

# **EFFICIENT WATER USE IN CALIFORNIA: WATER RIGHTS, WATER DISTRICTS, AND WATER TRANSFERS**

**PREPARED IN PART FOR THE CALIFORNIA STATE ASSEMBLY RULES COMMITTEE  
AND IN PART UNDER A GRANT FROM THE ROCKEFELLER FOUNDATION**

**CHARLES E. PHELPS, NANCY Y. MOORE,  
MORLIE H. GRAUBARD**

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## PREFACE

This report is one of seven documenting the findings of Rand's study of water use efficiency in California. The study was commissioned by the California State Assembly in the autumn of 1976 and was supported in part by a grant from the Rockefeller Foundation. Its purpose was to examine current water use efficiency and to suggest ways to improve it. The focus of the study was deliberately set statewide, although particular areas of the state receive attention in some reports. It was not designed to solve problems that have drawn recent attention, such as the 1976-77 drought and its exacerbation of the groundwater overdraft problem in the San Joaquin Valley. Rather, the focus has been widened across a broad expanse of time and across all sources and uses of water. It is a study of long-range water use problems and solutions, rather than of immediately perceived short-term problems.

The analysis documented here focuses on the legal and institutional structure of water supply and use, drawing inferences from both theory and observed data with respect to the effects of these legal arrangements on water use. In the course of the study, members of the Rand research team visited nearly fifty water supply agencies throughout the state; the study conclusions are based in part on the information acquired in these field visits. The companion reports include:

*Efficient Water Use in California: Executive Summary*, by Charles E. Phelps, Morlie H. Graubard, David L. Jaquette, Albert J. Lipson, Nancy Y. Moore, Robert Shishko, and Bruce Wetzal, R-2385-CSA/RF, November 1978.

*Efficient Water Use in California: Groundwater Use and Management*, by David L. Jaquette and Nancy Y. Moore, with Albert J. Lipson, R-2387/1-CSA/RF, November 1978.

*Efficient Water Use in California: The Evolution of Groundwater Management in Southern California*, by Albert J. Lipson, R-2387/2-CSA/RF, November 1978.

*Efficient Water Use in California: Economic Modeling of Groundwater Development with Applications to Groundwater Management*, by Bruce Wetzal, R-2388-CSA/RF, November 1978.

*Efficient Water Use in California: Conjunctive Management of Ground and Surface Reservoirs*, by David L. Jaquette, R-2389-CSA/RF, November 1978.

*Efficient Water Use in California: Water Supply Planning*, by Nancy Y. Moore, Morlie H. Graubard, and Robert Shishko, R-2390-CSA/RF, November 1978.

These reports should be of interest to those concerned with California water policy and its implications for other states and the nation.



## SUMMARY

Is water being used efficiently in California? This study concludes that water use throughout the state is *not* efficient. This lack of efficiency is not due to mismanagement or waste by water users (agriculture, business, and households) but rather to a myriad of legal and institutional restrictions on water pricing, transfer, sale, and use. In general, water users individually appear to use water efficiently, *given the circumstances they face*, but those circumstances (the body of water law, water supply institutions, and legal rulings) essentially dictate that water use be inefficient from a statewide perspective. More important, improvement in the efficient use of state water supplies could forestall or even eliminate the need for constructing expensive new water development facilities now being considered by the Legislature. The current system generates annual losses to California conservatively estimated to be \$60 to \$370 million, which is equivalent to a once-and-for-all wealth loss of \$1 to \$5 billion. It is this loss that should be contrasted against legal, political, and economic costs associated with a move to efficient water use.

## HOW EFFICIENCY COULD BE ACHIEVED

We define water use as efficient when the added costs of supplying water just equal the added benefits to water users. This concept of benefit measurement accepts as pertinent the users' valuation of the water. Since 85 percent of the water used within California is in agriculture, this primarily implies accepting farm profitability as the measure of water value. The best measure of cost is often the value of the resource to the user valuing it most highly, independent of actual production costs. The concept of cost is meant to include all costs generated by supplying the water, both private costs and "public" costs (i.e., those not borne directly by the water users). Private and public costs can diverge markedly, as, for example, in use of groundwater basins.

Efficiency of water use can *in concept* be enhanced under three different systems: (1) central planning of water use and supply; (2) pricing of water to reflect the incremental (marginal) costs of the supplier; and (3) enabling water users to buy and sell water, independent of the initial price paid for the water.

Central planning can lead to efficient use if the planners can assess the value of water in each use and the costs of delivery of water to each user, and can establish a distribution system to send the water to each user in such amounts and with such timing that added value to each user from receiving more water just equals the added costs of supplying that water. The informational difficulties in such an activity appear to us to be overwhelming, and we reject central planning as a feasible method of achieving efficient use of water. Instead we concentrate on other ways of achieving efficient water use.

Efficient use can also be achieved when the price to each user reflects the incremental costs to society of supplying the water. This concept is known as marginal cost pricing. Users can be expected to increase their use of any resource only to the point where the added benefit from the incremental amount used just

equals the price charged. For example, in farming, the farmer would add water to his crops only to the point where the added water increases farm profits by just the amount that the water costs. Any further use of water would mean spending more on water than it was worth; less use would imply that some profits had been forgone. In general, we anticipate that water use would increase until marginal benefit to the user equaled the price paid. When that price is also set equal to the marginal cost to society, then efficiency has been achieved, because the added benefit from supplying the additional water will have just equaled the added cost.

Finally, even if water is not priced to the initial buyer at marginal cost, efficiency can be achieved by allowing unhampered buying and selling of water among water users. Efficiency occurs because those who value water highest may purchase water from those who value it less, and both parties are made better off. Thus, in general circumstances, a free-trading market leads to the same pattern of use as a market with marginal cost pricing.

Our analysis concentrates on improving understanding of water trading and water pricing as mechanisms for enhancing water use efficiency. We discuss, in order, the possibilities for water sales and trades by water district, water district pricing practices, and finally a modification in the general pattern of water rights assignment which would enhance water sales at the final user level. Associated legal complexities arising from each of these concepts are next discussed.

Water districts have available to them basically three mechanisms to distribute or use revenues from outside water sales: They can add new physical facilities for the district, they can reduce the price of water actually sold within the district, and they can reduce property taxes collected within the district. Each of these mechanisms presents operational difficulties to the water district, as well as potential problems regarding efficiency of water use within the district.

Consider first the notion of adding new facilities. If a water district chose to sell part of its water resources systematically through time, the revenues would accumulate so much that it could not justify further capital expansion or improvement. The ultimate result of such a strategy for using water sales revenues would be "gold-plating" of district facilities. In addition, there would probably be tax reductions or water toll reductions within the district that would otherwise have been used for some of the capital improvement, each of which presents its own potential problems.

The problem with using water toll reductions to distribute district revenues from outside water sales is its effect on water use: A reduced water price leads to increased amounts demanded by members within the water district, thus leading to inefficient use. There may also be a disparity between amounts supplied and demanded under such a situation. Supply within the district is decreased (by the sale of water elsewhere) and demand is increased (because of the lower price). Thus a rationing system may be required, which could also potentially lead to inefficient use within the district. (If retrading of water within the district is permitted, this problem can be resolved, but some water districts we contacted seemed strongly opposed to such reselling of water, even within the district. Such intra-district sales are nevertheless fairly common.)

Property tax reductions are the third potential mechanism to distribute the profits from district water sales. Such reductions are not uniformly available to water agencies, because some agencies rely only very little upon taxation, whereas others rely almost completely on taxation to meet district costs. Those with only



little taxation revenue find tax reduction only a limited vehicle for water sales profit redistribution at best. Even if the mechanism is available, the directors of the district may have little interest in using it. There is the potential for significant income redistribution among residents within water districts through the taxation mechanism: In general, relatively heavy water users within a water district have incentives to rely more upon taxation than upon water tolls, particularly if the taxes are levied on some basis relatively independent of water use. (In one district, we observed that 80 percent of the taxes were paid by users receiving 20 percent of the water. This was, however, the extreme we observed in our contacts with over 50 water agencies.) If a majority of voters within a district has achieved such a favorable redistribution process, they may be loath to use tax reductions or rebates as a way of distributing any profits arising from water sales by the district.

The circumstances wherein such redistribution can potentially arise are too numerous for us to catalog. Voting rights within water districts may be based upon acreage owned or assessed valuation, or on a per capita basis. Thus various combinations of land ownership and tenant farming can be expected to produce a variety of potential redistributive systems. Without detailed knowledge of land ownership patterns within any given district, or about tax payments and water use, it is impossible to assess the extent to which such redistributions are actually employed.

A separate concern of financing water district operations through taxation is the potential for inefficiency introduced. Whenever property taxes are employed to reduce water tolls, there are incentives for overuse of water within the district. This arises because the tax payment is independent of actual water consumption, and thus does not affect water users' decisions about the amounts of water to consume. In general, taxation is desirable as a part of the pricing strategy for an organization only when average costs systematically decline as the scale of the organization increases. (A common example is the telephone system, where multiple systems of telephone lines, each connecting different subsets of the households and businesses within a community, would be more costly than having a single system serving every phone user.) But such is normally not the case within the operations of a water district. Many water districts have multiple sources of water supply, for example, one being more costly than the other. Consequently, correct pricing decisions by the water district—i.e., pricing at the full cost of the most costly water source—would lead to a profit by the district. In such situations, taxation should not be at issue, but rather how to dispose of the profits within the confines of the water district environment.

## THE ROLE OF PRICING

A large number of studies indicate that amounts of water used in virtually every water using activity are dependent upon the price of water. The sensitivity of water use to price depends upon the nature of the use—outdoor home use appears more sensitive than indoor home use; agricultural use appears more sensitive than homeowner use, and also becomes more sensitive as the price of water increases. (See the appendix for a summary of this literature.) Thus the pricing decisions of water agencies throughout the state could play an important part in determining overall water use.

As previously stated, efficiency in water use is achieved when the price of water is set equal to the cost of supplying additional water in the system. For a local water district, this means determining the cost of adding new water supplies to their system. For the State Water Project (SWP), this means adding new supply facilities. For the individual farmer, it may mean either obtaining more water from the water district serving him, or pumping additional water from the ground. In general, when a water system employs a variety of sources for its supply, some will be more costly than others. The marginal cost of the system is the cost of the most expensive source used. The average cost of the water, by contrast, will generally be less than the marginal cost, because it includes some water available from lower-cost sources.

Water agencies throughout the state tend to price water at its average cost, rather than its marginal cost, and since the average cost is lower, there is a general tendency to over-use water from such sources and inefficiencies arise. Water districts (and the SWP) chose average cost pricing rather than marginal cost pricing for a variety of reasons, but the predominant reason appears to be that marginal cost pricing would lead to a profit, and the water district (and the SWP) cannot legally make a profit systematically. Thus the legal constraints on the operation of a water district (and the SWP) generally force them to engage in a pricing policy that leads to inefficient water use. The problem is pervasive not only within local water districts, but also within state and federal water supply agencies. Within the SWP, the problem is so severe that current proposals for expansion of the SWP could lead to construction of water reservoirs which have a marginal cost of over \$250 per acre-foot, *just for the capital costs*, yet the water would be sold for less than one-fifth that amount. The reason is similar—if the SWP were to price water at the marginal cost, a substantial profit (possibly over \$100 million per year) would be made, and the SWP has no effective mechanism to deal with such a profit. (See the appendix for calculations supporting these numbers.)

The problem of average cost pricing is exacerbated by the use of taxation to support part of the costs of water districts. Whenever taxation is available to help finance water supply systems, it eventually leads to too much water used. The reasons are that the water toll becomes lower than it would be without the tax, and that reduced prices systematically increase amounts of water use.

A similar average cost pricing problem arises in the federal Central Valley Project (CVP). In addition, the CVP engages in several direct subsidies to water use, through pricing reflecting estimated ability to pay, through the use of very low interest rates for project construction costs, and through deferral of repayment of capital costs for a considerable period.

## **ALTERNATIVE WATER SUPPLY ARRANGEMENTS FOR EFFICIENT WATER USE**

Several mechanisms are available to enhance the efficiency of water use within the state. One prominently mentioned concept is that water districts should adopt marginal cost pricing. As discussed above, such pricing practices would violate the zero-profit constraint of most water districts, unless changes in the district organization are made. One method we consider is the one of increasing block pricing, by which some water is made available at low cost (or free) to each water user, with any added amounts of water supplied only at the correct marginal cost. The profit

of the system can thus be distributed through the use of fixed amounts of water to each user. Such a pricing system can lead toward efficient use of water if most or all water users actually consume more water than their initial low-cost allocation, so that they face the marginal cost of the system as the relevant decisionmaking price. There may be political difficulties in establishing the appropriate amounts of low-cost water to be received by each water user, but such problems do not appear to be insurmountable. However, even use of such pricing mechanisms within water districts cannot solve all problems of inefficient water use, because disparities in value of water can still arise across water district boundaries.

An alternative mechanism to induce efficient water use is to modify the way in which the rights to use water within a water district are held. In usual water district practice, water rights are typically held by the district itself, and the water district then apportions water use among landowners within the water district. The rights to receive water from the district are typically based upon acreage owned or tax payments, but the rights are not fully transferable to other persons or parties. Thus the ultimate user of 85 percent of the state's water—the farmer—is faced with the choice of receiving his allocation of water (at a price typically below marginal cost) and using it in his farming, or giving up that water use and gaining only the water toll that would have been charged by the water district. That water toll may be quite low—\$3 to \$6 per acre-foot of water—whereas users elsewhere in the district, or particularly persons outside the water district in less water-rich areas, evidence willingness to pay up to \$150 per acre-foot of water. The ability of the farmer to sell title to use of his allocation of water can improve the efficiency of water use within the state by providing incentives for voluntary sales or exchanges of water.

To achieve such a system of water sales, it is necessary for water districts to provide a clear title to the use of water from the water district to the ultimate water user. It is also necessary to eliminate prohibitions against transfer of that water, but the problem of providing appropriate incentives to the water user seems prominent in achieving efficient water use. In addition, the cooperation of local, state, and federal agencies is critical in supplying major cross-state transportation for the water through existing canals, while charging users appropriately. The important notion involved in establishing a water market is that the relevant price facing any water user would be the highest amount he could obtain while selling that water, rather than the price actually paid to the water district for delivering that water. Thus, even if water district pricing could not be rationalized to lead to efficient water use, mechanisms for water sales would reach the same goal through different channels.

## **OTHER LEGAL CHANGES TO ENHANCE EFFICIENCY**

Certain modifications in basic water rights law also appear desirable in terms of increasing efficiency of use. One issue involves return flows from imported appropriated water. Under some circumstances today, this water is considered available for later appropriation by downstream users, so that changing the point of use of the original appropriation can lead to claims of third-party damage. We recommend that any new appropriations explicitly state that return flows are a part of the original appropriation so that *no* downstream users can claim damage unless they

have contracted for use of that return flow explicitly. Further, we recommend that quantification of existing return flow dependencies should be made, so that every water appropriator can be certain of the potential damage claims, should he wish to sell his existing appropriation. Mechanisms to compensate for any damages must be arranged, but we believe that clearer indication of where title to such return flows lies will enhance the ability of water users to voluntarily transfer their water to more highly valued uses.

An expanded surface water market will almost certainly lead to increased groundwater extraction in some areas of the state. Groundwater users impose costs on others within the same basin through increased extraction, but they do not personally bear the brunt of these costs. Because total costs to society diverge from the sum of private costs, a basinwide management scheme is desirable. In companion reports, we discuss the basis by which such management can be undertaken in California, and the gains achievable to groundwater users.

The gains from these modifications to California water law and institutions are most productive if taken as an entire package rather than piecemeal. For example, improved management of groundwater basins allows more aggressive conjunctive use of surface and groundwater storage, thus enhancing the output of existing surface developments. The effects of surface water sales will almost certainly include increased groundwater pumping in some regions; hence, management of groundwater extraction in all basins will guarantee that no adverse social effects arise from the surface water sales. While each of the components is likely to be useful in its own right, the entire system of modifications is synergistic in benefits.

## ACKNOWLEDGMENTS

This study could not have been accomplished without the considerable assistance, early in the project, of numerous employees and directors of water agencies throughout California. We extend our gratitude to them for their assistance. Important conceptual developments were suggested by Rodney T. Smith, who was a member of the study team before his departure from Rand. Advice on legal and institutional matters was given by Clifford Lee and Harrison Dunning of the Governor's Commission on Water Rights staff. Also of considerable value was information on institutional and political aspects of California water use provided by Clyde MacDonald, Consultant to the California Assembly on Water, Parks, and Recreation.

Previous drafts of this report were reviewed by Julius Margolis of the University of California at Irvine; by George Eads, formerly of Rand and now a member of the President's Council of Economic Advisers; and by Rodney Smith. While our debts to them are large, these reviewers are, of course, absolved from responsibility for any remaining errors in the final report.



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## I. INTRODUCTION

The State of California, with possible assistance from federal sources, may spend some \$3.5 billion to expand a water conservation and delivery system that has been serving the state for decades. Proponents of this expansion of the State Water Project (SWP) and the federal Central Valley Project (CVP) argue that the construction is needed to fulfill existing contracts for water deliveries, and that diminishing groundwater supplies, the growing population (in urban areas), and growing demands for agricultural products in general prove the need for additional water.

Critics of the proposed expansion argue that environmental concerns have not been taken into account, that considerable water within California is being "wasted," and that the project expansion could be eliminated if we would all "tighten our belts" and use water more wisely. Indeed, California's Governor Edmund G. Brown, Jr., established in 1977 an independent Commission to Review California's Water Rights Law with a view toward finding possible savings in water supply and use through legal reform [1].

This Rand study was commissioned by the California State Assembly for the purpose of assessing whether water use in California was efficient or not, and if not, how a long-term improvement in water use efficiency might be achieved. Companion reports assess more directly specific components of water use and the water supply system, with particular emphasis on groundwater management alternatives and on the state's water planning operations. In the present report, we focus on the influence of water law, water transfers, and local water district organization and operation, to reach a fuller understanding of how these combine to affect water use in California.

Efficiency of water use is an elusive concept. One man's waste is another man's need. The conflicting uses of water in California contribute to this dilemma, and the tensions arising from this conflict can be considerable. A simple example suffices to portray the conflict: Agricultural interests view in-stream uses of water, which eventually must conflict with consumptive agricultural uses, as wasteful. Environmental and recreational interests feel that certain agricultural and household water use practices are needlessly wasteful, and that water could be saved for in-stream use if only such wasteful practices were eliminated. Probably most California citizens were angered at some time during the 1976-1977 drought by their neighbors' "waste" of water, such as lawn-watering that spilled into gutters, automobile washing, failure to recycle bath water, or even the serving of a glass of water in a restaurant. We will not adopt here a list of uses of water that are considered to be wasteful or beneficial. Indeed, we doubt the viability of such a mechanism. Rather, we adopt a general concept of what is meant by efficient use of water, which we will use to focus our discussions of water use in California.

We define water use as efficient when the added costs to society of providing more water for use would just exactly be offset by the added benefits of that water use to the members of society. Several things are immediately apparent from this definition. First, we accept the valuation by the consumer as the relevant value of water. Since 85 percent of water use in the state is agricultural and is a factor in

food production, we are interested primarily in how water is valued when it adds to farm profitability.<sup>1</sup>

By accepting this definition of water use efficiency, we immediately concern ourselves with the additional cost of providing additional water, rather than with the average cost of water. The concept of marginal cost is crucial to this study. In any inquiry about long-term water use efficiency, the concept of marginal cost must be meant to include all of the added costs to society that are incurred when the amount of water available for use is increased. This includes costs that are not directly borne by the water user, but which are imposed on others. We wish to distinguish two concepts of marginal cost that apply to water use. One concept is the added cost of providing the additional supply of water itself. We shall call this a *resource cost*. The other concept is the *value* of the existing water supply in its best alternative use. We shall call this concept the *opportunity cost* of the water. If water supplies are freely transferable, opportunity costs will equal resource costs. However, if supplies of water are limited, at least to some water users, then there may be a divergence between the resource cost and the opportunity cost of water, with the opportunity cost—the value to users of more water—being the larger.

The third important notion in our definition of efficiency is that all costs be taken into account when making the efficiency calculation. In groundwater use, costs directly paid by the water user differ substantially from the total costs to society, because of costs imposed on others. When any groundwater user draws water from the ground, his own costs reflect only a part of the total cost to society. His private activity has also increased the pumping depth for all other groundwater pumpers who rely upon the same basin, and their pumping costs are increased by any extraction from the basin. Other social costs also may emerge in some basins—salt water intrusion from the ocean, or general subsidence of land as water is removed from the ground. Falling groundwater tables may alter the amounts and types of trees and plants that can survive in the area. Thus social costs can exceed private costs. This concept is considered in more detail in companion reports by Jaquette and Moore [2], and by Wetzel [3]. These reports conclude that the interests of the state, and the interests of groundwater pumpers, can likely be improved by instituting groundwater management plans throughout the state to monitor and manage groundwater use. We shall not consider this important concept in great detail here, but defer such consideration in general to the companion reports.

There are other important areas where private costs and social costs may diverge in water use. Water quality considerations are paramount among these. The dumping of industrial or municipal waste into water basins or conduits obviously imposes a cost on others not accounted for by the private act of waste disposal. Using water for irrigation also degrades water supplies, since some of the water used in irrigation returns to the original stream source with an increased level of dissolved solids. The effects of such increases in salinity on the value of water have been studied by Moore, Snyder, and Sun [4]. In general, we will not discuss water quality considerations in this report, not for their lack of importance, but for lack of resources to study both the quantity and quality dimensions of water use.

