horizontal-Axis Washing Machines

Technology	Gallons per load	Source
Average vertical-axis machines in use (1995)	44	Kesselring and Gillman 1997
Average vertical-axis machines in use (1995)	37.5	CEE, 1995, DoE 1996
Average vertical-axis machine shipped (1995)	35.8	CEE, 1995, DoE 1996
Current generation horizontal-axis washers	24.2	CEE, 1995; Kesselring and Gillman 1997

[1] We use here the current California Department of Finance population forecast of 47.5 million people by 2020. We think it likely that this forecast will be reduced in mid- to late-1998 to around 45 million people, as current trends are reanalyzed. If this happens, the total potential savings from water-efficient residential washing machines will drop, but total demand for water statewide will drop much more.

Number of Households, Now and in 2020

Total savings statewide will depend on the number of occupied households, and the fraction of households with washing machines. Formal estimates of the current number of households in California are available from the 1995 American Housing Survey (Table 1A-4), the California Department of Finance (1998), the Center for Continuing Studies of the California Economy (CCSCE), and separate regional demographic studies. Table 2 lists these estimates. The 1990 U.S. Census estimates are almost identical to the 1990 Department of Finance estimates, but the DoF provides separate estimates of occupied and unoccupied households. For the purposes of this analysis, we believe the best data to use are DoF occupied household estimates.

Table 2
Total California Households: Current and Future Estimates

Measure	Number	Source
1990 California Households (occupied)	10,380,856	DoF 1998
1990 California Households (total)	11,183,513	DoF 1998
1990 California Housing Units	11,182,882	1990 US Census Data
1995 California Households (occupied)	10,896,000	DoF 1998
1998 California Households (occupied)	11,128,000	DoF 1998
2020 California Households (for a 2020 population of 44.96 million)	15,100,000	Levy, CCSCE, 1998
2020 California Households (computed using DoF population estimate of 47.5 million and 1995 household size)	16,620,000	DoF 1998; computed

In order to estimate future residential water use by washing machines, an estimate is needed of future number of occupied households. The California Department of Finance does not generate forecasts of household number. An estimate can be developed, however, by using projections of total state population, and estimates of expected household size. The best estimate of California household size for 1990 was 2.79 people per household (DoF 1998). In 1995, household size was slightly higher: 2.86 people per household (DoF 1998) and the trend between 1990 and 1998 was up, though according to DoF, actual household size may not be increasing as fast as the data show (Heim, DoF, personal communication, June 18, 1998). The CCSCE offers a lower estimate of total households in 2020, but these data were developed using lower overall projections of California's future population (S. Levy, CCSCE, June 18, 1998). Using larger household sizes will produce a smaller estimate of the number of households in 2020, but would require an increase in the estimate of total washer use (more people require more washer loads per week) – somewhat balancing each other. We therefore use actual 1995 estimates of household size and data on current washer use in order to project a 2020 household savings number. Because all other data can be obtained for 1995 (including water use per machine, population, housing estimates, etc.) and because the DWR uses 1995 as their base year for the Bulletin 160-98 draft, we adopt the 1995 DoF data here. These produce an estimated 16,620,000 households in the year 2020 (2020 population/estimated household size).

Number of Households with Washing Machines

Total household estimates must then be multiplied by the fraction of households with washing machines. Again, there is no accurate estimate of such a fraction, since it depends on future income, consumer preferences, appliance costs, and other unpredictable factors. The fraction of homes with washing machines has been increasing in recent years, but in order to be conservative, we assume here the same fraction of households have machines in 2020 as at present. In 1995, 73 percent of all U.S. homes had washing machines (see Table 3); a separate set of surveys for California cities and regions reveals a higher level of washing machine penetration: between 69 and 86 percent for total household surveys. The numbers are higher in surveys of single-family homes. For the purposes of this estimate, we assume a conservative penetration rate of 73 percent.

Table 3
Households with Washing Machines (U.S. and Regional Data)

	Total Households	Households with Washing Machines	Fraction with Washing Machines
United States 1995 (Total)	109,457,000	79,403,000	0.73
United States 1995 (Occupied)	94,000,000		0.86
Anaheim, California 1994	851,500	591,600	0.69
San Jose, California 1993	534,700	391,200	0.73
San Bernadino, Riverside, California 1994	932,900	747,200	0.80
San Diego, California 1994	898,800	606,700	0.68
Marin Municipal Water District, California 1994 (single family)	49,414		0.91
City of Santa Barbara 1994	16,488		0.86
City of Tucson, Arizona 1994	139,311		0.86

Sources: American Housing Survey, 1995 Table 1A-4; American Housing Survey, 1995, regional reports; Association of Home Appliance Manufacturers, 1993; Tucson Water, 1995; City of Santa Barbara 1996; Marin Municipal Water District 1994.

Estimate of Total Annual Potential Savings from Horizontal-Axis Washers

The ultimate potential savings depend finally upon the fraction of vertical-axis machines that are replaced by horizontal-axis machines. We assume here a 50 percent and a 100 percent replacement over the next 22 years.[2] An average replacement rate for washing machines is estimated at between 2 and 4 percent annually; machine lifetimes

[2] The California Department of Water Resources (1998) suggests 70 percent replacement by 2020 is possible but includes no actual savings in their baseline 2020 demand estimates.

typically range from 7 to 14 years (CEE 1995). Replacement can be accelerated by rebate programs, other incentives, and education. Some of these programs are already being tried.

Assuming 100 percent replacement, total annual savings would be between 172,000 and 194,000 acre-feet per year of reduction in total residential water demand. Proportionally lower replacement levels would lead to proportionally lower savings (see Table 4). The Department of Water Resources assumes a 70 percent replacement level is possible by 2020. The range reflects the difference in water demand between the average vertical-axis machine ***in use*** in 1995 and the average vertical-axis machine ***produced*** in 1995.

Table 4
Potential Residential Water Savings from Replacing Vertical-Axis Washing Machines with Horizontal-Axis Washing Machines in California

Penetration Rate Assumption [1]	Replacing Average Vertical-Axis Machine *in Use* in 1995 Total Savings (acre feet/year)	Replacing Average Vertical-Axis Machine *Sold* in 1995 Total Savings (acre-feet/year)
25 percent Conversion to H-Axis	48,501	42,905
50 percent Conversion to H-Axis	97,003	85,810
100 percent Conversion to H-Axis	194,006	171,621

1. Fraction of residences with horizontal-axis machines by 2020

Under natural replacement rates, the marginal costs of more efficient machines are between zero and the difference between the cost of a horizontal-axis machine and a vertical-axis machine. As of mid-1998, horizontal-axis machines were more expensive than vertical-axis machines, which is likely to be the greatest barrier to their use. Like all new technologies, however, the price difference has begun to decrease as competition among manufacturers has grown and as production increases. Furthermore, new energy standards that may be proposed by the U.S. Department of Energy may prove too stringent for vertical-axis machines and may "virtually ensure" a market for horizontal-axis machines (Kesselring and Gillman 1997).

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