Throughout this report, "inefficient water use" will be taken to mean that the water is not valued by the consumer at the full social costs of bringing that water

<sup>1</sup> Agricultural use accounts for over 30 million acre-feet (MAF) of water annually in California.

to him. In consideration of both value and cost, we will always mean these terms to refer to costs (or value to others) of *additional* supplies, and *additional* benefits, to the user, rather than *average* costs and benefits. Note that inefficiency can arise because there is too little water used as well as too much water used: The definition is perfectly symmetric. If a person values additional water more highly than the cost of bringing that water to him, but the delivery of water is somehow constrained, then there would be an improvement in efficiency if additional resources were expended to bring that water to the consumer, up to the point where his marginal benefit declined and the marginal costs had increased until the two were equal. Efficient water use is not synonymous with reduced water use—it means that added costs for more water just equal the added benefits to water users. The central questions of this report are whether means exist to achieve such efficient use, and if not, how one might achieve that end.

Efficiency is not the only concern of our study, although it is a central concern. The existing patterns of water law, water institutions, and water use have been accepted as a "given" for decades by the water using community. Changes in that environment have the obvious potential for conferring considerable financial benefit on some, while wreaking considerable financial havoc on others. We will in our study consider the wealth-transferring effects of changes in law and institutions. The changes in distribution of wealth arising from institutional legal changes will be important in establishing political support for or against any proposed changes.

The magnitude of wealth loss associated with this inefficiency is difficult to establish with accuracy, but rough approximations suggest that, at a minimum, California is annually losing somewhere between \$60 million and \$370 million per year, which is equivalent to a loss in wealth (in present value terms) of \$1 billion to \$5 billion or more (calculations are in the appendix). It is this wealth loss that should be considered when assessing the legal, economic, and political costs of achieving a more efficient use of water in California. If the sum of those costs is thought to be less than the wealth loss resulting from inefficient water use, then a change to a more efficient system of water use should be made. (Here we include the implicit costs of any wealth redistribution taking place as part of the total costs of achieving reform. If such a redistribution is considered favorable by society, then that part of the cost is negative. If it is an unfavorable distribution—but one which must be accommodated to achieve efficient use of water—then it is a true positive cost.)

We find inefficiencies in water use in California arising from three generic sources: (1) the presence of external and internal subsidies to water prices in water agencies at all levels of water supply, (2) lack of both opportunity and incentive for users to engage in voluntary water trades (sales), and (3) failure of mechanisms to account for costs imposed on third parties, particularly in the area of groundwater extraction. The first two of these are the subject of this report. To reach a more complete understanding of the issues, we first present brief summaries both of basic water law that is relevant and of the characteristics of the important legal institutions operating in the water market, i.e., the SWP, the federal CVP, and the large number of local water districts that account eventually for the distribution and sale of nearly all of the surface water distributed in California.

## II. SUMMARY OF WATER RIGHTS LAW IN CALIFORNIA

Before any analysis of water use can be undertaken, one must first understand the mechanisms by which people obtain the right to use water within the state. California has developed a set of water rights laws that are a mixture of English common law (developed in a climate and environment where water was much more evenly distributed by nature through space and time than is true in California) and of a newer type of water law better adapted to the characteristics of California's arid climate and unique fresh-water resources. A more complete summary of existing state water law can be found in *West's Annotated California Codes, Water Code* [5].

First, California's Constitution contains a basic requirement that water be used reasonably and beneficially. These restrictions apply to all water use within the state. Nowhere in statutes are there formal definitions of what constitutes reasonable and beneficial use, and the immediate judgment of the courts and the State Water Resources Control Board (SWRCB) in practice defines what is reasonable and beneficial.<sup>1</sup>

In English common law, the right to use water was heavily associated with ownership of the land through or beside which the water flowed. A riparian right to use water arises for any land actually adjacent to the water source. In California riparian law, the amount of water that can be used on riparian land is limited only by the concepts of reasonable and beneficial use, and by the requirement of reasonable sharing of available supplies among riparian users. Water used under that right cannot be used on any nonriparian land. There is no filing requirement, measurement of use, or permit associated with riparian use. If water supplies grow short in a river system, either temporarily or permanently, then legal decisions stipulate how the shortage is to be shared. The value of water used under riparian rights is the standard to be applied. Riparian users normally have the highest priority to surface water in California. An important court case has reached the California Supreme Court (*in re Long Valley Creek Stream System*) to determine whether riparian rights are lost through nonuse. Past interpretation of the law has generally been that no use was required to sustain a riparian right.

While there are large quantities of water used under riparian law, most of the surface water within the state is used under an appropriative right, whereby the appropriator, with the permission of the state (the SWRCB), may divert and use allotted quantities of water from a specified source, for a specified use, and at a specified location, in a specified part of the year. To change the place or purpose of use requires permission of the SWRCB. (Pre-1914 appropriative rights do not face all of these requirements.)

The other major water supply source within the state, and indeed a more important source for many areas of the country, is water extracted from the ground. In California, groundwater may be used under two criteria: Owners of land overlying the groundwater basin are entitled to all the water desired for use

<sup>1</sup> There is one specific indication in the Water Code that irrigation in excess of 2.5 acre-feet per acre on uncultivated land is an unreasonable use.

on that overlying land. This is known as "overlying use." If the groundwater basin provides excess water, that excess may be exported for use in other sites. An aquifer's "safe yield"—the average annual recharge of the groundwater basin—determines whether its groundwater may be used on nonoverlying sites. As is the case with riparian water users, if a shortage occurs (i.e., if legally entitled users attempt to consume more than the available supply), withdrawals of groundwater may be limited, typically proportionate to past use, so that average withdrawals do not exceed average recharge. In California, in most cases where groundwater use has been controlled, a legal process known as adjudication has been applied. (The prospect of adjudication to achieve this control obviously encourages active groundwater use by potentially affected parties, if they believe that future rights to pump will be based on historical pumping rates.) In many adjudicated basins, parties may rent or sell their allocations for use within the basin.

Effective groundwater law has been modified considerably by two court decisions involving an overdrafted basin. First, in *Pasadena v. Alhambra* (1949), the concept of mutual prescription was established. In this case it was ruled that every pumper had, in effect, been trespassing against all other pumpers, yet had, by lack of protest from other pumpers for five years, established a prescriptive right to their groundwater pumping. The total basin pumping was reduced by the court to the basin's safe yield, and every pumper's allowable rate of pumping was proportionately reduced, the rate being set as that in effect during the five years before the decision. In *Los Angeles v. San Fernando* (1975), this decision was modified by an important notion: The law does not allow prescription against public entities. Thus the concept of mutual prescription became no longer available as a basis to encourage or force agreement on pumping rates where cities or other public entities were involved. Thus, any agreements among parties involved in a groundwater basin management plan must be based on mutual agreement, rather than on the concept of mutual prescription. A more extended description of these concepts is contained in Jaquette and Moore [2] and in Lipson [6].

For analytic purposes, there are several important common dimensions to water rights law in California. First, water use is heavily tied to the land. Riparian surface water use and overlying groundwater use are legally defined on the basis of land ownership. The rights to use such water cannot be transferred independent of the land title itself. Hence, purchasing a piece of land with either riparian or overlying groundwater rights is akin to purchasing the land plus an option to use as much water as desired on that land, subject to its availability, to the constitutional requirements for reasonable and beneficial use, and other restrictions as discussed above.

Appropriative rights are legally transferable, and (subject to state approval) can be sold, independent of title to land. However, as we discuss in more detail below, the occasions on which this is done are limited and always subject to the uncertainty of SWRCB approval. Appropriative groundwater rights are relatively uncontrolled, except when a groundwater basin becomes "overdrafted" (i.e., average annual withdrawal exceeds average annual replenishment), at which time overlying groundwater users have priority, and appropriative groundwater rights can become worthless.

A key difference between riparian and appropriative rights is the method by which risk is spread among water users in the event of a drought. Risk-spreading

is accomplished here by allocation of water rights. Among appropriative users, risk decreases with the temporal seniority of the water right—the most senior appropriator may take his entire appropriation, subject to the general “reasonable and beneficial use” criterion, before a junior appropriator can take any water.

### **III. MAJOR FORMS OF ORGANIZATION IN CALIFORNIA WATER SUPPLY AGENCIES**

California water supply agencies are characterized by a wide diversity of scale, and a dizzying variety of legal forms. Recall that for surface water, there are both riparian and appropriative users. Riparian users are typically small, and by definition take water only for their own use. If there are any potential economies of scale in water development for riparian users, the law inhibits their exploitation under riparian water law. Thus, joint development in such cases must be carried out under appropriative water rights law, and typically by some agency.

#### **WHOLESALE AGENCIES**

By far the most important appropriative water suppliers within the state are large government agencies that develop immense and complex surface water storage and transportation systems. The U.S. government, through the Bureau of Reclamation, first developed these large, statewide projects under authority from the 1902 Reclamation Act. The act explicitly authorizes subsidies to users of project water, through low interest rates, deferral of interest and principal payments, and cross-subsidization of water sales from other revenues, primarily electric power revenues. Of the approximately 40 MAF per year of water used in California, about one-sixth comes from the Bureau of Reclamation's CVP. The bureau's Colorado River project provides another one-eighth of the state's water supply.

The other major government wholesale water developer is the State of California, through the SWP. This project currently delivers about 2 MAF per year, intended to grow to 4.23 MAF by the end of the century. Unlike the CVP, the SWP is intended to be self-financing and without subsidy. A later section discusses how well this is achieved.

#### **LOCAL WATER DISTRICTS**

Interfacing between these wholesale water supply agencies and the eventual water user is a set of local water districts, totaling nearly 1000 throughout the state, which buy wholesale water from other agencies, develop their own water supplies (or some combination thereof), and sell or otherwise supply water to the eventual users of water within the state. Little is known about the actual behavior of these water districts either from published literature or from official reports.

Analysis of water district behavior is considerably hampered by lack of pertinent data. Particularly during the drought years of 1976-77, several ad hoc surveys of water district pricing and supplies were undertaken by the DWR, by the California Assembly Office of Research and DWR (jointly), by the office of the Governor of California, and by the Association of California Water Agencies. The data obtained in these surveys were typically rather specialized and not sufficiently broad to allow full analysis of water district behavior. Surveys of voting

behavior within water districts conducted by Goodall et al. [7] were similarly useful, but limited in scope.

To gain first-hand knowledge of water district behavior, we visited nearly 50 water agencies. The agencies were selected by size, location, customer type, agency type, and type of water source(s). Additionally, we used suggestions from agencies we had visited earlier to select later contacts, basing our choice on the reputations of the various agencies among their fellow water supply agencies. The following discussion presents a broad overview of our observations.

## **WATER DISTRICT FUNCTIONS**

The growth of California water agencies can be viewed as a legislative response to increasingly competitive demands being placed on the water supply of the state. By the turn of the century, water districts had been formed to protect the locals' rights to nearby water supplies.<sup>1</sup> Currently there are over 3000 water suppliers in the state [8], nearly 1000 being public water districts. About 900 of these public districts were formed under 40 general water district acts; the remainder were individually created by the Legislature by special acts.

Initially, water development proceeded through private companies. Over time, however, many private water companies, mutual water agencies, and individual water rights holders have given way to public agencies. These public agencies are empowered to secure water rights, allow federal and state contracting, receive tax-exempt financing, protect the water supply, obtain revenue from property taxes, back bonds with property taxes, condemn land, spread charges over all lands, and create eligibility for grants and loans. However, unlike private water companies, public districts are constrained by law from making a profit.

The powers and purposes of public water districts are contained in their enabling acts. These acts generally authorize water agencies to provide one or more of the following services: water supply, water distribution, domestic water treatment, sewage collection, sewage treatment, sewage disposal, flood control, storm drain maintenance, levee maintenance, canal maintenance, water recharge, water for recreational use, water reclamation, groundwater management, and electrical power generation and distribution.

Although water districts organized under a given general district act usually have the same powers, implementation is up to the specific district. Therefore some variability in activities is often observed. Special-act districts, on the other hand, are specifically legislated to provide discrete services and therefore the variability observed in their activities is not surprising. A characterization of several of the most important functions is given below.

## **SCOPE AND LEVEL OF OPERATION**

The services provided by the districts in our sample vary a great deal. The most critical determinant of agency type (which in large measure determines the services provided) is the way problems are identified. Once a group of people define

<sup>1</sup> Irrigation Act of 1897.



the water problem they want to address, the institutional form most appropriate usually becomes apparent. However, it is also true that a great deal of variation in activity exists even among the same district types. This seems to be the result of local interpretation of broad general powers to meet specific local needs. For example, a general powers statement in a district act is generally thought to provide a district with broad enough powers to take essentially any action necessary to meet the needs of its customers. One district might use the statement to legally justify owning and operating district wells. A comparable district, perhaps even in the same groundwater basin, might not interpret the general powers statement in such a fashion and in fact might not even monitor groundwater use. We encountered districts that had specific legal authority to levy a pump tax and were unaware of their ability to do so. (This leads to speculation that district actions are not determined solely by their legislative mandate.)

Additionally, we found that the level of sophistication of an agency (data gathered and analyzed, reports, entrepreneurial skill, etc.) was strongly related to the amount of water sold, the customer type, and the complexity of the agency's water system. For example, it would make little sense for an agency that was explicitly formed to contract for water not yet available to rent large offices and retain many staff members. Rather, such an agency would be prudent to keep costs down, perhaps even to operate out of a private home (which we did in fact observe).

In contrast, those agencies with large water supplies, demands, distribution systems, and revenues maintain a large and specialized staff to manage, operate, and plan the agency. Most work is done in-house and data and planning reports abound. Typically, these agencies are located in elaborate agency-owned buildings and have well-known entrepreneurs as managers.

Somewhere in between these two extremes are most water agencies (mutual water companies excluded). Typical agencies have a moderate staff size. They produce limited reports and use engineering and legal consultants sporadically. Most agencies make maximum use of existing data sources and gather their own data only when necessary.

## **INTERAGENCY CONTACTS**

Interagency contact (other than through professional meetings) is determined in large measure by an agency's resource requirements. If a given agency depends entirely on water within its own boundaries and does not expect demand to exceed supply, there is little incentive to interact with other agencies.

By the same token, districts that are unable to meet either current or projected demand with either current or projected supply often enter into cooperative agreements with other agencies (local, state, or federal) to meet their demand. While in such a case there might be great incentive for cooperation, districts often have to overcome built-in local distrust of "foreigners" becoming important factors in their water supply.

## **LOCAL DISTRICT CONTRACTING ABILITY**

The original impetus to form local water agencies was often to develop or

protect local water sources. Over the years, as the obvious local supplies were tapped and the demand exceeded the available supply, it became necessary to consider nonlocal supplies. This search for additional water has resulted in many contractual arrangements between local districts and the federal and/or state agencies capable of supplying water.

The ability of many general-act districts to contract with the United States stems from the 1917 Irrigation District Federal Cooperation Law.<sup>2</sup> Under this law, Irrigation Districts can call for an election to approve contracts and can levy assessments to meet their financial obligations resulting from the contract. Special-act districts also are generally able to contract with the federal government.

Although not always specified in district law, essentially all water districts are also able to contract with the state. And although the per-acre-foot cost of water is generally higher in state contracts than when purchased from the Bureau of Reclamation, there is no 160 acre limitation attached to the use of the water, unlike the Bureau of Reclamation water. (For further discussion of the 160 acre limitation, see Sec. VIII.)

It is interesting to note that in the last 40 years, since the increase in large-scale nonlocal projects, many water agencies have been specifically formed to contract for water.

## VOTING RIGHTS

Water districts are generally formed on petition of voters or landowners to local county authorities. On receipt of a sufficiently large petition, the county officials hold an election, which will lead to formation of a water district if the voters in the election approve the proposal. How voting rights are assigned varies considerably among types of districts that can be formed. Three patterns are typical: one person, one vote; one acre, one vote; or \$1 of assessed value, one vote. The same basis of voting rights may be used for questions of district formation and actual voting within a water district, or a different basis of voting may be used at formation and during operations. The procedure established in each district is related to the district type and determines the district power base. Examples may be drawn from the two most prominent forms of water district within the state, the California Water District and the Irrigation District.

In a proposed California Water District, the petitioners must represent at least half of the land within the proposed district (or half of the assessed value, if the lands are not contiguous), and voting on the formation of the district is based upon assessed valuation. If the district is formed, voting rights within the district are established on the same basis.

In Irrigation Districts, the original petition must be signed either by 500 electors or by owners of land representing over half of the assessed value of land within the proposed district. If the district is formed, the pattern for voting on district activities is one person, one vote for residents within the district.

The choice of district type can be made with a particular purpose in mind by the persons proposing the district. For example, a few large landowners can pro-

<sup>2</sup> Sections 23175-23302 of the Water Code.

pose, elect, and then control a California Water District themselves, since voting is based on acreage and assessed valuation. There are examples of districts where a single landowner controls the water district [7].

The motives surrounding choices of water district types may be complex, because of the various opportunities to form coalitions among landowners, residents of the proposed district, and other affected parties. These same coalitions can control the operating decisions of the water district and the choices about raising revenue by taxation or water tolls. The basis for voting rights within prominent forms of water districts in California is shown in Table 1.

## REVENUE SOURCES

Water agencies have many sources of revenue. These sources include water rates, water charges, taxes (ad valorem on all property or land only), assessments (on land receiving benefit from water), pump charges (pump tax), power sales, sewer charges, sale of water rights, and recreational fees. However, water agencies principally utilize water tolls and taxes and assessments to raise revenue.

## Municipal Water Departments

Municipal water departments generally use water rates or fees to finance operations. These rates must be reasonable and cannot vary within class of service (i.e., the same rate is applied to all residential users). Cities may levy taxes to finance water facilities, however, such taxes usually cannot exceed \$1 for each \$100 of assessed valuation.

Table 1  
WATER DISTRICT VOTING BASIS

Type of District	No. of Districts	Voting Pattern		
		One Member, One Vote	One Acre, One Vote	\$ of Assessment, One Vote
<b>Agricultural Districts</b>				
Irrigation	103	X		
California Water	160			X(\$1)
Water Storage	8			X(\$100)
Water Conservation	11		X	
<b>Municipal and Industrial Districts</b>				
Municipal Utility	3	X		
County Water	189	X		
County Waterworks	88	X		
Community Service	122	X		
<b>Water Wholesalers</b>				
Metropolitan Water District	1	X		
Water Agency or Authority	27	X		
Municipal Water	46	X		

## Private and Mutual Water Companies

Private or mutual water companies, since they cannot tax, obtain revenue from water rates or tolls. Mutual water companies cannot make a profit and private water companies are restricted by the Public Utilities Commission to a limited profit percentage. Water from mutual water companies is sold only to its owner-shareholders, and these shares can be sold to any party capable of being served by the water distribution system of the company.

## Water Districts

Most major water districts in California (see Table 2) have the power to collect water charges or fees and the power to tax or levy assessments. The mix of taxes and water rates that individual districts impose varies from almost 100 percent taxes to almost 100 percent water rates, with all combinations in between. Table 2 shows major revenue sources and average percentage of total revenue derived from these sources for a subset of water districts.

Water districts that have the option of raising revenue from water sales or taxes or both choose varying policies. Statewide, the ratio of water sales revenue to tax revenue is about 2 to 1. We observed three major water district types that on average have revenue policies significantly different from the majority. Both Water Storage Districts and Municipal Utility Districts raise almost three-quarters of their revenue on average from water sales, and Water Conservation Districts raise almost two-thirds of their revenue on average from taxes and assessments.

Table 2

### SELECTED WATER DISTRICTS REVENUES AND REVENUE SOURCES

Type of District	No. of Districts	Source of Revenue (%)			Total Revenue (\$ M)
		Water Charges and Fees	Taxes and Assessments	Other	
<b>Agricultural Districts</b>					
Irrigation	103	57	26	17	79.6
California Water	160	57	22	21	56.9
Water Storage	8	78	10	12	24.7
Water Conservation	11	27	62	11	5.1
<b>Municipal and Industrial Districts</b>					
Municipal Utility	3	72	13	15	42.2
County Water	189	56	18	26	101.8
County Waterworks	88	55	27	18	14.6
Community Service	122	56	18	26	11.9
<b>Water Wholesalers</b>					
Metropolitan Water District	1	52	35	13	154.5
Water Agency or Authority	27	46	21	33	106.1
Municipal Water	46	61	21	18	126.9
Subtotal	758				724.3
Statewide	921	55	24	21	760

SOURCE: Ref. 10.

Revenue mix policies also vary within district types. For example, we found individual Irrigation Districts that receive a large majority of their water operations revenue from either water charges, acreage-crop assessments, or taxes.

**Water Rates.** A few water districts have no provision or power to charge for water (e.g., Drainage Districts, Flood Control, and Water Conservation Districts). However, Table 3 shows that a majority of major water district types have water charges as well as taxes.

Given an agency's mix of revenue from taxes and commodity charges, rate schedules differ considerably. At the extreme end of the spectrum are those agencies that recoup all costs from taxes and charge nothing for water. Following closely are agencies that have a fixed charge structure that is independent of actual water use. Usually the amount of the fixed charge varies according to type of user. We also found agencies that vary water charges with land size and land use pattern. The cost of metering is the current stated rationale for using these fixed charge and per-acre rate schedules. We found water districts that more recently viewed water rates as a management tool and hence, to promote equity or conservation, are shifting away from taxes. The effects of Proposition 13 in 1978 may accelerate this trend.

Some agencies use a decreasing block rate structure with different schedules for different classes of users (i.e., agricultural, industrial, commercial, and residential). Agencies also used one block rate structures with rates varying with type of water users. Usually these agencies with commodity charges also have administrative or hook-up charges that are independent of water usage.

Lastly, a few water agencies have shifted to increasing block rate structures. In fact there appears to be a trend, particularly among municipal agencies, toward increasing block rate schedules or at least away from decreasing block rate structures [9]. Some agencies are even planning establishment of zones to more accurately recover the cost of service (i.e., by charging higher rates to deliver water to higher elevations).

Today, water rates in California vary tremendously. Some users pay no direct charge for water, whereas others pay over \$175 per acre-foot. The average water charge for agricultural users appears to be near \$5 to \$6 per acre-foot, as derived from data in the California State Controller's annual report on *Financial Transactions Concerning Special Districts of California* [10].

**Taxation.** Virtually all water districts in California have the power to tax or levy assessments. However, some district acts specify the levying of assessments if revenues are insufficient.

Depending upon the district type, assessments are levied on (1) land, based on benefit received, (2) all land within the district, or (3) all land and improvements within the district. These last two assessment types are considered ad valorem taxes. Some districts have a choice of assessment basis. For example, Water Conservation Districts under the 1931 Act may assess land and improvements or land alone. Additionally, many districts can establish zones of benefit. Hence, assessments can vary within a water district's boundaries.

Some district acts place restrictions on assessment rates and others do not. For example, County Water Districts can impose unlimited annual ad valorem assessment on all property, whereas Irrigation Districts have a limit of 4 percent of assessed value of land only, unless changed by majority vote.

Table 3

## WATER DISTRICT POWERS AND FUNCTIONS

Function	One Extreme	Typical	Other Extreme
Voting rights	One member, one vote	One acre, one vote	\$1 assessed value, one vote
Revenue sources:			
Pricing	No water toll	Half of revenue from water toll	All revenue from water toll to cover costs
Taxation	No taxes used	One-quarter of revenue from taxes	All revenue from taxes to cover costs
Assessment basis	According to benefits	Ad valorem on all land in district	Ad valorem on all land and improvements in district
Debt service	No provision	General bonds on two-thirds vote, revenue bonds on majority vote	General or revenue bonds on majority vote
Groundwater management	No groundwater functions	Monitor and replenish groundwater	Authorized to meter and tax groundwater use and recharge basins
Surface water development	Not authorized	Authorized, but only limited use	All water in district developed by the district itself
Receipt of federal subsidized water allowed	No	Yes	Yes
Water sales outside district	Illegal	Legal only for surplus water	Legal always

**Debt Service.** District acts typically provide for debt service. Depending upon the act, most districts can issue one or more of the following: general obligation bonds, revenue bonds, refunding bonds, warrants, direct assessment warrants, and notes.

Criteria for issuance varies by district and debt type and includes: four-fifths, two-thirds, or 60 percent or majority voter approval; or four-fifths or majority board of directors approval; or no approval.

Most districts can issue general obligation bonds subject to two-thirds voter approval and revenue bonds subject to majority voter approval.

In addition, district acts limit the maturity period and/or amount of debt. These limits vary by district and debt type from no maturity period limit to a 1 to 50 year limit, and from no maximum debt amount to a fixed percentage of assessed value or income.

## **GROUNDWATER MANAGEMENT**

Water agency participation in groundwater management ranges from none to one or more of the following functions: well monitoring, groundwater replenishment (spreading, sinking), well metering, pump tax (pump assessment, groundwater charge or toll), district ownership and pumping of wells, and underground water storage.

Of course, agencies that do not overlie a groundwater basin have no power or control of groundwater supplies. Those agencies that do overlie groundwater basins have developed diverse management styles. Table 4 provides a summary of these powers by type of district. A more extended discussion is found in Jaquette and Moore [2].

The nature of an agency's groundwater management operation stems from both the needs of the area and the agency's powers. For example, several areas with severe groundwater overdraft problems formed special-act districts, which either overlay or consolidated existing agencies (Orange County, Santa Clara County). These special districts were explicitly given the power to replenish the basin and levy a pump tax. We also found areas with groundwater problems that used existing district organizations and either selected the district type most able to meet their needs, changed district type as needs changed, changed their district type's powers, or broadly interpreted existing district powers.

Many agencies today monitor groundwater levels and participate in groundwater replenishment. Very few agencies meter pumping or levy pump taxes.

## **SURFACE WATER DEVELOPMENT**

Over 35 percent of California's dependable water supply—over half of all surface water—is developed by local sources. All but one general district act and most special district acts empower the agencies to store and distribute this water. Less frequently, district acts contain the specific authority to build dams. Implicit in local surface water development is local ownership and control of water rights. When a water district holds water rights, court decisions have interpreted this as a trustee

relationship, where the equity interest in the water right is held for the local landowners.

Early in California's history, water rights were available at the cost of development on a first-in-time first-in-right basis. With California's arid climate, a dependable water supply made the difference between valuable irrigated cropland and less valuable pastures. Hence, local water supply developed early and expanded rapidly. By the 1930s most of the economical reservoir sites had been developed and federal and state agencies had begun to take over California surface water development. Therefore, local surface development has not expanded greatly since then.

Meanwhile, local agencies control a large segment of developed water supply, which in many cases is paid for and thus available at little or no cost. Additionally, some of these agencies find it necessary to contract for federal and state water, often at a higher cost than local water, to meet their demands. Hence, water agencies deliver a mixture of locally developed and federal- or state-developed water.

Table 4

## EXPLICIT POWERS OF WATER DISTRICTS OVERLYING GROUNDWATER BASINS

Type of District	Spread, Sink, Replenish, or Conserve Groundwater	Store Groundwater	Levy Groundwater Charges, Assessments, Tolls, Taxes	Obtain Groundwater
Agricultural Districts				
Irrigation	x			
California Water			x <sup>a</sup>	
Water Storage			x	
Water Conservation: 1931	x	x	x	x
1927	x			x <sup>b</sup>
Municipal and Industrial Districts				
Municipal Utility				
County Water	x			
County Waterworks	x			
Community Service				x
Water Wholesalers				
Metropolitan Water District				
Water Agency or Authority	x	x <sup>c</sup>	x <sup>c</sup>	
Municipal Water	x			

<sup>a</sup>Not all districts.

<sup>b</sup>Only if done before 1 October 1953.

<sup>c</sup>Kern County Water Agency only.



## IV. MECHANISMS TO PROMOTE EFFICIENT WATER USE

Earlier sections of this report have described the general legal system under which water supplies are developed and used in California (Sec. II), and the major institutional arrangements that have emerged to undertake this water supply function (Sec. III). We now turn to the central question of this report, namely, which mechanisms would promote efficient use of water.

The primary allocative system for water use in California is a quasi-market, with initial rights to use that water granted by the state (see Sec. II for summary). However, the market part of the current system appears to fail on several grounds in serving the functions of a true market, because of legal and institutional restrictions on market-like activities. That is, despite the general reliance on market forces (if anything) for efficient distribution of water within California, neither of the arrangements stated above is being applied fully to achieve efficient water use in the state. Since there are only limited forces—legal, economic, or institutional—that could lead to efficient use in a general sense, we must consider modifications of the present system to achieve efficient use of water.

Three paths appear available that could lead to efficient use, two of which improve the market functioning in the area of water use. It may be that no significant improvement can be made over the current system, or that potential improvements come only at a high risk of disrupting existing conditions. The burden must be to prove that change is desirable; we will attempt to establish that our proposed changes meet this test.

The first possible approach is to modify—by statute if necessary—the water pricing rules of local water districts and other agencies to achieve marginal cost pricing. This concept is attractive, and indeed, is espoused by many analysts observing the water industry.

The National Water Commission has recommended that water charges be based on "(a) the costs that users impose upon the system, and (b) the costs imposed on society from the loss of the use of the resource for other purposes." These correspond to the concepts of "resources cost" and "opportunity cost" defined above. To implement this, they recommend, where legally feasible, the "imposing of withdrawal charges on self-suppliers of water diverting from surface and ground-water sources as a means of improving efficiency in the use of water" [11].

A state-administered tax on water use could achieve efficient pricing in concept but such a tax would create two important problems. First, for the taxation to truly lead to efficient water use, the state agency administering the tax would have to know the true social marginal costs of supplying water to each agency and to establish a tax equal to the difference of that marginal cost and the price as perceived by the water users. Under such a system, for example, the incentives to overuse water present in the subsidized projects of the Bureau of Reclamation could be offset. However, the knowledge required to administer a true efficiency-producing tax would nearly replicate that necessary for a complete central planning system. The second point is that use of such a tax would heavily redistribute wealth away from current water users toward the state as a whole. Thus such a

plan is likely to meet heavy political opposition from existing water users and their representative agencies.

Hirshleifer, DeHaven, and Milliman, in their study of water use throughout the country, urge that marginal cost pricing be adopted [12]. Bain, Caves, and Margolis, in their study of Northern California water, urge that prices be set at marginal costs [13]. The Department of Water Resources (DWR), the state's primary administrative agency in water resources, has typically taken a less specific view toward pricing as an efficiency-inducing tool. In their study of the California drought, for example, they state that water prices should be set to recover system operating costs, be equitable, and should discourage waste. They argue, however, that "many agricultural water users already are paying the full cost. These include groundwater users and members of agricultural water districts that have developed their own surface supplies" [14]. Unfortunately, this is incorrect for groundwater use, since in nearly every case costs imposed on other pumpers are not paid by each individual pumper. The statement is correct for local water districts with their own surface supplies only in a very limited context, i.e., considering the water district as an isolated society. Even then, it may be possible for water prices to differ from the true economic cost of the water, as will be discussed in the next section.

The second option available to enhance market operations is to enhance the transfers of water, particularly across water district lines [15]. We will review the operations of water districts within the state to study the possibility of undertaking either or both of these activities at the water district level. Unfortunately, both marginal cost pricing within the district and sales of water outside the district are likely to present problems that cannot be solved within the context of existing water district organizations. We will suggest that modifications of water district law could present a solution that could improve efficiency of water use and that also appears feasible technically and politically. We will present this proposal after our discussion of the possibilities for marginal cost pricing and transfers of water at the water district level.

Alternative mechanisms exist, which in concept could also achieve efficient use of water. For example, a broadly based central planning operation could in concept achieve an efficient, nonmarket-oriented allocation of water. This would be accomplished, for example, by specifying that certain amounts of water be used in various types of use, specifying which lands were to be used in agricultural production, specifying what types of water using devices were to be installed in homes, or specifying the types of ground cover in domestic lawns. The current water "market" is in fact a mix of a quasi-market approach and a central planning approach, with the SWRCB serving as the "planner" in partly determining what uses of water are "reasonable and beneficial," and what uses are to be excluded under those general criteria. Although the SWRCB actually rules on only a few uses of water, the precedents set—like legal precedents—will in part shape the nature of water use within the state.

A major shift to central planning for water use decisions appears to us to require far too much regulation of water using activity to be feasible. Such regulation could possibly be challenged on legal and constitutional grounds. Thus we reject a widespread central planning approach as infeasible and focus on the opportunities for improving market functioning.

## MARGINAL COST PRICING IN WATER DISTRICTS

Water districts are constrained in general by their inability to show accounting profits in the long run. While there may be profits or losses on a year-to-year basis, there is no mechanism available to distribute long-run profit accumulations, unlike the typical business organization in the United States, where profits are distributed to the owners of the firm. Indeed, there are no owners of a water district, for it is a public agency. It is accountable to its public, but it is not owned.

It is commonly argued that pricing goods or commodities at their marginal cost will lead to efficient use of that good or commodity. The concept of the appropriate marginal cost can be elusive, particularly in the context of local water districts. The distinction between a marginal resource cost and an opportunity cost is important. If the water supply cannot be extended beyond a specific amount, even though its resource cost is only a given amount per unit (e.g., a cost "p"), the value of that water may be considerably higher to the water using community than that per-unit cost. The value of additional water supplies in such a case is the opportunity cost of using any of the water within the district. If water supplies can be expanded, and users all pay the marginal resource cost for that water, then resource marginal costs and opportunity costs will be equal.

Several typical situations for water districts in California are indicated in Figs. 1a - 1e. In Fig. 1a, a groundwater supply (G) is indicated to be available (at increasing marginal costs as the rate of extraction increases in a given time period), and an unlimited surface supply (S) is available at a constant cost of  $p_1$  per unit. In that situation, pumping will be used to the point ( $q_1$ ) where surface imports are cheaper than marginal pumping costs, and the rest of demand will be met by the surface supply. The marginal cost of surface water ( $p^*$ ) is  $p_1$ , and an amount ( $q_2 - q_1$ ) is imported from the surface source.

In Fig. 1b, two surface sources are indicated, one cheaper ( $p_1$ ), but fixed in amount available, and the other more expensive, but freely available at price  $p_2$ . Here the marginal cost  $p^*$  is equal to the more expensive surface price  $p_2$ .

A third case, typical of many agricultural districts in California, is shown in Fig. 1c. Groundwater is available to augment a fixed quantity surface supply. The fixed surface supply ( $q_1 - q_0$ ) is typically available either from the local district's own water rights water, or as an entitlement from the SWP or a contract from the CVP. The effective marginal supply price to the district is at first the price of the groundwater source (up to  $q_0$ ), then it is the surface delivery price  $p_1$  up to  $q_1$ , and then it becomes the groundwater pumping cost again. The equilibrium marginal cost,  $p^*$ , is shown as the point where the demand curve intersects the groundwater pumping cost curve (as shifted).

The special case of a limited fixed supply of surface water as the only water source is portrayed in Fig. 1d. Here no groundwater is assumed available (or if it is available, only at costs too high to be of interest to the water users). Even if water is priced to the district at  $p_1$  per unit, the marginal cost is  $p^*$ , the point where the demand curve intersects the quantity available. The marginal cost is completely demand-determined in such cases and is independent of the price charged for the surface water so long as that price is lower than  $p^*$ . This is a specific example of what is meant by "opportunity costs." In fact, the expansion of the "fixed" quantity available from  $q_0$  to  $q_1$  (as in Fig. 1e) will cause the true marginal cost (opportunity cost) to fall from  $p^*$  to  $p^{**}$ .

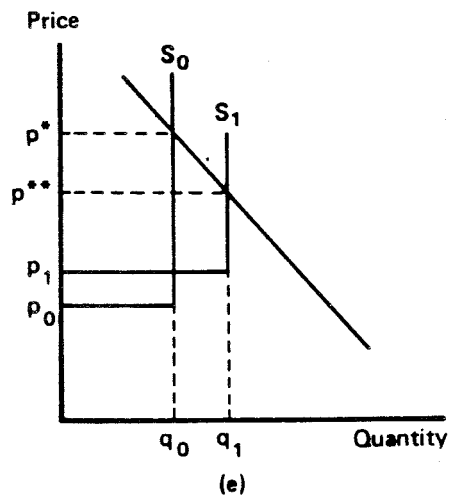
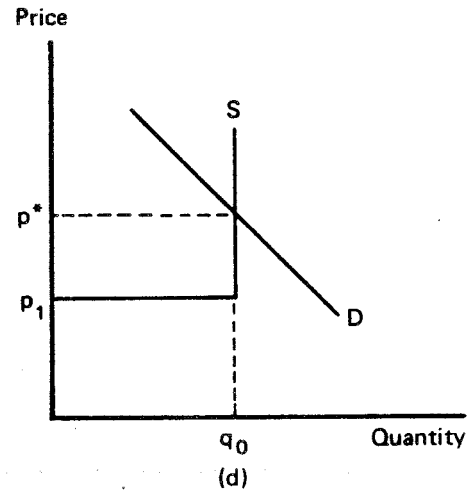
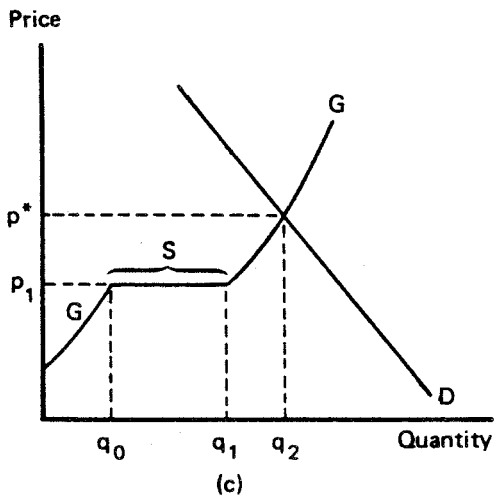
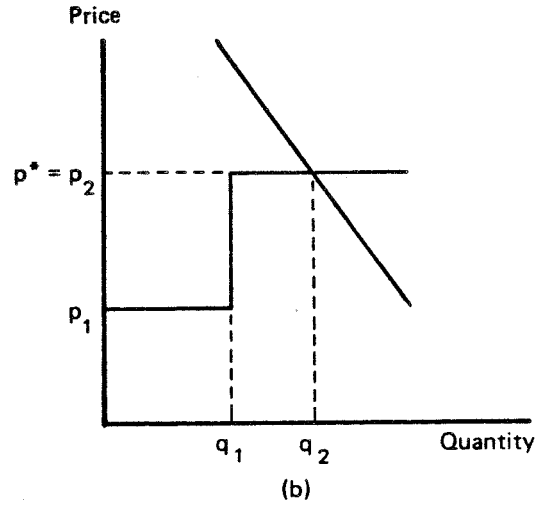
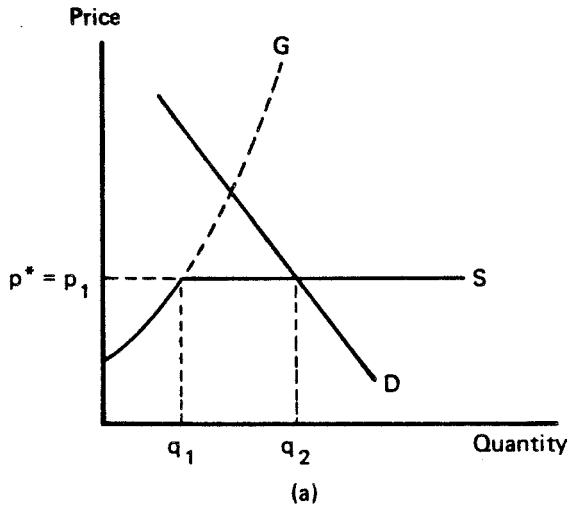


Fig. 1 — Examples of the true marginal costs of water supply

In all of these situations except those with unlimited availability of surface water (the first two cases), the marginal costs of water within the water district are unrelated to the surface delivery price. In circumstances where groundwater is available, knowledge of groundwater pumping costs may suffice to learn the marginal costs of water within the water district, but often, the true economic marginal cost (opportunity cost) will be unknowable from readily observed data. (The situations portrayed in Figs. 1d and 1e are examples of this.)

Those admonishing water districts to price at marginal costs have tended to overlook the point that, where surface supplies are limited, the true marginal cost—the opportunity cost—is not necessarily observable to the water district. More important, even in cases where such a cost is observable, pricing at marginal cost would lead the water district to earn systematic (and sometimes considerable) profits. The water district, by its form and structure, really has very little it can do with such profits, particularly if they accrue systematically through time. Probably the most typical case is where the water district has multiple sources of water, e.g., some water rights within the district and some imported surface supplies purchased from an entity such as the SWP or the CVP. Even if the more expensive source is available in sufficient quantities to meet all demand within the district, the sales of both the imported surface water and the water rights water within the district at the “marginal cost”—say, the SWP cost—would likely lead to substantial profits being accrued by the water district.

An example may help to clarify this discussion. Suppose the district has 10,000 acre-feet of water rights water in a “normal” year and purchases SWP water to meet remaining demand. At a SWP price of \$25/acre-foot, and a cost of diverting and delivering the water rights water of \$2/acre-foot, sale of all the water rights water at \$25/acre-foot would lead the district to make profits of \$230,000 per year. Even the most active and enthusiastic development program planners within the water district may soon find themselves unable to expend profits at this rate.

The water district instead is nearly certain to price all the water sold within the district at *average* cost. Figure 2 portrays the average cost curve of a water district with a fixed quantity of water rights water and an entitlement to purchase a large quantity of SWP water at a higher cost per unit than its costs for delivering water rights water. The average cost curve shown in this figure provides the amount that just covers the weighted average costs of the water rights water and the SWP water purchased. This water district under current practice would ask for  $(q_1 - q_0)$  of SWP entitlement (at  $p_2$  per acre-foot), and would charge  $\bar{p}$  per acre-foot for all water in the district—both their water rights water and the SWP water. Pricing at marginal cost would lead the district to sell all water at a price of  $p_2$  per unit, and only a total of  $q_2$  would be chosen by water users in the district. However, the district would then make a profit of  $(p_2 - p_1) \times q_0$ . (This is the \$230,000 in the previous example.)

We might point out here that the waste—the measure of inefficiency arising from the average cost pricing—is the shaded area in Fig. 2. This is “waste” because it costs more to society to capture, divert, and deliver the water ( $p_2$  per unit) than water is worth to the consumer for every amount used above  $q_2$ .

We should also point out another important fact: The profit arising from use of this water is already in the hands of the water users. The profit arises because of the presence of some lower-cost water (here, water rights water). Currently,

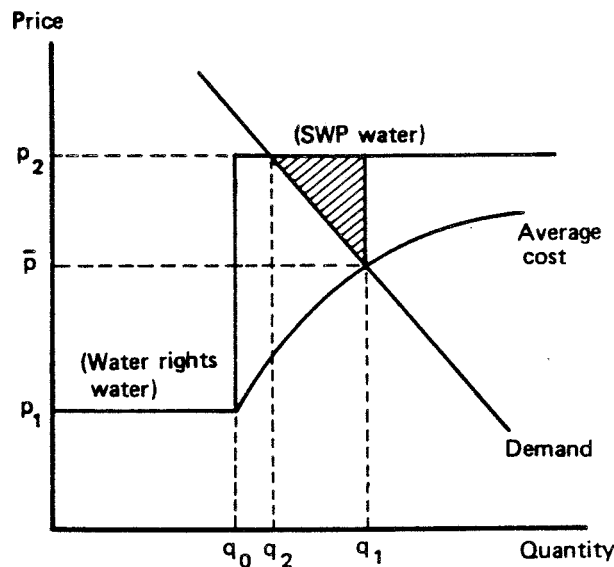


Fig. 2 — Water district pricing with two sources of water

water districts distribute that profit to the water users in the form of subsidies to the higher-priced surface water. It is the form of distribution of that profit—average cost pricing of water—that is in part leading to the inefficiency of water use in California. It is important to realize that neither passage of laws nor specifications of regulations will alter the presence of that profit. It is there, and must be dealt with in some fashion.

Several choices are available to the water district under current law and practice to distribute actual or potential profit in other ways than through average cost pricing. Some of these could make water use considerably more efficient, in concept, than under current practice. These mechanisms are (a) modification of property taxes, (b) use of profits for internal capital improvement or retirement of debt, or (c) use of an increasing block pricing mechanism where some fixed amount of water is sold at one lower price, and all remaining units are sold at the higher marginal cost. These mechanisms are next analyzed.

### Property Taxes

The desirability of property tax cuts within the directorship of a local water district is likely to be small. To understand why this is the case, one must understand how the water districts are formed and how directors are elected, as was summarized in Sec. III. What is clear is that majority coalitions can be formed within a water district that have the *potential* for using the district to the benefit of the majority at the expense of the minority. This potential arises primarily through taxation. For example, within the California Water District Act, a single large landowning corporation can form a California Water District including surrounding lands, can elect a board of directors representing the interests of that single corporation, and can levy taxes on all lands within the district boundaries

to pay for water delivery to (possibly) a subset of that land. A combination of several (or many) landowners within a geographic area has the same opportunity. So long as there are other lands available nearby that will use less water per acre in general than the lands of the majority, this taxation apparatus can be used to benefit the majority of landowners. The current law prohibits the extreme case of taxation of lands that are not amenable to irrigation.

In another example, under the 1927 Water Conservation District Act, land ownership (assessed value) voting establishes both a district and its board of directors, and assessments can be levied on both land and improvements. Such assessment powers may make it particularly attractive to include residential areas that use less water within the boundaries of the water district. The uses to which this broad taxation power is put are indeed varied. Unfortunately, we were unable to find consistent data encompassing land ownership patterns, district voting patterns, and economic conditions of land supply and demand, or other relevant data, to undertake a systematic analysis of how taxation is applied. The theoretical framework for such an analysis has been established, showing in general what would be required to reach a full understanding of how such powers are used [16]. Here we can only catalog some of the examples we have found.

Some water districts use almost no taxation. Others rely heavily or entirely on taxation. The average for the state is that one-quarter of all revenue is derived from property taxes or assessments [9]. This ranges from an average of 10 percent in Water Storage Districts (there are 10 throughout the state) to over 60 percent in Water Conservation Districts. But this is only a portion of the relevant information. Particularly for those districts with large tax receipts (as a function of total budget), there is the question of relationship between tax paid and water used. At an extreme (and we would in no way indicate that this is "typical"), we found one water district that collected 80 percent of its tax payments from persons getting 20 percent of the water, and conversely. Another prominent example of such tax-based redistribution is in the Metropolitan Water District of Southern California, where taxes have over recent years ranged near 40 percent of total revenues, and where a wide disparity exists between tax payments and water use. The City of Los Angeles has been the primary "minority interest," paying some four times the taxes in recent years (by share) as it received in water deliveries (by share). The Counties of San Diego, Riverside, and Orange have been in general the beneficiaries on the reverse side of this ledger [17].

Of what relevance is this taxation to issues of water use efficiency? Two things are clear. The first is that when tax receipts, from whatever their source, are used to reduce the price of water, this will tend toward an inefficient overuse of water. Second, to the extent that there is a majority/minority redistribution being achieved within the district through taxation power, there will likely be a considerable reluctance to reduce such taxation as a way of distributing any profits from water sales or profits arising from full marginal cost pricing. To make such a tax-based distribution would likely fly in the face of earlier uses of the tax authority.

Taxation to pay for part of a system of water supply is one example of a general set of pricing arrangements known as "two-part tariffs." The idea of such pricing policies is to collect any fixed costs of a supply system in a way unrelated to actual water use, and to charge the short-run marginal cost of the system as the variable part of the price. Such systems are desirable when the average cost of supply

decreases with additional output, or in general where average cost exceeds marginal cost. (In such a case, pricing at marginal cost will not return sufficient revenues to pay for the resources used to supply the good.) If two-part tariffs are not feasible, the "second-best" solution typically involves prices *above* marginal costs to cover what would otherwise be operating deficits [18]. Such is not the case in many water supply systems within the state. For example, within the SWP, average costs increase substantially as the system capacity is increased from its current level (about 2 MAF per year) to the proposed 4.2 MAF. The same propositions hold for the CVP, the Metropolitan Water District of Southern California, and virtually every groundwater pumping operation within the state.

The notion that average costs are decreasing with output is relevant only in the short run, i.e., when capital is taken to be fixed. In such a situation, the price that leads to the greatest social gains is the price that equals the short-run marginal cost. However, when constraints on the output appear, the short-run marginal cost can rise rapidly and may become very large (see Fig. 1d for an example of such a case). With such capacity constraints, short-run marginal cost is not the same thing as "variable costs" measured by accountants. In fact, when output is constrained, the short-run marginal cost becomes the opportunity cost of the water—its value in the best alternative use. When capital is a constraining feature of a system's output, then conventional analysis shows that users of that system should in fact pay a price that can recover the entire long-run cost of operations, including capital [19].

Given these issues, one can rightly ask under what conditions continued use of taxation by water districts is justified, and when should it be curtailed. Efficiency considerations suggest that taxation use be reduced or eliminated in circumstances when marginal cost pricing would in fact produce sufficient revenues to meet total costs of the water districts. In circumstances where long-run average costs decline with output, of course, taxation continues to be justified. The extent to which efficiency of water use could be increased by limiting use of property taxes and increasing reliance on water tolls is an empirical issue that cannot be answered with available data. However, particularly in circumstances where average costs are not declining with output, a case can certainly be made for reevaluating the use of taxes and reduced reliance on taxes when marginal cost pricing would in fact produce revenues sufficient to reduce or eliminate those taxes.

We finally note that numerous water districts have in the past issued general obligation bonds, which depend ultimately upon taxation authority for support of the bond. Elimination of taxation for such districts is almost certainly infeasible at present, and we do not recommend that this be undertaken. Similarly, contracts with external agencies, for example the SWP, often require taxation authority to be used if insufficient funds are obtained from water sales or other revenue sources (see SWP contract, article 34a) [20]. Such a clause would probably have to be maintained, particularly for water districts that have not yet begun to receive water deliveries but that are still obligated to make payments for project facilities. However, use of water tolls is permissible as the entire source of revenue, and movement in that direction is certainly desirable, in many cases.

### **Internal Financing of Construction and Renovation and Debt Retirement**

The few water districts that now engage in water sales at the district level almost always use the profits from such sales either to refurbish or expand the



water conservation or distribution facilities of the districts or to retire debt from previous outlays. The effects of such operations on efficiency of water use can be mixed. There is no clear indication from either theory or evidence on whether this is to be considered generically desirable or undesirable. On one hand, activities such as lining of canals and ditches will save water, thus reducing the district's demands on external water supplies. The test of efficiency is whether the resources used for such activities produce enough water savings to compensate for the cost. The measure of value of the water in such a calculation should be the social value, i.e., what the water could be valued at if sold in a free market, and this may well be higher than the accounting cost facing the water district. (For example, if the district receives Bureau of Reclamation water under its considerable subsidies, the true social opportunity cost of the water is much higher than the price charged by the bureau.) On the other hand, if the district has no other uses for the profits from water sales, it may be compelled to use them in activities that—at least on the margin—have little or no social value. Such activities might be termed “gold plating” of district facilities. There is no way to determine in advance whether such activities will be socially desirable or undesirable, and hence we can suggest no obvious policy prescription concerning such uses.

The alternative of retiring debt from previous construction or renovation activities is also available to the water district. Typically, such a decision would be accompanied by a reduction of taxation or assessments, if such were being used for debt servicing. This would raise the general issues of choice of tax levels discussed previously.

It is clear, however, from conversations with water district managers, that they really have few incentives to sell water at the district level under current law unless they have capital improvement or expansion projects on which to use profits derived from water sales. Some district managers have simply reported to us that they would not make external sales they are now planning to begin if they did not have capital projects on which to spend the money.

## **EFFICIENCY-INDUCING PRICING SCHEMES**

Mechanisms exist with which water districts can disburse profits from operations, while minimizing distortions of correct incentives for water use. One mechanism is increasing block pricing. If correctly established, increasing block pricing has the potential to introduce efficient water use decisions by most or all water using parties, and to maintain the zero-profit restriction of the district. In practice, unfortunately, two hazards arise that make it unlikely to be a useful tool in many agricultural water districts, but its use within residential water districts or within residential customer sections of agricultural water districts can be very valuable.

The idea of increasing block pricing is to issue a specific amount of water to each user for some low price—possibly free—and then to charge him the full marginal cost for all subsequent water used. The low block is (hopefully) designed such that all of the accounting profits of the water district are fully distributed through making available this low-priced water. Efficiency criteria are maintained by keeping water priced at full cost for any additional consumption. The first problem that arises is when there are large variations in consumption by different customers of

the water district. If the low-priced block must extend to a fairly large quantity of water to distribute fully the profits of the district, it may be the case that some or many of the water users within the district face the reduced price for water use. Their water consumption decisions will not be optimal from a social point of view. This will most likely arise when there are large differences in the sizes of farms served by a water district. Increasing block pricing is not a wholly useful tool to apply in such situations, especially when there are large quantities of water within the district available at a lower cost than the remainder of the water.

The second problem is a political one. Under average cost pricing arrangements currently in practice, the distribution of profits on cheap water is roughly proportional to farm size—profits are literally proportional to each farm's water use.<sup>1</sup> If a block pricing mechanism is established, large farms may find their share of those profits reduced, possibly substantially, and they will not view such a pricing scheme as desirable.

An alternative proposal for increasing block pricing would solve this problem of varying scale of farming operations, but could potentially lead to a different type of inefficiency. If water is distributed in an increasing block that is based on per-acre water use, then it is much more feasible to establish a block rate structure that would lead to full distribution of profits of the water district, and yet retain full marginal cost pricing for added units of water used. This pricing structure is common among mutual water companies in California, which also face zero-profit constraints but have incentives to price water to achieve efficient allocation [21]. However, by pricing the water on a per-acre basis, there is a subsidy to bringing land into agricultural production that would not otherwise exist. For example, if water is priced within the district at \$0 for the first 2 acre-feet per acre, and then priced at a marginal cost of, say, \$25 per acre-foot for subsequent use, there is an implicit subsidy of \$50 per acre per year brought into agricultural production. Put differently, to expand his share of the profits of the district, each farmer would attempt to expand the amount of farmland in production, and some land would be farmed that was actually inefficient in a subsidy-free market equilibrium. If every farmer was able to so expand his land, the extent of the price reduction on the first 2 acre-feet of water in this example would have to be reduced, and each farmer would end up with about the same distribution of the profits on low-cost water as before. The only difference would be that there would be inefficient land in production and too much water used in general because of extension of lands being farmed. The extent to which this is an important problem depends both on the amount of water distributed in the low-priced block (i.e., the amount of district profits to be distributed) and the possibilities for expanding land for irrigation. It may well be that conditions permit a per-acre block pricing structure without introducing a serious distortion, but this would have to be decided locally with pertinent facts and judgment in individual applications.

A third difficulty with increasing block pricing arises in circumstances where it would be desirable for a farmer to reduce water consumption—in total or per acre—below the cutoff level for the low-cost block of water (2 acre-feet per acre in the above example). The farmer lacks the correct incentive to do so, even if others may be willing to pay enough for the water to make it worth the farmers' efforts

<sup>1</sup> We are mainly discussing farming activity, since that accounts for 85 percent of surface water used in the state.

in other circumstances. For water use amounts in the range below the shift to the highest price level, the farmer faces the wrong incentives. He saves nothing by reducing his water use further (e.g., by staying out of farming for a year), because the marginal cost to him is zero, but he forgoes his share of the district's profits on low-cost water, since those profits are distributed on the basis of using the first units of water allocated to him.

Fourth, for a district with all of its water supply arising from district-owned facilities, the lack of an external water market may make increasing block pricing still incorrect from a social view. Suppose a district has a dam and facilities that can produce water for a current accounting cost of \$1 per acre-foot, as would be the case, for example, with a dam that is essentially paid off, and a water distribution system that is in good condition. Even pricing at full marginal cost to the water district would lead to a price of \$1 per acre-foot, if the district supplied water entirely internally. (This is an extreme example, but it carries through to much broader circumstances.) Alternative uses of that water outside of the district may be worth \$20 per acre-foot, but there is no incentive for water users within the district to reduce their water use and make it available to those external uses. The district can literally price at its own marginal cost, and still be acting incorrectly in the context of the entire state as an interdependent water system. Thus, while increasing block pricing is frequently desirable, at times it would fail to achieve efficient use of water within and across water district boundaries.

An alternative pricing policy is suggested by economic literature, which would allow for pricing at other than marginal cost, but with deviations from such pricing in a particular and deliberate pattern. The literature (summarized by Baumol and Bradford [18]) has developed around the problem of financing deficits in large-scale operations with persistently decreasing average costs. The problem for most water district pricing (and for other water agencies as well) appears to be the opposite, namely, that average costs increase with overall water use, so that profits would arise with marginal cost pricing, but the same concept can be applied to solve this problem. The notion, in general, is to deviate from marginal cost pricing in inverse proportion to the sensitivity of water users' demands to the prices charged. Those with the *most* elastic demands are charged an amount closest to the true marginal cost of water, and those with the least elastic demands are charged prices deviating most from marginal cost. Such pricing practices minimize inefficiency and waste, *given* that some such pricing policy must be adopted. The overall level of pricing deviation from marginal cost is dictated by the extra revenue needed to be raised (in the case considered by Baumol and Bradford) or the amount of "profit" needed to be dispensed, as would be the case in most water district operations.

Available evidence suggests that the most elastic demands for water are for agricultural uses, where the least elastic demands are for municipal and industrial use. If such pricing policies were adopted by water agencies throughout the state, it would probably reverse the commonly prevalent policy of offering the greatest discounts for agricultural water use, and would in fact offer such users the smallest discounts. While we have not examined such pricing carefully, it appears to us that the current pattern of water price subsidies to agriculture cannot be justified under "second best" pricing theory as described in Baumol and Bradford and elsewhere.

Both increasing block pricing and "second best" pricing (discussed by Baumol and Bradford) face potential legal, political, and economic problems in implementa-

tion. Thus we turn to other alternatives to enhance water use efficiency within California.

## WATER TRANSFERS BY WATER DISTRICTS

An alternative to marginal cost pricing to enhance efficiency of water use is to increase the ability of water districts to transfer water by sale to other districts. There are in fact a few occasions in which such transfers take place under current law and organizational structure. We also know of several attempted transfers that were thwarted by existing legal and institutional structure. Hence one might consider the prospects for removing impediments to transfer as an efficiency-enhancing move.

The prospects for a water transfer under current law are not good. Before most transfers can take place, the water rights authorities (SWRCB) must approve. Second, transportation to move the water from one district to the other must be arranged. Third, there must be incentives for the transfers to take place, particularly on the part of the water district making the sale.

Most transfers of water take place within the context of the state's appropriation system. Riparian water, by definition, cannot be transferred from one source to another, nor can overlying groundwater users transfer that water to other lands. Recall that an appropriation defines not only the amount of water available for use by the appropriator, but also the point of diversion, the actual use to which the water must be put, and possibly even the timing of the diversion of water. For a transfer of a water right to occur, whether on a temporary or permanent basis, the permission of the SWRCB must be obtained. (Recall that pre-1914 appropriative rights do not face this problem.) The SWRCB is empowered to deny the transfer of water rights if it does not feel that the new use is reasonable and beneficial, or if another party will be harmed by the transfer. The issue of third-party harm is particularly relevant. On appropriations currently issued by the SWRCB, a standard term is that return flows from upstream appropriators should *not* be considered as dependable supplies for later appropriation. It is unknown how long this provision has been included in SWRCB permits, and there is no way to determine the fraction of all appropriations to which such terms apply.

Current appropriators report that they fear losing their appropriations if transfers are requested and denied. The SWRCB and state law require continuing beneficial use of a water right, or it reverts to the state. There is nothing in the Water Code regarding this, and one California Supreme Court case explicitly states that sale of water is a reasonable use (*Stevenson Irrigation District v. Roduner*, v. 36, Cal. Reports 2, P. 270). The persistently reported beliefs to the contrary may make desirable explicit statutory language confirming this situation.

Other difficulties may arise in transfers of appropriations. Courts, for example, have found that downstream users who become dependent on return flows can in some circumstances build vested rights in those flows (*Scott v. Fruit Growers' Supply Co.*, 202 Cal. 47, 50, 52-53, 258 P. 1095, 1927). A key distinction is whether the source of water for the appropriation is "foreign." The original importer retains property rights if he demonstrates clear indication of intention to recapture or

reuse the water. If the appropriation returns to its native source, it is considered available again for appropriation.<sup>2</sup>

The second important concern in a prospective voluntary water transfer between water districts is whether or not the water can be transported ("wheeled") from one location to another. It is important to recognize that the California water system is enormously interconnected, despite the lack of direct sharing of water supplies by most water agencies in the state. The interconnectedness begins in the northern parts of the Central Valley in the CVP project at Shasta and Trinity Reservoirs, and the SWP's Oroville Dam, and continues down through the Sacramento Delta, through the lower Central Valley (with the SWP and CVP canal systems) and then throughout Southern California via the distribution networks of the Metropolitan Water District (MWD) of Southern California and its constituent agencies. Even much of the eastern Sierra region is interconnected with this system, because of the flow of water down the Los Angeles Aqueduct to the City of Los Angeles, which is also interconnected with the MWD. Only the northern and central coastal regions of the state are essentially independent of the remaining parts of the state. Interconnections for those areas have been proposed or authorized for much of the water using communities in the central coastal areas (Monterey Bay and Santa Barbara), although these connections may not be built in the near future.

The connections are in general "one-way" connections, typically relying on gravity for the major impetus of water movement, but the current rates of water flow in fact make substantial amounts of "two-way" water traffic feasible.

Water transfers can indeed be made to serve the same function as having water flow uphill. Suppose, for example, that incentives for transfers existed and that transfers were freely made. Suppose that an agency in the Sacramento River Basin was willing to sell water at \$25 per acre-foot, and an agency in the eastern Sierra region wanted to buy water. With unrestrained transfers of water possible, the Sacramento agency could "sell" water to the SWP, which could in turn increase its deliveries to the MWD in Southern California. MWD could increase its sales to the Los Angeles Department of Water and Power, which could then offer for sale to Bishop equivalent amounts of water that it had purchased from the MWD. To "deliver" Sacramento River water to Bishop, water would physically have to be pumped over the Tehachapis into Los Angeles, but not clear over the Sierras. The magnitude of such a transaction would, of course, be limited by the current amount of export from the Bishop area to Los Angeles, but the example serves to point out the potentially powerful advantages of a fully functioning water transfer system.

The third element needed for voluntary transfers to take place by water districts is that the incentives must exist for such transfers to occur. Two circumstances appear relevant: either (a) the selling district must have "extra" water supplies within its district, e.g., water rights water, beyond the water desired by its constituent members at the price it charges its members, or (b) the selling district must obtain water by inducing reductions in water use within the district in some fashion.

In both cases presented, the water district must also have some intended use for the money earned from the sale, or a mechanism by which the profits of the sale can be distributed to the constituent members of the water district. In fact, the mechanisms available to distribute profits from an external water sale are exactly

<sup>2</sup> Water Code Section 1202.

those indicated above as being available for distribution of profits generated internally by marginal cost pricing of water. Exactly the same problems arise.

The importance of incentives and also of uses of profits earned in sales increases with the magnitude of water being sold or transferred. In short-term sales, not recurring frequently, the amount of money coming into a water district may be small relative to its total budget, and simple adjustments in taxation, pricing, or one-time additions or improvements in capital facilities can be found to use the money from the sale. In long-term transfers, particularly those involving relatively large amounts of water, the problems of incentives and profit distribution loom much larger. It is particularly in these cases where existing district enabling acts tend to reduce incentives for transfers.

The problem of obtaining water for external sale is also large. The water district will not typically have extra water storage and delivery capability within its district, for several reasons. First, to have obtained that water, it would have had to expend resources with no particular gain in mind, or demand for water would have diminished, so that originally planned water supplies were greater than actually needed. Neither of these cases occur with regularity in water supply districts in California, because general growth of demand, rather than reduction, is the observed rule. Also, since appropriative water law requires development and use of the water, it is difficult for any water district to systematically maintain water rights in excess of immediate uses. The extent to which water districts and other agencies have succeeded in acquiring and keeping unused water rights is an empirical issue on which no data are available.

If the water is to be obtained within the water district, there is a question of the incentives for water users to "supply" that water by reducing their own consumption. To appreciate how this might arise, one must understand the functioning of water allocation systems within the water districts of California. A typical arrangement is next detailed.

### **Water District Allocation Processes**

By its presence within a water district, each parcel of land within a water district is given the option to receive a specified share of the district's water supply. The water received by the user must be paid for at the water toll established by the board of directors of the district. The district generally tries to obtain enough water supplies to meet the demands of their members, where the demands depend upon the price charged by the district. Numerous studies of water use in California and elsewhere show that water demands are considerably sensitive to water price, other things equal, so that the price chosen by the district will partly determine the quantities to be sought from various water sources (see the appendix for details). Whatever quantity is obtained is parceled out among the various farmlands within the district, and to any municipal or industrial users on demand.

A farmer facing decisions about water use (dependent in part on his crop choices, in part on his irrigation practices, in part by soil conditions, and in part by his expectations about the weather during the growing season) must pay for the water he actually has delivered according to the water toll established by the district, as noted. In some cases, this amount is zero. In other cases, the amount depends only upon the acreage under irrigation, but not on actual water use per acre. In some cases, the charge per acre depends upon crop patterns of the farmer.

In still other cases, a per-acre-foot charge will be levied, which may range from \$1 per acre-foot to as much as \$20 per acre-foot or more, depending on the region, the district practices, etc. The remaining costs of the district are generally funded from taxes, and from interest earnings from the investment portfolio of the districts.

A farmer deciding to reduce his water use saves the marginal water toll, but gets nothing for the value of this "option" to obtain water from the district. This option may be a small part, but in some cases is the entire cost of water to the farmer. In the latter case, the farmer gets nothing in return for his decision to use less water. The options to receive water within the water district may often be bought or sold within the district, but almost never outside of the water district boundaries. Even within-district sales are sometimes forbidden, but the practice of land leasing is used broadly to circumvent such restrictions among farmers. As indicated in an earlier section of this report, there are often explicit prohibitions against extra-district sales, but in practice the prohibitions are even more binding, because districts will not engage in such transactions, and the cooperation of the district is required to accomplish a sale. We thus conclude that existing arrangements within water districts are not likely to produce significant quantities of water for sale to external buyers.

#### **Actual Transfers—Evidence on Importance of Barriers to Trading**

A series of actual water transfers took place within California during the 1976-1977 drought, and they were all under rather specific circumstances. Nearly all of the transfers occurred outside of the SWRCB appropriations system, and with few exceptions, the sale of water was made by a person or corporation with a clear direct title to the water, rather than by a water district. These sales also tend to be short-term, rather than the potentially desirable long-term transfers.

The major set of transfers that occurred were within the Bureau of Reclamation's CVP, with a number of farmers selling water to the bureau at prices offered by the bureau. The bureau calculated what they thought was a price that "would not confer any undue benefit or profit to any person or persons compared to what would have been realized if the water had been used in the normal irrigation of crops adapted to the area."<sup>3</sup> Actual purchases were from \$15 to \$87 per acre-foot, and the bureau obtained 46,438 acre-feet of water through this "water banking" program. The sellers were in all but one case individual farmers or corporations, not water districts.<sup>4</sup>

There were several other sales of water within the dry year of 1977, as reported by various sources. Perhaps the most prominent was the "sale" of some SWP water by the MWD to the DWR, which used the water in its drought relief program. The motives behind this sale are uncertain, but probably depended in part on the MWD's perception that the sale would enhance the likelihood of passage of Senate Bill 346 which was being discussed then, containing legislation to build the Peripheral Canal and other water resource development projects. The MWD views these projects as necessary to obtain reliable water supplies in future years. The price of the water sold was determined by the cost to the MWD of bringing in

<sup>3</sup> Public Law 95-18, April 7, 1977.

<sup>4</sup> The sales were by three mutual water companies, two firms, one reclamation district, and a number of water purveyors on the Sacramento River.

alternative sources from the Colorado River, and indeed, the DWR seemed anxious to undertake the actions necessary to complete the sale only under conditions that the MWD made no profits, but merely covered costs of getting water from alternative sources. Thus this sale circumvented the problem of profit distribution by passing that problem back to the SWP, who then determined the water distribution (and hence the distribution of economic profits) on the basis of rules established by the department.

The City of Redding sold some bureau entitlement water to four local water districts in early 1977, for prices ranging from \$9 to \$20 per acre-foot. That the City of Redding is a multipurpose governmental entity, and could use the receipts from the sale for a large variety of purposes (general fund monies), was probably important in their willingness to sell. There were no downstream users of this water to protest the sale, and it was approved by the SWRCB.

The City of Roseville attempted to sell its discharge water to four downstream users, the city's original water supply being from the Bureau of Reclamation. The SWRCB sought and obtained a restraining order prohibiting such sale, on the grounds that a considerable community of water users already depended on the discharge waters of the city.

Finally, there have been over the years a considerable number of sales of rights to pump groundwater within the adjudicated Southern California groundwater basin. Watermaster reports show large numbers of such transactions annually. These continued unhampered during the drought period. (The owners of the water pumping rights have such clear title to the groundwater right that they are taxable as personal property.) Since the adjudication takes place outside of the SWRCB appropriation system, here, as in other transfers described, no approval of that board is necessary to accomplish the sales.

### **Characteristics of Observed Transfers**

Three common elements appear in these transactions. First, with only few exceptions, the transactions took place with no necessity of approval by the SWRCB. Second, there were no problems associated with downstream users of return flows from appropriated water. Third, there was generally a clear title to water, at the point of use, so that those reducing water use were immediately and fully rewarded for their decisions.

For most observed transfers, no change in appropriation was required. This was true of the Southern California groundwater pumping rights sales and rentals, of the Bureau of Reclamation water banking activities (since the entire CVP is a single point of appropriation for purpose of the SWRCB), and of the transfers within the SWP (for the same reason). The purchases of water by the Paradise Irrigation District were one counterexample, because there was a transfer of appropriation water from the California Water Service (one of the selling corporations) to the Paradise Irrigation District. Some of the MWD water made available to the DWR also required SWRCB approval for transfer, e.g., the water made available to Marin County residents, because those users were not part of the basic SWP distribution system.



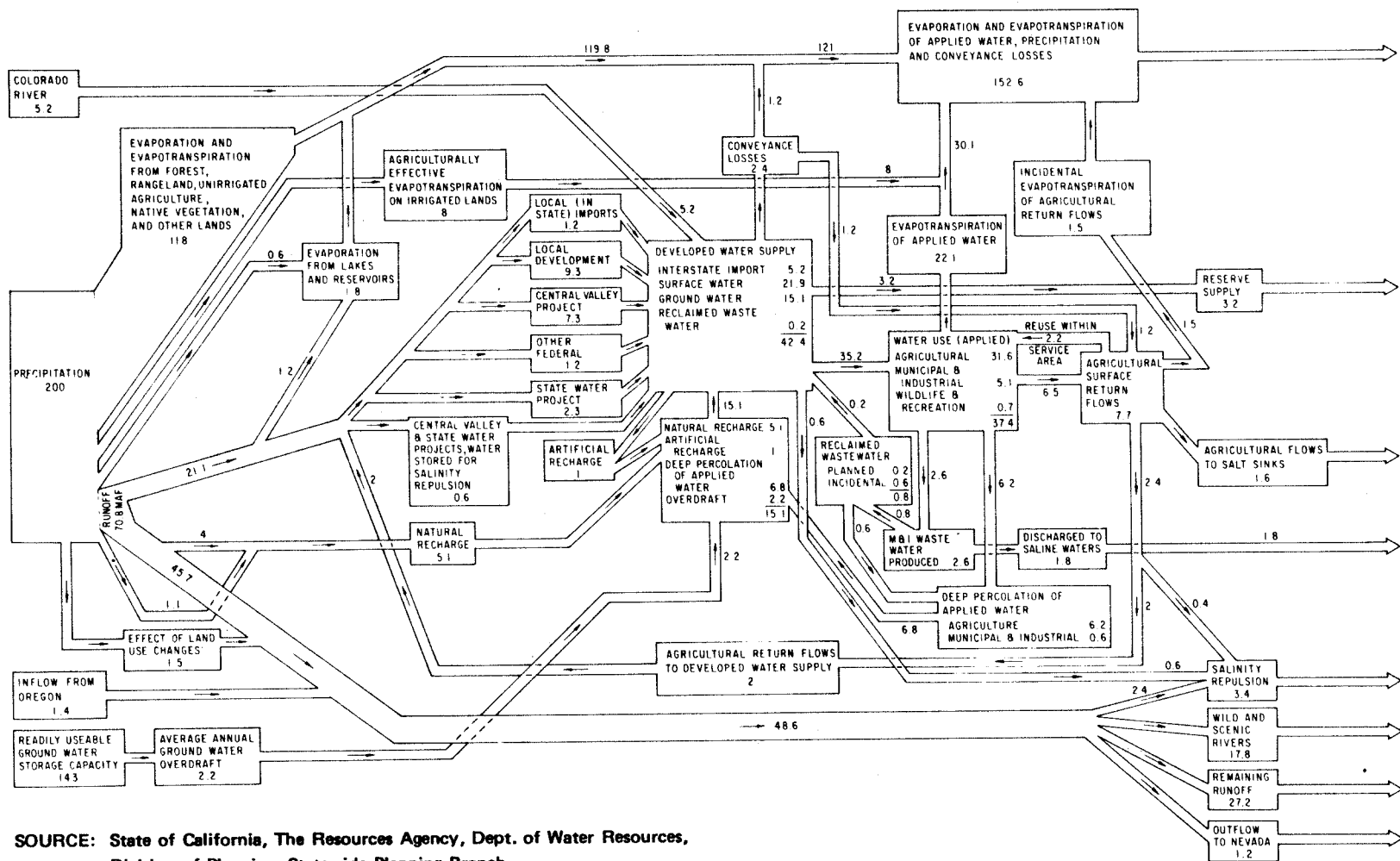
### The Problem of Return Flow Property Rights

The National Water Commission recommended that for new appropriations, the original appropriator should be allowed to retain property rights to the return flows. From an efficiency criterion, this is desirable because it allows a clear indication of the transactions that are required to effect a subsequent resale (perhaps to a distant point) of the appropriated water. The current SWRCB appropriation notes that return flows from imported waters or waste water are not to be considered as reliable water sources for appropriation. This is now a statement of administrative procedure, but not (to our best knowledge) contained in any statutes. Because of the widespread uncertainty regarding actual status, we recommend that the law be clarified to contain clear wording about title to return flow water imported from foreign sources, and that such flows be vested in the original owner. As is currently the case, downstream users could make use of that water, but they would not be able to block a sale of the appropriation under such a mechanism.

Further, it would be of value in existing water rights to quantify the extent to which downstream appropriators depend upon existing return flows from foreign sources, and limit the extent to which damages could be claimed if the original foreign appropriation were discontinued. Under current law and interpretation, it appears that the mere presence of users downstream of an appropriator's discharge may be sufficient to disallow a sale of the appropriation. This was the ruling of the SWRCB in the attempted sale of water by the City of Roseville during the 1977 drought, for example.

Clarification of downstream users' dependence on appropriated water serves to increase the extent of transfers feasible, and assignment of property rights to original appropriators serves this purpose. One must ask if the increased efficiency arising from reduced transaction costs could be more than offset, however, by externalities arising from a transfer of that water to other locations. If there were *no* transactions costs, the answer would be unambiguous—welfare would be improved with the clearer assignment of property rights. This must be the case because downstream users would, in effect, be able to state fully their willingness to pay for the water, and would be able to bid against alternative users of that water. The alternative users would also take into account any potential resale of water to users downstream of them when making their offer to buy the water. Thus all social benefits from the water would appear in the bidding process. In the real world, unfortunately, transactions cost can loom large, even with the best possible assignment of property rights. It is for just this purpose that agencies such as the SWRCB are established—to make judgments in cases where individual actions cannot account fully for all social costs and benefits. The SWRCB, of course, best serves the water using community by balancing off benefits and costs on all sides of a proposed water transfer, rather than just considering only the recipients of return flows from existing uses.

The question of return flows is always raised in the discussion of water transfers, but it is important to keep in mind the magnitude of the associated activity. Figure 3 demonstrates the hydrologic balance for California for a typical year of precipitation. The state receives some 200 MAF annually of precipitation, about 10 percent of which is eventually captured in surface water projects (which accounts for half of within-state surface water use). Added to that are some 5 MAF of out-of-state imports of surface water (Colorado River) and some 15 MAF of extract-



SOURCE: State of California, The Resources Agency, Dept. of Water Resources, Division of Planning, Statewide Planning Branch.

Fig. 3—Hydrologic balance for California in millions of acre-feet

ed groundwater. Of this 42 MAF, 32 MAF are used in surface irrigation, and of that, only 7.7 MAF return from agricultural use into the surface water system, or approximately one-quarter of the original amount used in surface irrigation. Of that 7.7 MAF, 2.2 MAF are used again within the original service area, and another 2.0 MAF arise through recapture in surface development systems, for a total of 4.2 MAF of water supply arising through return flows. In addition to the return surface flows, 6.2 MAF (20 percent of irrigation water) enter groundwater basins after agricultural use and are available for subsequent groundwater pumping. Thus while subsequent reuse of irrigation water through surface development is non-trivial, it represents only one-fifth of the actual within-state surface water supply.<sup>5</sup> Thus it must be the case that for many prospective water transfers, the problem of dealing with return flows cannot be considered overwhelming.

<sup>5</sup> This represents actual return flows ( $2.2 + 2.0 = 4.2$  MAF) divided by total surface supply (22 MAF). The calculation is  $4.2 \text{ MAF} \div 22 \text{ MAF} = 19$  percent. The fraction would be 15 percent if we included Colorado River water in the denominator, but the return flow use of that water is small, with most entering the Salton Sea or proceeding directly to the Pacific Ocean from the Southern California area.

## V. A PROPOSED SOLUTION

Substantial amounts of water transfers will not take place, given current water rights and incentives for use or sale of water, particularly at the water district level. The current system of water allocation within water districts could be modified to achieve more beneficial transfers.

Voluntary sales of water would occur more often, and benefits would accrue from such transfers, if the title to use of water were assigned clearly to water users themselves and were made freely transferable both within and outside the district supplying the water. Removal of prohibitions against selling water is insufficient to achieve transfers. A clear title to use must be assigned to the persons using the water. Title to water can be assigned by long-term contract, or by direct modification of water district law, so that the title to water use passes clearly and directly to the prospective water user. Because of the potential variability in water yield from any physical facility, it is probably easiest to allocate such title to use on the basis of fractions (shares) of available water supply, rather than in fixed quantity amounts, although other arrangements appear feasible. This study recommends that the following modifications be considered and adopted if legal and administrative difficulties can be overcome.

1. Each water district should issue clear title to use of the water it delivers.
2. Legal prohibitions against sale of such contracts or options should be eliminated, including prohibitions against sales outside the water district.
3. The water district should be authorized and urged to cooperate in any way feasible to enhance such sales of contracts and options. Any costs incurred by the water districts in transfers or sales should be paid by the parties to the transaction.
4. The SWP and other state agencies should be authorized and urged to cooperate in such transactions whenever possible. This is necessary when the water district is linked only through wholesale delivery systems with other agencies.

Current contracts with the SWP require the approval of the director of the DWR before any exchange, sale, or trade of the firm yield entitlements can be made.<sup>1</sup> The current DWR director views such exchanges as acceptable in temporary situations but generally not acceptable on a permanent basis, because of (a) associated financial changes that might impair the SWP's fiscal integrity, and (b) because he does not want any long-term dependency on that SWP water to develop, as might happen if, for example, agricultural communities used that transferred water to expand or to form new communities.<sup>2</sup> Further evidence is found in a DWR report on the SWP for 1976 [22], which indicates the following in a section entitled "Transfer of Water Entitlements."

<sup>1</sup> Section 15(a) of the SWP standard contract [20].

<sup>2</sup> Personal communication from DWR Director Ronald R. Robie and Southern District manager Jack Coe at The Rand Corporation, June 14, 1978.

In the spring of 1975, negotiations involving the sale or transfer of entitlement water were taking place between some long-term contractors and other agencies. One such negotiation culminated in an agreement which was submitted to the Department for approval. After careful consideration, the Department indicated it would not approve the agreement, *nor would it approve any similar agreements at that time* [emphasis added].

Since the financial viability of a water district would not necessarily be impaired by the sale of water outside the water district, we see no reason for such generic opposition to water entitlement sales. The contracting water districts will still continue to sell water to the original parties, or will have a contractual obligation with a new party, so the revenue received by the water district could even be in excess of their cost from the SWP.

The type of activity proposed here for water districts in fact has a near analog in present-day water development in California, namely, the mutual water company. The mutual company owns water rights, develops facilities to capture and distribute the water arising from those rights, and sells the water to its customers/members. Typically, ownership of part of a mutual water company brings with it the right to receive a fraction of the water supply available from that mutual company. If a mutual company makes a profit on its operations, it typically redistributes that profit back to the shareholders in the form of reduced commodity charges, since water use is proportionate to shareholding. The shares may be bought and sold, and it is the opportunity to sell such shares that in fact makes the water use within the mutual company "efficient" by the standards we have proposed. The efficiency arises because there is always the opportunity to sell the water to a buyer who would value that water more than the previous shareholder. (In the context of most mutual companies, there is an implicit restriction that the new buyer must be able to be served by the mutual company's facilities, since it is difficult or impossible to "wheel" the water from their sources to buyers located away from the service area of the mutual company.)

## THE POLITICAL PROBLEM IN ASSIGNING WATER SHARES

One obvious path toward efficient water use in California is to have clear and unambiguous assignment of the title to water to the users of water, e.g., the farmers. However, an important problem arises when trying to implement this solution to the water use inefficiency that we face in the state. That problem is how to assign the title to water supplies currently in existence. We take as an example a local water district that might have two sources of water supply currently, a locally-developed project (perhaps fully paid for through the years) and some purchases from the SWP, acquired at a cost to the district of \$15/acre-foot of entitlement, and (say) a capital transfer-facility charge of \$10/acre-foot and a short-run variable delivery cost of \$10/acre-foot. (Such a district might lie somewhere in the central San Joaquin Valley.) The lands within this hypothetical district would be receiving water that cannot be distinguished by source, since the water districts blend their water supplies and average their costs in general. Some lands will not fully use their implicit share of water, and others will take more or less than the average amount within the district, depending on crop patterns, irrigation techniques used,

etc. The history of water charges paid by the farmer will depend upon rates set by the district and water use by the farmer. Taxes paid by the landowner (tenant or absent) will depend upon total acreage, the tax rate set by the district, and potentially on the amount of improvements on the land (since in some cases they are also assessed). In this environment, we ask how can equitable distribution of the title to water available within the district be achieved.

To achieve efficiency, this title must be transferable independent of the land title. Thus the water will not automatically be applied to a given parcel of land within the water district. Indeed, it is just that linkage that we argue must be broken to achieve efficient water use. But it is clear that however title is assigned to those water supplies in the district, this assigns wealth to the recipients. Title to an acre-foot of water supply (for presumably a nearly perpetual period of supply, since we are in effect dealing with shares of dam output, or shares of a SWP entitlement) is worth the present discounted value of many years of that water. If the market establishes a value of water of \$30 per acre-foot, then each acre-foot of water "title" is worth something in excess of \$400.<sup>3</sup> This is true whether or not the farmer chooses to use that water on his own land. For a "typical" 160 acre farm using 4 acre-feet of water per acre per growing season, the average allocation of water rights titles would be to 640 acre-feet of water. The present value of the title to that amount of water would be in excess of \$250,000. Costs of that water, of course, must be subtracted to determine net benefits.

*It is important to realize that this wealth has already been conferred on the recipients of water.* In some cases, they are fully paying for the facilities to provide that water, and in other cases, they receive subsidies to support the facilities providing that water, but the recipients already are receiving that water, and the wealth associated with it. Providing them with clear title to the water will not add to their wealth but will merely allow them to transform their wealth from water into money, if they so wish, by reducing their water use. New wealth will be created only in the sense that former inefficiencies in the use of water will be eliminated, and that new wealth will be shared widely throughout the state.

Assignment of shares of water supplies within a water district could in concept be undertaken on a variety of bases, including acreage, past tax payments, past history of water use, or combinations thereof. However, two rather different considerations suggest that by far the most likely outcome would be a distribution based on land ownership. The first consideration is one of data: Many water districts will not have available records to indicate past water deliveries or payments for water. Presumably, tax payments could be more readily constructed, if not actually available in records. Legal considerations may dominate the decision, however. Under present case law, the water district holding water rights is a trustee to the *landowners* within the district, and equitable title to the water right is held by the landowner, even if the legal title is held by the water district (*Merchants' Bank v. Escondido Irrigation District*, 144 Cal. P. 334, 1904; also *Ivanhoe Irrigation District v. All Parties and Persons*, 47 Cal. II., P. 624, 1957, reversed on other grounds, 357 U.S. 275, 1958). Thus, any other basis of assignment of water within the district could require compensation to landowners on grounds that alternative forms of distribu-

<sup>3</sup> At an interest rate of 7 percent, the present value of the right to receive \$30 worth of water for 50 years is  $13.8 \times \$30 = \$414$ . A recent sale of water rights in Utah for power plant cooling led to a price of \$1750 for the perpetual right to each acre-foot of supply, according to newspaper reports [24]. This is equivalent to about \$122.50 per acre-foot per year at a 7 percent discount rate.

tion of the water deprived landowners of a valuable property right.

To achieve efficient use, the ability of the recipients to transfer the water outside of the district is crucial. This, for example, is explicitly excluded in current Irrigation District law, despite the fact that the allocation can be assigned within the district itself.<sup>4</sup> Current case law (*Jenison v. Redfield*, 1939) does not favor the transfer of water outside the district, even if the land to which it is being transferred is owned by the same person receiving water within the district. Thus a legal change is required.

## TRANSACTION COSTS AND ALTERNATIVE SCHEMES

It is apparent that some water districts will face a set of customers too large in number and too small in average water use to justify the sort of water-title assignment discussed above. Some districts, for example, serve both large agricultural customers and also a large number of small residential customers. The costs of implementing a title assignment/sale of water mechanism would in all likelihood far exceed the benefits obtained.

An alternative to the water-title assignment system could be to establish increasing block pricing for such users. If there is to be a legislative change mandating clear assignment of title in water districts dealing with large customers, it would also be desirable to allow the water districts to substitute an increasing block pricing plan, with the top block matching the marginal cost of water, for all customers using small amounts of water.

The situations in which increasing block pricing would be desirable as an alternative to title assignment are at present uncertain, and may have to be modified on a case-by-case basis through time. The average annual residential use in California is about one-half an acre-foot per household, or about 500 gallons per day. Thus the water consumed by a typical 160 acre farm annually represents the equivalent of over 1000 households. The farm is almost certainly within the range where title assignment of water rights is feasible and desirable, and the household is almost certainly not. We suggest as a preliminary basis that any farm larger than 40 acres, and any commercial establishment using more than half an acre-foot per day of operation, would be likely candidates for title assignment, with smaller users put on an increasing block pricing arrangement, although the cutoff point is strictly speculative.

## POTENTIAL LEGAL PROBLEMS

### Implementation

There are potential legal difficulties with implementation of such a system of water transfers. One set of problems relates to potential tests of the right of all landowners within a district to receive water allocations. If a landowner has not been using water in the past, and has no obvious intention of doing so, some might argue that there was no reasonable and beneficial use intended by that party, and

<sup>4</sup> Section 22251 of the Water Code [5].

hence that there was no basis to assign water contractually to that party. Conflicting with this is the notion that the water district holds water rights in trust for *landowners* within the district, as expressed in *Merchants' Bank v. Escondido Irrigation District* (144 Cal. P. 334, 1904), and as affirmed in *Ivanhoe Irrigation District v. All Parties and Persons* (47 Cal. 2d, P. 624, 1957, reversed on other grounds, 357 U.S. 275, 1958). Further, there is one case upholding a sale of water as a reasonable and beneficial use (*Stevenson Irrigation District v. Roduner*, V. 36, Cal. 2d, P. 270, 1950), which may be taken as indication that a landowner not using water could legally both receive and sell water allocations from the water district. A court test would probably be required before the matter would be fully settled.

Second, under current law, all conditions of the original appropriation of water by the water district would be continued under the proposed contractual arrangement between water districts and landowners within the district. Thus, any subsequent sale would almost certainly have to pass general tests of approval of the SWRCB for change of point of use, for example. The mechanisms of the SWRCB might be put under more stress if there were a substantial increase in the frequency of applications for transfer. Consideration should be given to ways to streamline such procedures for some transfers, e.g., if the amount of water involved is small relative to total water use within the basin.

The third problem relates to the county of origin and the watershed of origin statutes in the Water Code (Sec. 10505.5 and Secs. 11460-11463) [5]. The watershed of origin law states, regarding Department of Water Resources operations:

In the construction *and operation* by the department of any project . . . a watershed or area wherein water originates or an area immediately adjacent thereto which can conveniently be supplied with water therefrom, shall not be deprived by the department directly or indirectly of the prior right to all of the water reasonably required to adequately supply the beneficial needs of the watershed area, or any of the inhabitants or property owners therein [emphasis added].

Since many prospective transfers would likely be from north to south, the obvious transportation mechanism for the water is the Department of Water Resources' SWP canal (and possibly the MWD distribution system). It is possible under this law that inhabitants of the area of origin of the water supply could prevent a transfer out of their basin through limitation of the SWP's ability to "wheel" the water for the buyer and seller. There may be specific modification of the language in these sections required to allow the SWP to facilitate transfers such as could arise under our proposed system, allowing such wheeling to take place.

An alternative protection of areas of origin would be to require that for any transfer, a protesting party within the area of origin be given the right of first refusal on any sale of water outside the basin. If the buyer in the basin matched the offered price of the out-of-region buyer, he would receive the water transfer. (The relevant price is that received by the seller after all transportation costs are paid.)

### **Local Community Protection**

Other issues arise with potentially expanded transfers of water. One, associated with the area of origin concept, is the fear that substantially large transfers of water out of one region would harm local economies or ecologies. Because there is



such little relevant experience with a system of water transfers, the state may wish to institute some temporary protections against massive transfers. It is worth noting that the economics of the situation makes complete transfers of water out of one region extremely unlikely, if not impossible. The most likely adjustment to water marketability would be changes in cropping patterns, rather than elimination of farming in any given area [23]. Further, there are obvious limits to the physical capacity of canals to transfer water southward, which is the anticipated direction of flow. The available capacity of SWP and CVP canals sets some limits on overall transfer.

However, if these economic and physical constraints seem too frail, legal constraints can also be imposed. For example, one could phase in allowable transfers, allowing only 25 percent of any person's water to be transferred in the first year of the new system, 50 percent the second year, 75 percent the third year, and unlimited transfers in subsequent years. This would give ample time to observe effects of the transfers and take mitigating action if undesired side-effects arose. A second potential constraint would be to limit over time the cumulative transfers that any individual might make. For example, a 10 year limit of no more than half a person's total water allocation being transferred might be established. While this would allow 100 percent transfer in any given year or series of years (e.g., during a multiyear drought), it would prevent massive evacuation of economic activity from any region.

If any such constraints are imposed, it would seem best to eventually phase out such limits, so as to eventually allow unconstrained transfers. The purpose of such limits or constraints is to protect third parties from unanticipated economic harm (for example, businesses depending on a certain level of agricultural activity in any area). If the phasing of transfers is known in advance, sufficient time for economic adjustment could take place to make any permanent damage minimal. Although our analysis suggests that massive transfers out of any given region would not occur, it does seem apparent that (if necessary) local community interests could be accommodated through temporary constraints on the amounts of water transfer allowed.

### **In-Stream Appropriations**

A final issue associated with water markets is the question of in-stream use. Under current law, in-stream uses of water are to be protected through the judgments of the SWRCB as to the desirability of allowing further allocations on any river. A wide variety of alternatives are available to modify current law. Some have suggested that the state set specific in-stream standards, condemning existing water rights, if necessary, to achieve the established standard [1]. Others have opted for allowing in-stream appropriation, rather than limiting the ability to appropriate to those actually taking control over the water through diversion or other means. In two recent California court cases involving the SWRCB as defendant, plaintiffs sought the ability to appropriate water for in-stream use (*California Trout v. SWRCB* and *Fullerton v. SWRCB*, the latter case involving the State Department of Fish and Game). Appellate court decisions specified that in-stream appropriation should not be allowed, and the Supreme Court refused to hear the case. From the perspective of water markets, it seems clearly desirable to allow in-stream appropriation of water, although some changes in operating budgets of such agencies as

the Department of Fish and Game may be required. Allowing in-stream appropriation serves in several ways to enhance efficiency of water use. First, it places in-stream use in the same arena as consumptive use in terms of value of water. In other words, it more closely indicates the opportunity cost of in-stream use than current administrative deliberations could possibly accomplish. Second, if in-stream use became more valuable in the future, the mechanism would be available to increase in-stream flow through purchase of existing appropriative rights from other users. Such purchases could be made either by private parties (e.g., the California Trout case) or by public agencies (e.g., the case involving the Department of Fish and Game). For public agency acquisition of in-stream appropriations, either the normal process of appropriation could be used (where unappropriated waters are available) or purchase of existing appropriation could be made. The latter could be financed through user fees, e.g., for fishing or river rafting, or through general funds, as appropriate, but either method would require adjustment of state agency budgets in some fashion.

In-stream appropriation purchases by (for example) the Department of Fish and Game do not necessarily add significantly to the budget of such a department, if the "return flows" of the in-stream use are available downstream for subsequent resale. Acquisition of an in-stream permit allows the water to be resold (in its virtual entirety) downstream, if the property rights to return flows are clearly indicated. An in-stream user would obviously deny a consumptive use of water at the same point in the system, but would not necessarily deny eventual consumptive use of that water, unless the important aspects of in-stream use were such that the only subsequent flow of the water were to the sea.

## **WATER DISTRICT PRICING OF WATER SUPPLIES**

Logic and evidence suggest that efficiency of water use would increase if water districts pass firm title to water supplies to the eventual consumers of that water, with no restrictions on resale of that title to other parties. The question now arises as to what types of pricing mechanisms should be utilized by water districts as they sell their water. The water district is really faced with two generic choices, and one is clearly preferable to the other. The choices are to continue an average cost pricing arrangement, or to move to some sort of efficiency-inducing pricing structure. Both would preserve the zero-profit constraint imposed by water district law, but the average cost pricing algorithm could lead to distorted behavior, unless there were totally unobstructed ability to conduct market transactions in water. Thus, we also consider alternative pricing policies by water agencies as a way to enhance efficient water use.

Consider a water district with multiple sources of water supply, such as water rights water and purchases from the SWP as an example. The water rights water "costs" the water district \$1.25 per acre-foot (data representative in the Sacramento Basin, according to Hedges [23]), and the SWP water costs the district, depending on its location along the California Aqueduct, from \$10/acre-foot to over \$200/acre-foot. For illustration, consider a district that pays \$20 per acre-foot for water. The most efficiency-inducing way for the water district to price this water is to sell water from each source at its actual cost to the water district. Thus if the water district had available 10,000 acre-feet of water rights water, and used 5000 acre-feet of SWP

water, it would, under this system, sell each acre-foot of water from the first source to its constituent members at \$1.25, and each acre-foot of SWP water at \$20. The average cost to the water district members would be identical, under this pricing plan, to their current average cost of water, if their behavior in use of water remained identical. Thus this change in water pricing effects no changes on water users unless they wish to change their behavior. Under the commonly used average cost pricing arrangement, the district would have to expand its SWP entitlement water supplies to meet further demands (assuming its water rights water was fixed in availability), but would (under current practice) sell additional water at the average cost to the district, rather than at the marginal cost of \$20/acre-foot. (The average cost in this example is  $\$1.25 \times 10,000/15,000 + \$20 \times 5000/15,000 = \$7.50$  when 5000 acre-feet of SWP water are purchased.) This is clearly a misleading signal to send to water users, and one which will overstimulate demand for water within the district. If the water users face the opportunity cost of selling their water to another buyer, then the market would set their opportunities higher, but if for reasons such as lack of transportation facilities no effective water market develops to some water users, it will require a block marginal cost pricing system to induce efficient use. Most water districts have only one or two important sources of water within their districts. Thus the administrative problems associated with transmitting a clear title to that water will not be large, even if it must be done on a source-by-source basis. Naturally, new supplies acquired by the water districts should be priced on the same basis, i.e., on the marginal costs of acquisition. In this manner, the zero-profit condition can be sustained within the water district and a pricing system set forth that will encourage efficient use.

### **Interaction of Water District Pricing with Water Rights Assignment**

If a fully implemented system of water rights assignment is indeed accomplished, the pricing by water districts is of less importance in achieving efficient water use. Nevertheless, we believe that attention should be paid to pricing by water districts on the grounds that a "perfect" water market may not arise. If water rights assignment within water districts is accomplished, and if water districts price water supplies at marginal cost, then only the initial assignment of water rights within the district has any effect at all on wealth redistribution, because any subsequent increases in water use within the district would be priced to the user at marginal cost. If for no other reason, marginal cost pricing within water districts is desirable to reduce subsequent income redistributive issues.

## VI. THE EFFECTS OF INCREASED WATER TRANSFERS

Water transfers can add to the effective firm yield of the state's water system, possibly in substantial quantity, without the necessity of constructing new capital facilities for water storage. To make this assertion, of course, it is necessary to modify what one normally thinks of as "firm" water. An engineering approach is to view the firm yield of a system as the projected average water flowing out of the system with variation, both seasonal and annual, smoothed by use of storage. These firm yields are then matched against "requirements" for firm water. In an economic sense, the concept of a "requirement" for firm water is really at the heart of the issue. Evidence shows that water use is sensitive to water prices, even in times of drought (when a firm yield concept is most relevant to discussing capacity constraints). In a system with water transfers, the *supply* of firm yield water arises not only from the physical capacity of the system itself but also from the willingness of some water users to part with their share of that capacity, given proper incentives. Firm water can be supplied to those who value it most highly from those who value it less highly, no matter what the aggregate level of water availability really is.

It is hazardous to estimate how much water might actually be made available from water transfers under different pricing conditions. The difficulty arises because available estimates (and data available for new estimates) do not allow a complete understanding of how demand for surface water varies with water prices, groundwater pumping costs, crop prices, etc., particularly in the more general context where land prices respond to the price of water. Unfortunately, the omission of land prices from existing analyses of water demand means that the estimated demand elasticities for water will likely be overstated. The actual demand for water is likely to be less responsive to water price changes than existing estimates show. (The case where land prices are allowed to vary is important in assessing changes in water use where broad-reaching changes in water prices arise.) Given this important caveat, it is possible to construct a prototype scenario of what would happen under a system of water transfers such as have been proposed in this report. This scenario should be taken as indicative of the type of response that is likely to emerge under water transfers, but it should be kept in mind that the magnitudes of response in the study to be cited are almost certainly an overstatement of what would actually be observed. The study in question analyzes water use within the Sacramento Valley, focusing particularly on farms engaged (in part) in rice farming.

According to Trimble Hedges [23], there were recently some 430,000 acres of land in rice farming, the vast bulk of which is located in the Sacramento Valley, and in particular in the counties of Butte and Colusa. This farmland received water from the Biggs-West Gridley Water District (29,000 acres of irrigated croplands), Butte Water District (14,000 acres), Richvale Irrigation District (25,000 acres), Colusa County Water District (30,000 acres), Glenn-Colusa Irrigation District (150,000 acres), and Princeton-Codora-Glenn Irrigation District (11,700 acres). In the years studied, almost half of the rice grown in the state originated in these two counties, and Hedges reports similar conditions for other areas in the Sacramento

Valley devoted to rice farming. The average water supply per acre for these ricelands was between 9 and 11 acre-feet per acre per season; in our discussion, we will use 10 acre-feet per acre for computational simplicity. The same lands when farmed with other crops, used about 4.5 acre-feet of water per acre. Hedges shows considerable increases in net profitability for rice farming above other crops, but acreage restrictions applied by federal farm policy restricted rice farming to between 33 and 40 percent of the total land available.

Farming costs were broken down by Hedges as "fixed costs," i.e., land and equipment, and variable costs, e.g., water, labor, and materials. Fixed costs were about \$700,000 to \$800,000 per 1280 acre farm, or \$68 to \$77 per acre in carrying and maintenance costs. He showed that rice farming, at an existing water price of about \$1.25 per acre-foot, had returns in the neighborhood of \$200 per acre above variable costs, i.e., to pay "fixed costs" and to provide profits for the farmer. Alternative crops, at this water price, produced per-acre net returns of from \$60 to \$70 for grain sorghum, \$100 for beans, and about \$20 for grain hay and alfalfa. Most other crops studied were grains (barley, wheat, oats, corn, plus safflower), and had net returns per acre in the range of \$50 to \$70. Unirrigated wheat farming gave a net yield per acre of \$65 to \$75. Clearly the binding constraint on farming profitability was the federal rice allocation, and eventually (if that constraint were relaxed) the physical availability of water.

Consider now what would happen in such farming districts if there were a freely accessible water market, with a price of \$20 per acre-foot for water at the point of origin. *If the farmer had clear title to use of the water he had been receiving previously*, he would be faced with the decision either to use his water in farming, or sell it at \$20 per acre-foot, or some combination thereof. At an extreme example, if he decided to shift an acre of land entirely to dry farming of wheat, and sold all related water, he would make available to the market 10 acre-feet of water at \$20, receiving \$200 revenue, plus the \$65 to \$75 from wheat farming, or about \$260 per acre. This is \$60 to \$80 per acre more than he can make in rice farming under previous practice, or about \$75,000 to \$100,000 per year more for a 1280 acre farm.

Again, carrying things to an extreme, if all rice production in the state were turned to other dry crops, such as wheat, something in excess of 4 MAF of water per year would be "produced" at zero capital cost. A substantial river network (Butte, Sacramento, and Feather Rivers, for example) is available to deliver this water to the Delta, and the canal capacity to carry it to other parts of the state exists in SWP and CVP facilities, the former with designed capacity of double current deliveries, or about another 2 MAF per year. (Naturally, adverse timing of water deliveries may reduce the effective size of the canal system.)

While this extreme result is unlikely, Hedges has estimated the water demands within two counties studied at various water prices, and predicts the various cropping patterns that would arise. He shows a price of water of \$34.50 per acre-foot leading to complete withdrawal of irrigation, with a considerable shift toward shallow-irrigation rice farming at any prices above those existing. At water prices of \$25 to \$35 per acre-foot, Hedges finds water released for other uses of 3000 to 5000 acre-feet per 1280 acre farm, or about 2.33 to 3.9 acre-feet per acre. Recall that in these estimates, it is assumed that land prices are fixed, but there would probably be a fall in land prices if water prices did actually increase. Offsetting this tendency, land prices would likely rise if water rights currently tied to land use became more

flexible, but were still *initially* assigned according to land acreage. Thus Hedges' results should be taken only to indicate the *types* of response that might occur.

Currently proposed legislation would lead to increments in water supply for the SWP at *marginal social costs* well over \$200 per acre-foot *at the Delta* for some projects, and the average cost (which is what would be translated into the Delta charge to SWP contractors) could rise above \$30 or more per acre-foot (see the appendix for details). The ability to transact in water with farmers from the other regions of the state represents a clear gain to both parties. The selling farmers would have more profits than under the current situation, so long as the price rose to levels indicated. Buying farmers would receive a substantial benefit in reduced water costs, relative to surface development fully paid for by the water users.

Total land in farm production would not necessarily decline under this scenario, and in fact could rise. Each acre taken out of rice production can account for 2 or more acres of farming in the San Joaquin Valley, but the riceland can be sustained in other farming uses. The water would be used more efficiently within the state, and all farming parties would gain.

Under our proposed system of water transfers, no farmer would be forced to make such transactions against his will. Water within his water district will still "cost" him the same from his water district as it costs today, because none of those supply conditions will change. Water district operations will be maintained, possibly with costs reduced as some delivery networks are cut back. (This would be plausible under long-run water sale contracts by any given farmer, who would then not need many years of canal maintenance on canals and ditches distributing water to his land. More likely, however, is that such maintenance would be continued, and some water deliveries would be made to the farmer throughout the year, but at reduced rates relative to current practice.) If any farmer wished not to sell part or all of his water to other buyers, he would merely maintain current operations, i.e., farming both rice (as permitted by federal allocations) and other crops, and would forgo the additional profits available from selling his water to those who value it more highly than he.

Consumer interests would also be potentially affected by such transactions. What happened in general would depend on the complex interactions of crops and crop prices that change from year to year, and in a large part on federal agricultural policy responses to the changes in California growing practices. For example, if the (anticipated) reduction in California rice growing was offset by increases in acreage allotments in other rice states, there would be little or no change in rice prices. Indeed, since rice is traded in world markets, it is possible that no change would be observed in any event, although California's substantial share (approximately one quarter) of total domestic rice production would suggest some changes in rice prices otherwise.

Prices of other crops would be altered as production changed. The data in Table 5 indicate the general dominance of California agriculture in various markets. Those markets where California has the largest fraction of production would have crop prices most sensitive to water pricing in general. However, an immediate increase in the surface water price accompanying more trading of water could in fact spell a reduction in many crop prices, because the expansion of water available would lead to increased planting in those crops.

This seeming paradox arises because, although existing water is priced "low," it is in fact not freely available at that price, and there is an implicit "shortage



value" of the water higher than the posted price. The value of expanding water supplies in water-short regions can exceed the levels of cost associated with a free-trading water market. Data are not available to study such a broad sweeping change in detail, but consideration of food markets in general indicates that food consumers as well as producers could well be better off with an active water market than under alternative water arrangements.

It almost goes without saying that such potential augmentations of water supply for use outside the Sacramento Basin would help alleviate, if not eliminate, the groundwater overdrafting problem, if a corresponding basin control plan is put in place, but without forcing reductions in acreage in that area. This is true because the increased availability of surface water would lead some current groundwater pumpers to switch to the surface water market for their water supply.

A secondary effect would occur in groundwater use, because the very high water tables in the Sacramento Basin would become economically attractive for local use. With increased surface exports, local pumping would increase, and the basin level would fall. This is probably desirable, since it is "too high" now in the sense that groundwater pumped from some basins is far cheaper than water obtained through alternative surface supplies. The increased pumping would almost certainly necessitate a basinwide control plan in the Sacramento Basin eventually, but such a plan could be made available long before a serious problem resulted from too much mining. (See Wetzel [3] for a further analysis of how optimal groundwater extraction varies with the cost of surface water.)

Finally, such increased pumping would make some dewatered space available locally in the Sacramento Basin with shallow pumping lifts, thereby making an aggressive groundwater and surface water conjunctive management system desirable (see Jaquette [26]). This would result in a further expansion of the apparent capacity of our existing surface storage systems. (Jaquette shows that within the pumping lifts present in the Sacramento Valley, up to 1 to 2 MAF of additional surface water can be produced at a marginal cost of \$25 per acre-foot from existing surface reservoirs.)

*It is critical to realize that little of this proposed readjustment of water use is likely to take place under current incentives facing water districts and farmers. Much of the water used in this farming activity is from water rights held by local water districts, not by the individual farmers. (A portion is Bureau of Reclamation water, subject to acreage limitations and other restrictions on transferability.) Unless water districts pass a clear title on to farmers for the water they have been using, the farmer will see insufficient return to reducing his water consumption, e.g., by shifting out of rice farming into other crops. Arranging for the farmer to receive the profit directly from selling the water is crucial in determining how much water would be offered for use elsewhere. Otherwise, the farmers (through their votes in the water districts) will have no way to pass the returns from the water sales back to themselves. For example, within the Sacramento River District of the CVP, over 80 percent of the water rights are held by water districts and farmers. (Bureau of Reclamation data for 1976 show 1.76 MAF of water supply in this district, with 1.43 MAF of water rights supply, and .62 MAF of CVP water.)*

This report by no means suggests that the best way to achieve gains in effective water supply is for rice farmers to get out of that business. Indeed, we hold that the collective and individual judgments of the water users themselves would produce the best solution. The dimensions of possible adjustment are considerable:



Rice farmers can switch to shallow irrigation, using about 6 acre-feet per acre rather than 10 acre-feet per acre; alternative crops can be chosen; farmers raising other water-intensive crops may also choose to sell some of their water for use elsewhere, either altering irrigation patterns or changing crops. Some farmlands may actually leave production, although this would probably not be a large-scale phenomenon. The point is simply that the economics of farming indicate that possibly substantial increments in "firm" water supply could come from farmers, given the appropriate legal structure and incentives. The important notion is that the current system cannot lead to maximum *value* of the water actually available, for any quantity of water in any year. Water sales can improve upon this thereby increasing the overall efficiency of water use in California.

## VII. THE STATE WATER PROJECT AND EFFICIENT PRICING AND MARKET BEHAVIOR

The SWP currently produces only about 5 percent of the total state water supply and is scheduled to produce about 10 percent of that supply at full capacity. The SWP is important in considerations of efficient water use, even though its relative market size is small. This is true for two reasons. First, much new construction of water systems scheduled for the remainder of this century and beyond will be a part of the SWP. Therefore, the incentives for new construction within the SWP system loom large in importance. The second reason is less structural but has the potential for importance within the water system of the state: The SWP is in effect setting an example for pricing and water use efficiency for the remainder of the state, including local water agencies and possibly also the Bureau of Reclamation. Thus, the incentives within the SWP are of considerable importance.

The fundamental principles of the SWP appear at first glance to be desirable. The SWP was organized to prevent external subsidies from entering SWP water development and is intended generally to be self-financing.<sup>1</sup> Users are charged for water in a multitiered pricing system that has many generally desirable features. Unfortunately, several features of the SWP financial structure lead inexorably to overdevelopment of water systems within the project.

The primary mechanism by which this arises is the treatment of system "fixed" costs, namely, the primary water storage facilities upstream of the Sacramento Delta. Potential recipients of water from the SWP were required at the beginning of the project to sign contracts promising to pay for above-Delta projects in proportion to their contractual water delivery schedule. Those who contracted for more "firm" water pay for more of the water conservation and storage projects. The cost share and the water delivery share are identical. What contractors are buying when they enter the SWP contract is an *option to buy* up to the stated amounts of water in each year listed in the contract. When water is actually delivered, a water toll, stated to represent the cost of operation, maintenance, repair, and power, is assessed. For example, a water contractor with 500,000 acre-feet of "firm" water from the SWP for 1978 has the legal option to buy and have delivered up to 500,000 acre-feet at the going water charge for delivery. This charge ranges from \$1 to \$150 per acre-foot, depending upon the length of conduit and the total altitude gain required for pumping the water to the customer. There are three unusual aspects to this contract that are important for purposes of efficient water use:

1. The options to buy SWP water are not generally transactable. They cannot be freely bought, sold, or leased, without approval of the SWP, and the current policy of the SWP is to deny transfers.
2. The contractors agree to an open-ended cost structure for basic water conservation facilities. They agree in advance to pay for *whatever* projects the SWP decides to pursue.

<sup>1</sup> Some uses of general funds and tidelands oil revenues for "non-reimbursable" projects are the exception.

3. When conservation facilities are added at a cost per unit of capacity greater than the original facilities, the capital costs are *averaged in*. Capital expansion of the SWP is priced to the water user at its average cost, which is currently far, far below the incremental (marginal) cost to society to make such capital additions. The economic profit from earlier, cheaper projects can be used only for the purposes of expanding the system. This profit could be something on the order of \$50 million per year for the SWP, and the sole uses to which this can be put (i.e., water development) could lead to considerable unnecessary or premature water development in the SWP.<sup>2</sup>

A graphical presentation of the concept of economic profit will explain better the issue at hand. In this presentation, a considerable abstraction from reality will be depicted, but the essential features of the problem will be retained.<sup>3</sup>

Consider a capacity cost curve for water as represented by the step function labeled S in Fig. 4. The first step represents the cost per unit of capacity up to the maximum size of the most favorable dam site, e.g., the Oroville Dam on the Feather River. The next step up represents the cost of adding to the system in the most favorable way, e.g., by construction of proposed elements of Senate Bill 346, including, e.g., the Glenn Reservoir, Cottonwood Reservoir, or Los Banos Grandes Reservoir. The Oroville Project has a payoff schedule that represents approximately \$10 per acre-foot, and is the basic "Delta charge" for SWP contractors. This project, together with withdrawals from the Delta itself, represents approximately 2.3 MAF of water per year on average. Proposed projects, listed above, provide additional water with amortized *capacity* costs of \$37 to \$245 per acre-foot of water, or an order of magnitude higher than the original Oroville facility, to give some idea of the height of the "step" in the cost function.

The demand curves labeled  $D_1$ ,  $D_2$ , and  $D_3$  represent the maximum amounts that buyers within the SWP would be willing to pay for water of a given amount, under three separate sets of events. These are the aggregate of a set of demand curves from individual water districts that contract with the SWP, and those demand curves represent the aggregate of all users' demand curves within the water districts. The demand curve slopes downward because users individually and collectively desire less water as the price rises. The extent to which this is true, and the magnitudes of adjustment to water price differentials, are discussed in the appendix.

The economic profit associated with this water "market" depends upon where the demand curve truly lies. Suppose that the true demand curve was  $D_1$  when the original SWP was built ("Situation 1"). It would have been sized exactly correctly, and there would be no economic profit associated with the SWP. All of the costs would exactly be paid by the water users, and the charge of  $p_1$  would exactly cover total costs. Suppose that through growth in population, growth in income, or a

<sup>2</sup> Deliveries are 2.3 MAF per year. If the true marginal value of water is \$20 per acre-foot higher than the price the SWP charges, then the economic profit is  $2.3 \times \$20 \times 10^6 = \$50$  million.

<sup>3</sup> It is assumed that each increment to the water system can be obtained at a constant cost per unit of capacity. In reality, marginal costs for a specific project may decline, since the capacity of a dam can be raised by a given percentage with less than the same percentage increase in cost. However, each dam site eventually reaches a point of maximum development, at which time costs typically rise when consideration of the next best dam site is included. Second, the discontinuity in capacity cost may not be as abrupt as specified, e.g., if groundwater can be used as the incremental water source.

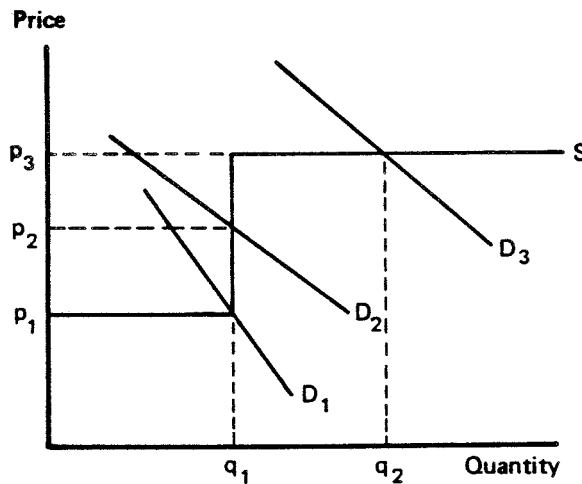


Fig. 4 — Hypothetical SWP pricing and water use under marginal cost pricing

climatic change, for example, the demand curve shifts to  $D_2$  ("Situation 2"). Here the desirable and "welfare maximizing" solution is to raise the price to all users to  $p_2$ , so that the market just "clears." The same total quantity of water would be delivered as before, since by assumption, no new supply would be built. The economic profit under such a system is the price differential  $p_2 - p_1$  for each unit of water sold, or the product  $(p_2 - p_1)q_1$  in total. It does not matter whether the SWP retains that profit, or the contractors retain it: *The economic profit is still there.* The value of a small increment of water to its users is  $p_2$ . If the SWP continues to sell the water for  $p_1$ , the contractors receive the economic profit. If they could resell water among themselves in Situation 2, they would almost certainly reallocate the water differently than when they originally chose water quantities in Situation 1 (demand curve  $D_1$ ). It is also important to notice that it would not be economically efficient to build any additions to the SWP at this occasion if the cost structure is as indicated.

Suppose now that the demand curve had shifted instead to  $D_3$  instead of  $D_2$  ("Situation 3"). Here, it would be desirable to build additional facilities (so that total capacity was  $q_2$ ). The welfare maximizing behavior is to sell water at  $p_3$ , in which case the SWP produces an economic profit of  $(p_3 - p_1)q_1$ . The economic profit goes to the contractors, if the water is sold at  $p_1$ , or is shared between the SWP and the contractors at any intermediate price. However, the price at which water is to be sold will in a large part determine the amount of capacity sought by the SWP buyers. It is to this question that we must now turn.

The SWP contract specifies that the "Delta charge" must exactly cover the total accounting cost of above-Delta conservation facilities. Under the cost structure previously described, the average accounting cost curve can be portrayed as in Fig. 5, constant up to quantity  $q_1$ , and then rising upward and eventually approaching  $p_3$  as the capacity expansion becomes very large. (It will never reach  $p_3$ , and certainly in "real life" it would be necessary to "stairstep" to an even more expensive project. The appendix estimates how this average cost would rise if the SWP constructed proposed facilities without federal subsidy.)

Consider now what would happen in Situation 2 with demand curve  $D_2$ . Under the actual SWP contract system, there would be an expansion to  $q_2$ , and water would be sold at a price,  $p_2$ . This is because buyers would seek to expand the water system until more water gave marginal benefit equal to the *average* cost of the system. This price would, by construct, exactly pay for the above-Delta system as a whole. But the pricing system *must* lead buyers to ask for more water than would be the case if water to the water supply system were priced at *marginal cost*. (The clearest indication of this would be to ask clients of every SWP contractor how much new water they would desire at an annual capacity cost of \$150+ per acre-foot.) The economic profit from the first project can be used, under the SWP contract, only to subsidize further construction, and this leads to inefficient development of water systems, and inefficient use of existing water.

The same problem arises in Situation 3. There is, as before, some desirable expansion of the water system, but with the pricing of new projects at the average cost of the system, there is overdevelopment. Under the current SWP system, Situation 3 leads to eventual capacity of  $q_4$ , if the contractors' desires are met. The inefficiency is measured by the overbuilding  $q_4 - q_3$ , and the welfare loss associated with that overdevelopment is the difference between actual incremental costs and actual benefit, i.e., the shaded triangular area in Fig. 5.<sup>4</sup>

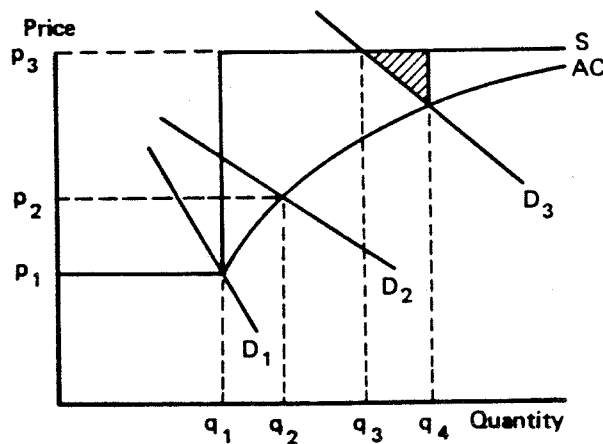


Fig. 5 — Hypothetical SWP pricing and water use under average cost pricing

<sup>4</sup> Gardner Brown, in an analysis of the SWP, attempts to show that the failure to charge a scarcity cost to water probably leads to a very small extra expansion of the SWP [27]. His analysis is incorrect for two reasons—one structural and one factual. First he presumes that the increase in water development cost would be only 50 percent above the cost of the Oroville facility. The current proposed facilities have per-acre-foot cost increases of 350 percent to 2500 percent above Oroville on a per-acre-foot basis. Second, he fails to realize that the increase in water price to the contractors of the SWP would not be 50 percent if a 50 percent more expensive facility were built. Depending on the relative sizes of the new and old facilities, the average cost to the contractors would rise much less than that. Brown also chooses a price elasticity of  $-.5$ , which is one of the smallest reported in the literature. At higher prices (\$25/acre-foot), elasticity estimates of  $-1.0$  to  $-4.0$  are found in the literature (see the appendix).

There appear to be two important modifications necessary to lead to efficient water use within the SWP. First and foremost would be to allow SWP firm water shares to be freely transacted. Another important question is how the firm yield shares to the SWP should originally be priced, and how the financial integrity of the SWP could be guaranteed.

The SWP contract specifies a "Delta charge" to pay for the water conservation structure of the SWP and a variable charge to pay for variable costs. (Buyer-specific transportation systems are also priced separately.) The sum of these is intended to meet total costs of the SWP. For purposes of maintaining the SWP as a nonprofit entity, it makes sense to have the variable water toll continue to be priced as under current practice. The question then becomes one of deciding the appropriate price at which to sell firm yield shares.

If the SWP continues to price its firm yield shares to initial buyers at the *average* cost of water within the SWP, this will lead to too much water being requested by the contractors. The apparent demands on the system will be larger than would be the case if water were priced at marginal cost.

Two changes can be suggested to introduce full marginal cost pricing to the SWP contract. (Both of these assume that variable costs continue to be treated as under current practice.) The first would be to alter the contracts of the SWP so that entitlement water was sold at the marginal capital cost. If a new project is added at the contractors' behest, costing \$150 per acre-foot for capacity alone, then *all* water would be sold at \$150 per acre-foot. Current analysis of water demand suggests that there would be few if any contracts sought at such a price. The Peripheral Canal has capacity costs of \$39 to \$78 per acre-foot, depending on its yield (see the appendix) and it is conceivable that this component of the SWP would be demanded even at full marginal cost. But even selling all SWP water at \$39 per acre-foot for the Delta charge would make the SWP an enormous profitmaking center for the state, earning at least \$60 million annually in new revenues, at current water use levels. This solution violates existing contracts and principles of the SWP, and would certainly be offensive to current SWP contractors.

An alternative would be to allocate existing water from low-priced sources according to previously stated amounts of water deliveries planned (for example, proportional to ultimate firm yield volumes), and to continue to price those at the Delta charge currently existing. However, any expansions of the water system could be priced at their full marginal cost, and buyers of new project water would be faced with the decision of paying \$150+ per acre-foot for new capacity or finding other water sources. The existing distribution of income among the water agencies would be preserved, and yet the SWP would be put onto a marginal cost footing for water development.

There would be several implications for local water districts. We have earlier argued that if local water districts price each source of water sold at its marginal cost, and also allow transactions in rights to water among its users, efficient use patterns will emerge. Once the SWP enters into a true multiple-facility structure, with the marginal costs differing by project, then the SWP must in effect treat each of those projects as independent if it is to induce efficient demand for water development. This requires that each agency contracting with the SWP issue shares *to each facility of the SWP as a separate source of water* to each water user, with each water user presumably paying the full marginal cost for these new shares. Among other

reasons, it is because of the rapidly increasing marginal costs of water supply to the SWP that it is necessary to have local water districts separating their water supplies by source, and charging the full cost for each source. Only through such a mechanism will the SWP be able to avoid the circumstance where they price water to contractors at full marginal cost, but find that the local water districts price at average cost to their water users. This unfortunately adds to the complexity of the accounting that will be required to maintain an efficient water market, but it is the only mechanism we have been able to construct that would stimulate efficiency of water use within the SWP system, while still retaining the zero-profit constraints on the SWP and local districts.

## VIII. THE BUREAU OF RECLAMATION'S CVP

A considerable amount of water supplied within the State of California is developed and delivered by the Bureau of Reclamation's CVP. Under the 1902 Reclamation Act, the CVP develops water and sells it to contractors under certain restrictions that do not apply to other water use within the state. By far the most important of these restrictions is the "160 acre limit," which is the operational definition of a family farm to which the subsidies of the CVP are intended to be passed. The second restriction of importance here is that the bureau maintains title to the water after it passes out of the service area in which it was originally delivered. CVP water is typically delivered to water districts, rather than individual farmers, although there are some small amounts of water delivered directly to farmers. Indeed, many water districts have been formed specifically for the purpose of receiving and distributing CVP water.

The restrictions on water use imposed by the CVP are severe in terms of the potential effects on water use efficiency. However, both the intent and the effect of the subsidization of family farming within the CVP can be retained while efficiency of use is potentially enhanced through a simple change in operations of the bureau. Congressional action is almost certainly required to accomplish this change.

The change, in parallel with our previous discussions of water rights assignment within water districts, is to have local water districts assign shares to the CVP water, just as for water from other sources, and have those shares *tradable*. This, of course, requires CVP approval, both to allow the shares to be sold, and for the CVP to forgo ownership of the water once it leaves the original point of service.

The intent of the CVP to subsidize family farms would be maintained under this proposed modification, because the sales of water would be purely voluntary by current CVP beneficiaries. They would be able to farm with all the water they were allocated from the CVP if they wished, and could sell part or all of it for other use if that proved to be a better financial opportunity, but the family farm concept would not be damaged by this type of transaction.

There exists also a potential intergenerational transfer of wealth associated with such a CVP reauthorization, depending on how title assignment was carried out. If the title is assigned in perpetuity to current recipients of CVP water, they would capitalize all future benefits of the CVP themselves. If the title is assigned on a shorter-term basis, e.g., year by year or in five-year intervals, then current family farms would receive the CVP benefits only so long as they remained in farming. Future farmers would also share in that benefit to the extent that they were reallocated the shares to CVP output.

The CVP, like the SWP, would be faced with the prospect of having to price both current water development and future water development under a revised concept of water use. With resale of water as one potential use of CVP water, the concept of "ability to pay" that is currently used for pricing of some CVP water is rather meaningless. If the CVP is to retain its current zero-profit status, and also were to price in an efficiency-inducing manner, it would best be moved to a facility-by-facility pricing structure for water just as has been proposed for the SWP in a previous section of this report.



We recommend that the state initiate action with the federal government to achieve these changes in CVP authorization, as a part of other efficiency-inducing activities undertaken.

## IX. RECOMMENDATIONS AND CONCLUSIONS

In this report, we have reviewed the operations and legal basis for water rights allocation within the State of California, with particular emphasis on the incentives arising within that structure to use water efficiently. We find that incentives are currently lacking, but that changes are available that would enhance the efficiency of water use. These changes would cause little or no change in many water users' situations, and could be structured to leave many if not all of them at least as well off as they are now if they do nothing in response to the incentives we propose be introduced. However, we believe the evidence is strong that there would be a response to the incentives, and that *voluntary* transactions in water would take place with more frequency and volume than is currently observed within the state. In voluntary transactions, both parties have by definition been made better off. Thus the aggregate of society would almost certainly be improved by enhanced trading of water. Two areas where this conclusion must be tempered—groundwater extraction and return flow use of water—appear to be tractable problems. The simultaneous introduction of a groundwater management system and a better definition of property rights to return flows of water will help eliminate "externalities" in both of these areas, so that the enhanced trading of water will benefit the state.

The modifications in water law and institutions that would enhance efficiency of use are summarized here:

1. Pricing structures of water supply agencies in general promote inefficient use of water. Prominent among the problems in water pricing are use of average cost pricing (particularly where water supplies come from different sources within the same agency and have different costs of supply), and use of taxation to finance costs of the water districts and water supply agencies (particularly where taxation is used to finance operating costs). Several alternative pricing policies are presented to alleviate the inefficiency generated by current pricing policies. Full marginal cost pricing of water supply is one solution, but that will almost certainly violate the zero-profit constraint of the water districts. A second option of increasing block pricing policies is available both for agricultural districts and for municipal and industrial water agencies. However, implementing an increasing block pricing structure might be a problem in water districts with considerable diversity in size of water users. An increasing block pricing structure based on acres owned (rather than on total water use) provides one alternative that may be more acceptable politically in such situations, but it has the disadvantage that there are incentives to increase the amount of land in agricultural production, which may be undesirable.

2. The second source of inefficiency in water use within the state is the lack of strong incentives for water trading and sales. There are also present some institutional and legal restrictions on water sales. Removal of the impediments is an obvious policy prescription, and one shared by such diverse groups as the National Water Commission, the Governor's Commission to Review California's Water Rights Law, and many other observers of the water market (e.g., Hirshleifer,

DeHaven, and Milliman [12]). The lack of incentives for individuals to engage in water sales also seems of major importance to us. Under existing water district operations, there is little incentive to make water available for transfer, since the original water user often cannot capture the returns from selling the water. We have proposed a modification in water district operations that should enhance those incentives, namely, to make clear assignment of the water available within a district to the members, with a sufficient title to that water that it can be resold by the recipient if desired. Such a system faces many potential problems in implementation. The assignment of property rights to the water supplies of a district may result in a redistribution of wealth within the district that differs substantially from current practice. The mechanisms by which rights to water supplies would be assigned would likely be a source of major controversy within districts. Some legal impediments may be faced as well. The choice of mechanism by which title is transferred to water users may be important. If the transfer is viewed as a sale of appropriative water, then any resale could in concept be subject to hearings by the SWRCB. How the board would deal with a large volume of requests for transfer is a subject we could not analyze. It is possible that legislative action could establish a set of conditions under which some transfers could automatically take place, while others remained subject to usual SWRCB proceedings. With such a system, the Legislature could build checks into the magnitude of transfers to alleviate concerns that too much water might be moved out of one region into another through a series of voluntary transfers.

3. Federal reauthorization of the CVP to allow resale of Bureau of Reclamation water by family farmers would enhance the amount of water available for potential sale. The CVP would also have to give up rights to return flows to existing water uses within the CVP for sales to be meaningful. If a water market is desired within the state, then authorities should also consider seeking federal reauthorization of the CVP. Average cost pricing by the CVP also promotes inefficiency (see below).

4. The SWP's own contract specifies average cost pricing of water supplies. This can be shown to lead to inefficient demands for water, because users face only the average cost (near \$20 for proposed expansion of the SWP), when the marginal costs could rise above \$84 or even above \$200, depending on which elements of the SWP will be constructed to meet contractual demands. Water use would proceed at a more efficient level within the SWP if that contractual feature could be removed, so that the SWP sold water basically through an increasing block pricing structure. It is shown that if demands for water remain unchanged under such a system of pricing, the same costs would be borne by water using agencies and their members as is true under the existing contract.

The current contract will lead the SWP into constructing water supplies at marginal costs above \$100, and possibly above \$200 per acre-foot, while users will face a marginal price for that water that is considerably lower—possibly near \$20 or \$25. We do not know if such a contract would withstand a legal test of reasonable and beneficial use, but the contract certainly cannot withstand a test of efficient use of the state's water resources.

5. An expanded water market will almost certainly lead to increased sales of water rights from northern to more southern parts of California, with a likely increase in groundwater extraction in the northern areas. Thus, as discussed in companion reports, there may be considerable value to installation of groundwater

management entities throughout the state, even in areas where there is currently no appreciable overdraft of the water basins. These issues are not discussed in detail in this report, but are raised here for completeness.

6. The rights to return flows of water must be better defined. Under current law, these rights are in some cases poorly defined, with return flows from imported water having the perceived possibility, at least, of being available for later appropriation. Existing dependence of appropriators on return flows of other appropriators could be quantified, and existing procedures regarding availability of return flows could be strengthened beyond existing administrative procedure in the SWRCB. This will reduce transactions costs in the case where a change in point of use is contemplated, thus enhancing the ability of participants to make transfers. Such a change is beneficial unless remaining transactions costs are so large as to leave significant externalities still present in the system.

These changes will almost certainly benefit existing water users throughout the state, who can be made at least as well off collectively as they are currently. Enhancing the ability of these users to voluntarily buy and sell water among themselves can only lead to benefit to those parties. Under no circumstances are we recommending that water rights be reassigned or reallocated in a fashion that would cause involuntary changes in water use. While no firm predictions can be made on the basis of existing data, there are indications that such a system of transfers could offset or delay the need for construction to augment the water supply for the state with new dam construction. Thus the \$3+ billion in dam construction now proposed for the state might be eliminated or postponed into the more distant future, either of which action confers a substantial savings for California water users and the state as a whole. The added benefits of having fewer environmental disruptions from these added dams would be a plus from this arrangement that we have not attempted to quantify.

We believe that it is important to reiterate that the changes proposed here will leave water use within the state largely unchanged unless current water users voluntarily change their patterns of water use. But the evidence available to us strongly suggests that when the appropriate incentives are presented to current water users, they will respond by making their water use more efficient, that water within the state will on average be put to higher-valued uses, and that the construction of new and expensive facilities for water development can be postponed or eliminated after the water users of the state respond to the incentives we propose be established.

## Appendix

### THE DEMAND FOR WATER AND STATE WATER PROJECT COSTS AND COST ALLOCATIONS

#### DEMAND FOR WATER

In agriculture (and in other commercial enterprises) the value of water is determined in general by how much additional use of water will add to the profitability of the farming operation. Many adjustments in the patterns of water use are possible. At a general level, the amount of land involved in agricultural production can be expected to vary with the price of water. Unfortunately, no reliable estimates exist; nor could estimates be made with available data of the extent to which land use and land prices respond to water price. Given the amount of land in production, simply altering crop patterns also has substantial impact on water use. The average amount of water applied for irrigation of crops ranges from 8-11 acre-feet annually per acre of land for rice to well below 3 acre-feet annually per acre for crops such as barley, tomatoes, sugar beets, truck crops, and grapes. Consumptive use is less than applied use, because of return flows and groundwater recharge. Water use obviously varies considerably with soil conditions, rainfall, and ambient temperature. But it also varies by price of water, even holding constant the region, soil type, and crop. The method of irrigation chosen, subject to general constraints on salt leaching, can also significantly affect water use; also, farmers can choose to irrigate with less water, thereby harvesting fewer crops, or to use greater amounts of water to enhance the crop output.

It is difficult to find studies of the responsiveness of water use when allowing all of these factors to be controlled for, and the responsiveness of water use to price may still vary because of other conditions. Nevertheless, the available literature on California agriculture still reaches the consensus that water price affects agricultural water use. Bain et al. [13] found that a 1 percent rise in the price of water reduced water use by .64 percent, although their study did not allow the amount of land in agricultural production to vary. A number of linear programming studies of water use within California (Moore, Snyder, and Sun [4]; Shumway et al. [28]; Moore [29]) all show rates of response to water prices that depend on the price of water. Studies have found that when water costs \$15 to \$20 per acre-foot, water use declines by 2 to 4 percent for each 1 percent increase in the price of water in such areas as the San Joaquin Valley, the Imperial Valley, Tulare, and the Sacramento Valley. (See Schelhorse et al. [17] for a summary of this literature.) These studies are based either on observed water use and price combinations or on linear-programming estimation techniques that replicate the cost-minimizing behavior of farmers in these regions.

The response observed under historical conditions might not be extremely useful in predicting changes in demand for agricultural water if substantial water transfers become possible. Development of a water market could lead to water prices at the Delta of about \$15 to \$30 per acre-foot—the exact amount is impossible to predict with present data. At those prices, farmers who currently face water costs

of \$1 or so per acre-foot would suddenly have the opportunity to sell water for, say, \$20 per acre-foot, and might decide not to use so much water in their own operations if its marginal value to them were less than that amount. How rapidly and how much their demands for water would adjust to the new water prices cannot be forecast with certainty. Available studies that have attempted to estimate demand for water costing about \$20 to \$35 per acre-foot in some areas of the state have found that water use would decline substantially (Hedges [23]). Unfortunately, the techniques used to calculate this demand hold constant the price of land, and it seems apparent that land prices themselves would vary with the price of water. It is important to realize, from a technical point of view, that these studies become more reliable when land prices do not change. Land prices will not change significantly, and in fact may increase slightly, if the allocation of water rights within a water district is made proportional to land area. This is because the land value will capture the value of the water, whether the water is used on that land or sold elsewhere.

In summary, we expect from available studies that agricultural water use would respond, possibly substantially to changes in water prices. The most obvious adjustment would be seen in modification of cropping patterns (see Hedges [23]).

Urban water use accounts for another 13 percent of water use within the state, divided roughly evenly between residential use and commercial/industrial use. The remainder of water use is accounted for by fish, wildlife, and recreational activities, and (.1 percent) by power plant cooling. In concept, water has value to consumers in each of these categories. Homeowners value the water for its irrigation of their landscapes, for cleaning people and dishes within homes, and for providing a key element in the sanitation systems of cities and homes. It also provides fire-fighting capability, cleans streets, and creates greener parks. In each of these uses, there is in concept a value to water that consumers would be willing to pay to receive more water for those uses. When consumers turn on the taps at their houses, they indicate a willingness to pay at least the billed cost of water per unit. When they turn the taps off, they indicate that additional uses of water are then not worth the costs to them.

Economists generally assume that for any commodity, the additional value people place on additional amounts of the commodity will fall as the amount of consumption increases. This relationship is generally summarized in a demand curve for water, which indicates the maximum amount that consumers would be willing to pay to receive various amounts of the commodity. The demand curve evidences a negative relationship between amounts used and the price people are willing to pay. The literature is replete with studies showing that this negative relationship holds over a broad range of circumstances. Within California, studies by Conley [30], Morgan [31], and Bain et al. [13], and within western states, studies by Howe and Linaweaver [32], Young [33], and Hanke [34], all show substantial negative relationships between household water use and price of water. An excellent summary of this literature is presented in Schelhorse et al. [17]. The consensus of this literature is that as price rises by 1 percent, demand will fall by some .5 percent to 1 percent or more.<sup>1</sup> This relationship is well established in

<sup>1</sup> This is summarized in the concept of a price elasticity of demand, which is the ratio of the percentage change in quantity divided by the percentage change in price. The elasticity estimates for California urban use range from -.3 (Schelhorse et al. [17]) to -1.1 (Bain, Caves, and Margolis [13]; and Conley [30]).

statistical analysis, and the general reliability of results across studies lends confidence to the belief that the general magnitude of the price responsiveness is well understood.

## STATE WATER PROJECT COSTS AND COST ALLOCATIONS

The State Water Project contract specifies the method by which construction costs will be repaid by contractors during the next decades. The technique used is financially sound and would have no unfortunate economic incentives embedded in it if construction costs for new facilities could proceed at the same cost per acre-foot of capacity as initial facilities' costs. Unfortunately, new projects are more costly, and the pricing system specified in the SWP contracts induces the overdevelopment of water.

The contract specifies that the average costs of facilities be paid by contractors. In effect, a loan is taken out by the contractors to construct the SWP facilities and the repayment schedule is made proportional to actual water deliveries. The mechanism used for this is to calculate the discounted present value of all costs incurred by the SWP for capital and to divide that expenditure by the discounted present value of all water quantities remaining to be delivered. The discounting rate employed is the average interest rate of the bonds used for the project. Thus, the payments through time must exactly equal the costs, including the interest on the loans outstanding.

Under recent amendments to the contract, new project facilities' costs are added to the Delta charge only as the costs are actually incurred—under previous contracts, those costs could be added into the contracted Delta charge sooner. The current Delta charge includes a payment of some \$3.60 per acre-foot for Delta transfer facilities (the Peripheral Canal), which will apply to all water deliveries for the project through the 50 year repayment period. The costs for capital components of the SWP are presented in Table A.1.

Table A.1

### SWP CAPITAL CONSTRUCTION COSTS AS CALCULATED BY SWP

Period Commencing in	Present Value of Remaining Capital Costs Reimbursable by Contractors (\$ millions)	Quantities of Future Water Remaining to Be Delivered (MAF)	Cost per AF (\$)
1977	572	72.7	7.86
1984	667	59.8	11.17
1988	734	51.0	14.39
1992	742	42.0	17.67
1996 (to 2035)	680	34.14	19.93

SOURCE: Ref. 22, Table B-20.

The increments in capital costs are associated with four construction activities, specified as Phase I through Phase IV, with financing "entirely by the state." The DWR Bulletin [22] describes these projects as follows:

The first Phase with about . . . 300,000 acre-feet of yield would be capable of meeting the increased demand in 1988. Increases in demands after 1988 would be met by the second, third, and fourth phases, which provide yields of . . . 300,000, 300,000, and 200,000 acre-feet, respectively.

In other words, the tables in Bulletin No. 132-76 assume that 1.1 MAF of capacity will be constructed, adding some \$12 per acre-foot to the average cost of the SWP's system. These estimates have now proven to be unrealistically low, if indeed the capacity expansion is to be financed "entirely by the state." If the projects proposed in S.B. 346 are those available for expansion of the SWP, then a more accurate accounting of the system costs can be made.

A true accounting of the social costs of the S.B. 346 component reveals a different picture. Part of the problem lies in choices for the discount rate to be used on the project. While the average interest rate on current SWP funds is 4.462 percent, the marginal rate on new revenue bonds to finance any new construction is presumed by the SWP to be 7 percent.<sup>2</sup> The actual interest cost of SWP bonds will depend on the perceived risk within the financial community at the time of issue. The current estimate of 7 percent interest rate on these bonds is probably a reasonable approximation of the eventual outcome.

An important question is the actual firm "yield" of the Peripheral Canal. That yield is highly dependent upon water quality standards set by the SWRCB and other agencies involved in the Four-Agency Fish Agreement, the other agencies being state and federal fish and wildlife agencies and federal water quality agencies. If the currently proposed standard of water quality for dry years is reached, then the yield of the canal will be approximately 1 MAF per year. If that standard is not reached, but rather the existing SWRCB-imposed standards are maintained, then the yield will be .5 MAF per year. Since the Peripheral Canal is generally the least-expensive component of the S.B. 346 package, this means that an additional .5 MAF of much more expensive yield must be found to maintain the same level of firm yield water supply. Further, it is generally assumed that the Peripheral Canal is required to transport any additional water acquired through other conservation facilities development. We place the firm yield of the existing facilities (primarily Oroville Dam) at 2.1 MAF per year, although this number is not explicitly stated in Bulletin 132-76. (The contracts specify an eventual delivery of 4.23 MAF per year, and the proposed new facilities are specified to contain 1.1 MAF of yield. Thus, the implicit yield of Oroville plus the cross-Delta facility must be 3.13 MAF. If the Peripheral Canal is assumed to have 1 MAF of yield, then the Oroville complex must yield 2.13 MAF. This is also consistent with projected entitlement deliveries through time, as shown in Table B-4 of Bulletin No. 132-76.)

The yield and costs of the SWP system are shown in Tables A.2 and A.3 under these assumptions. Choices of different incremental additions to the system would modify slightly the actual numbers. If the projects are built and shared jointly with

<sup>2</sup> In fact, current tax-free revenue bonds from public agencies throughout the country bear current yields of near this amount [35]. New York City bonds produced yields of over 8 to 9 percent. Revenue bonds associated with the Alaskan pipeline have current yields of approximately 5.75 to 6.38 percent.



the CVP, roughly the same picture emerges, if cost-sharing between the CVP and the SWP is equal to shares of output of the various facilities.

Table A.2

PROJECT YIELD AND AVERAGE AND MARGINAL COSTS OF SWP  
WITH FOUR-AGENCY FISH AGREEMENT ADOPTED  
(7 percent interest rate, 50 year loan for new projects)

Facility	Total Cost of Construction (\$ thousands)	Marginal Yield (MAF)	Cumulative Yield (MAF)	Average Capital Cost/AF of Yield (\$)	Marginal Capital Cost/AF of Yield (\$)
Oroville	429 <sup>a</sup>	2.1	2.1	10 <sup>b</sup>	10
Peripheral Canal	540	1.0	3.1	19	39
Glenn	1,160	1.0	4.2	34	84

<sup>a</sup>Reference 22, Table 8.

<sup>b</sup>A 50 year level repayment of \$429 million at 4.46 percent requires \$21.57 million annually. At deliveries of 2.1 MAF per year, this gives a capital cost per acre-foot of \$10.

Table A.3

PROJECT YIELD AND AVERAGE AND MARGINAL COSTS OF SWP  
WITH CURRENT DELTA WATER STANDARDS

Facility	Total Cost of Construction (\$ millions)	Marginal Yield (MAF)	Cumulative Yield (MAF)	Average Capital Cost/AF of Yield (\$)	Marginal Capital Cost/AF of Yield (\$)
Oroville	429 <sup>a</sup>	2.1	2.1	10 <sup>b</sup>	10
Peripheral Canal	540	0.5	2.6	23	78
Glenn	1,160	1.0	3.6	40	84
Colusa	910	0.46	4.06	52	143
Los Vaqueros	540	0.16	4.2	59	245

<sup>a</sup>Reference 22, Table 8.

<sup>b</sup>A 50 year level repayment of \$429 million at 4.46 percent requires \$21.57 million annually. At deliveries of 2.1 MAF per year, this gives a capital cost per acre-foot of \$10.

Two comments must be made to clarify apparent discrepancies between our calculations and those shown in Table A.1. The DWR method of calculating capital repayment rates provides for an increasing repayment rate per acre-foot through time, rising from the current \$7.86 per acre-foot to an eventual \$19.93 per acre-foot. For simplicity, we have calculated a level annual repayment schedule for the current conservation facilities (\$10 per acre-foot at 4.462 percent interest), and a similar repayment structure for assumed future construction, using a 7 percent interest rate. Second, the \$10 per acre-foot calculation does not include any payment for cross-Delta facilities, even though part of the current "Delta charge" of the SWP does have such an inclusion. Because the actual Delta charge of the SWP contract is computed on the basis of discounted remaining capital costs and discounted remaining water deliveries, the numbers appearing in Tables A.2 and A.3 do not directly reflect the amounts in any specific year that would be incorporated into the capital component of the Delta charge. Rather, they reflect the amount that would have to be raised on a level annual payment basis to pay the construction costs incurred.

Two elements are key: The first is that the Four-Agency Fish Agreement is a dominant factor in determining how costly the state's future water development will be. If the Peripheral Canal can yield 1 MAF per year, construction of very expensive facilities (e.g., Colusa and Los Vaqueros) can be forestalled or eliminated.

The second and perhaps more important point is the major discrepancy between average and marginal costs of the SWP under these proposed construction plans. Even under the best scenario, where the Peripheral Canal and Glenn Reservoir together fulfill the SWP contractual agreements for 4.2 MAF of water, marginal costs are nearly 2.5 times the average costs of the SWP capital component. Since contractors and the water users among those contractors view the average cost of the system as the relevant cost of adding capacity, there will be strong incentives for overconstruction. Under the less favorable situation (the current Delta quality standards must be maintained), marginal costs rise well in excess of \$200 per acre-foot of yield to fulfill the contractual agreements of the SWP.

These conclusions are not very sensitive to the actual choices of projects within the SWP. For example, if the Cottonwood Creek project is used instead of Los Vaqueros, the marginal system costs will fall to \$183, rather than the \$245 indicated for Los Vaqueros, and the average costs will fall to \$52. Timely introduction of Southern California groundwater recharge and extraction facilities promises to reduce system costs of firm yield, but the mechanisms for this have not yet been developed.

### **Approximating the Welfare Loss Resulting from Inappropriate Pricing**

A simple model establishes a technique for estimating the welfare loss resulting from inappropriate water pricing in California, based upon estimates of price elasticities of demand for water and variation in water prices. If we specify water use of any individual as  $y_i$ , the price he faces as  $p_i$ , and his demand responds to water price, then a linear approximation to his demand curve is

$$y_i = a + b \cdot p_i$$

where  $a$  is the amount he would consume at  $p = 0$ , and  $b$  reflects the sensitivity of his water use to price, i.e.,  $b < 0$ . If water is mispriced to him from the appropriate price  $p^*$ , then his change in use of water from the appropriate level is

$$\Delta y_i = \frac{dy}{dp} \Delta p_i = b(p_i - p^*).$$

The welfare loss is approximately

$$\frac{1}{2} \Delta y_i \Delta p_i,$$

as Fig. A.1 illustrates. This figure shows two otherwise identical consumers who face water prices of  $p_1$  and  $p_2$ , rather than a price  $p^*$  reflecting the true marginal cost of delivering water to those consumers. Consumer 1 values water at more than it costs to society to deliver to him, but the price  $p_1$  curtails his consumption at an amount  $q_1$ , rather than his using the "optimal" amount  $q^*$ . The triangle A measures the total value lost by consumer 1. Its size is approximately

$$\frac{1}{2}(q_1 - q^*)(p_1 - p^*) = \frac{1}{2} \Delta q_1 \Delta p_1 = \frac{1}{2} b \Delta p_1 \cdot \Delta p_1.$$

Similarly, consumer 2 is consuming water in a range where it costs more to society to deliver that water to him ( $p^*$ ) than he values it at. The triangle B represents the total resource expenditure in addition to the value placed by consumer 2 on the added water ( $q_2 - q^*$ ) received. By similar calculation, its value is approximately

$$\frac{1}{2}(q_2 - q^*)(p_2 - p^*) = \frac{1}{2} b \Delta p_2 \Delta p_2.$$

Adding up such welfare losses to all consumers gives a loss  $L$  as:

$$L = \sum_{i=1}^n \frac{1}{2} b (p_i - p^*)^2.$$

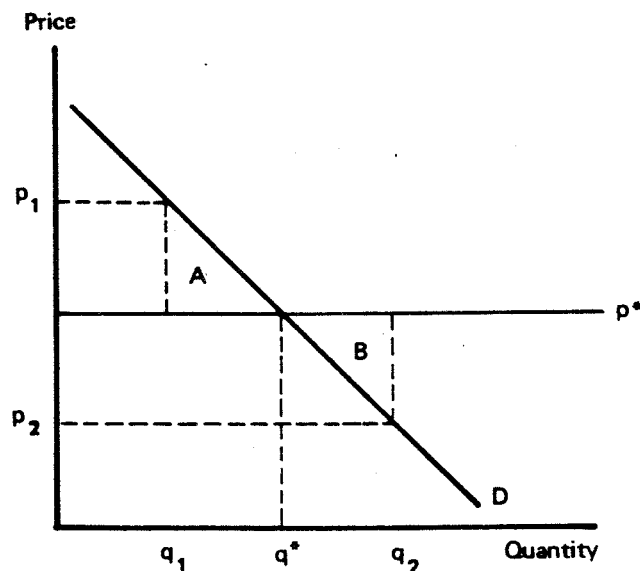


Fig. A.1 — Welfare loss from mispricing of water

This is readily shown to be equivalent to

$$L = \frac{1}{2} \eta \cdot \frac{\sum q_i}{p^*} \cdot \text{Var}(p) = \frac{1}{2} \eta p^* \sum q_i [\text{c.o.v.}(p)]^2,$$

where  $\eta$  is the elasticity of demand for water,  $p^*$  is the *marginal cost* of water to society, and *c.o.v.*( $p$ ) is the coefficient of variation in prices actually facing buyers. All of these terms except the coefficient of variation in prices can be readily determined (to a reasonable approximation) from existing data and studies. The demand studies cited above show that a price elasticity in the range of 2 to 3 is probably appropriate in the range of \$20 for water prices. A conservative estimate is to use a value of 2. The marginal costs of water to society *today* are in excess of \$100 per acre-foot in the San Joaquin Valley, i.e., the costs of pumping groundwater from the deepest basins in that area. This is equivalent to a price at the Delta of something on the order of \$80 per acre-foot, netting out pumping costs. For surface water delivery, the SWP is the marginal supplier, with current costs of expansion (using the Peripheral Canal as the cheapest source) at \$39 per acre-foot, as estimated above. Thus a conservative value, when approximating welfare losses, would be a value of \$40 per acre-foot for  $p^*$ . Total water use in the state is approximately 37 million acre-feet per year on average, providing a value for  $\sum q_i$ . All that remains is to provide estimates of the coefficient of variation in water prices. Our own contacts with water districts in the San Joaquin Valley, and data from an informal survey drawn during 1977 by the state officials, show surface water prices ranging from \$0 per acre-foot in some districts to over \$30 per acre-foot in others. The coefficient of variation within a given area (for example, the San Joaquin Valley) appears to be somewhere between .2 and .5 for surface water; inclusion of groundwater pumping prices would increase the estimate. Using these data, a lower bound on the annual welfare loss to California from mispricing of water can be estimated at approximately \$60 million. If the coefficient of variation is set at .5 instead of .2, this number is raised to \$370 million per year. Evaluating the marginal cost of water at only \$20 per acre-foot halves these numbers, respectively, holding constant the estimated coefficient of variation. The present value of such a loss is indeed considerable. Using a discount rate of 7 percent, the present value of a \$60 million annual welfare loss is nearly \$.85 billion. If the annual welfare loss is more accurately estimated as \$370 million, then the present value of the welfare loss is on the order of \$5.3 billion. It is this wealth loss that should be used when considering the value of a once-and-for-all change in water law and the water industry, rather than the annual rate of welfare loss.

The purpose of this exercise is not to establish a perfect estimate for the welfare loss to California from mispricing of water. Rather, it is to demonstrate that even a cautious estimate of the welfare loss suggests that the present value (wealth) loss from mispricing is at a minimum nearly a billion dollars, and could well range upward to \$5 billion or more. Unless the legal and political costs of modifying the water system toward efficient use exceed that estimated welfare loss, the state should proceed with modifications to eliminate the loss.

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