Economic Efficiency of Water Use and Allocation in California

A Scoping-Level Analysis

For Delta Vision Process

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Summary of Findings and Recommendations

This report identifies key issues related to the economic efficiency of water development, allocation and use in California and discusses general policy changes that might improve economic efficiency. Policy options focus on water pricing, water transfers, water use efficiency (i.e, conservation) and State development and enforcement policies. Analysis is provided at a scoping level of detail. Some important empirical issues that weigh on the relative merits of potential policy changes are not addressed.

Efficiency of water use has never been more important in California. There is a need to save water and money. California has recently made progress in improved economic efficiency of water use, but major issues remain. Also, recent changes in the amount and location of supplies suggest a review of allocation efficiency.

There are two important efficiency topics that this paper does not address in detail. First, economic efficiency of water use for ecosystem purposes is a viable concept, but it is difficult to apply given the state of Delta ecosystem science and the current range of possible futures. We can not quantify the relationship between water and ecosystem functions and values. Therefore, our ability to prescribe efficiency changes related to Delta water for ecosystem purposes is limited.

Second, this paper also does not address the economic efficiency of major new storage or Delta conveyance facilities. The efficiency of specific water supply projects including regional or local conjunctive use and groundwater storage projects are also not considered. These are being addressed in different forums.

This report focuses on other types of uses, allocations and development of water. A variety of potential actions and policies that might improve efficiency in the allocation, use and development of water resources are discussed. Some of the efficiency issues are

- Are water allocations under California's water rights systems efficient?
- If there are inefficiencies, could an effective water transfer market increase efficiency?
- Are there barriers or constraints to water transfer markets that should be removed?
- How could water pricing be changed to increase efficiency?
- How could California encourage efficiency in the use and development of water through incentives such as grants and loans, and through enforcement?

In all cases, our findings represent potential improvements from the perspective of economic efficiency alone. There are usually other, non-economic considerations which would play into the larger question of the laws and policies that might be changed.

In general,

- Some current surface water use may be economically inefficient because the water can not be transferred (riparian rights or no rights), the transfer markets are not robust, and/or because water prices do not reflect total marginal costs including opportunity costs and external costs.

- Groundwater use laws lead to inefficient use and unsustainable overdraft in some groundwater basins. With scarce water conditions and high commodity prices this problem may get worse. Unrestricted ability to pump groundwater limits agricultural users willingness-to-pay for more reliable Delta water supplies.

More specific findings and recommendations for changes to improve economic efficiency of water use are provided below. Some of the recommendations need more development from the analytical, legal, engineering, biological and/or hydrologic perspectives.

Water Pricing

California laws and local initiatives have improved efficiency associated with water pricing but there are still significant opportunities to use water pricing to improve water use efficiency. Efficient water prices should include water opportunity costs provided either as the opportunity to transfer water or directly as part of the price. Many water users are unable to participate fully in markets (see discussion below) and opportunity costs are not included in prices.

- The potential for expanded volumetric pricing for agricultural water in some areas is limited by the accuracy of existing measurement and the costs and accuracy of improved measurement. In some areas these costs may exceed potential efficiency gains.

- There may be important inefficiencies in federal, State and private water pricing because the price charged for energy required to pump and convey the water is less than market rates. On the other hand, some prices include fixed costs, and this would tend to make the prices too high. More analysis is needed.

- For water suppliers, the main purpose of water pricing is cost recovery, not economic efficiency.

- Urban water suppliers normally have several possible revenue mechanisms including volumetric pricing, connection fees and service charges. Tiered water pricing, variable volumetric pricing (prices that change with supply) and connection fees for urban supplies could be used more to obtain more efficient water use. The potential for rate structures using all revenue mechanisms to provide incentives for efficiency while achieving cost recovery and other goals has not been fully explored.

- Efficient connection fees should be based on the incremental cost of developing new supply capacity. Residential connection fees should be varied based on the amount of water supply capacity required by homes. Larger homes should have larger connection fees, and homes that include water saving design and technologies should have smaller fees.

- Some urban water users such as some tenants, guests and club members do not pay a price for their water use. The potential for water pricing to obtain efficient use is very limited in these situations.

- Proposition 218 may be a practical impediment to efficient water pricing where opportunity costs or external costs are not borne by water agencies

Water Use Efficiency

Recent State and water user conservation initiatives in California generally provide a good framework to promote and obtain economically efficient water use.

- Generally, the urban water use efficiency standards and economic framework described in the 1991 MOU and as continuously updated are appropriate and reasonable.

- For water use efficiency analysis from the California perspective, water should be valued based on opportunity costs of energy and water, not necessarily the price paid for water.

- More information is needed regarding the reasons why urban users do not adopt conservation technologies that appear to be efficient.

- There can be important end-user costs and benefits of adopting water use efficiency technologies that should be quantified.

- Water use efficiency standards are most appropriate where actual water users do not pay the price of water.

- Additional research as described by A&N Technical Services (2005) is needed to improve urban water use efficiency estimates

- Legislation and policies to implement the recommendations of the Independent Panel on Appropriate Measurement of Agricultural Water Use (2003) are recommended

Water Transfers

California initiatives have recently improved water transfer markets. However, there are still many constraints in water transfer markets that should be addressed.

- Some unknown amount of water use occurs without any water right. This water use may be relatively inefficient because it can not be transferred.

- Legislation is needed to establish an ability to conduct voluntary water transfers from land irrigated under riparian rights.

- There are opportunities to reduce legal and institutional barriers to water transfers to obtain more efficient water allocation. Currently, some barriers to transfers appear to be cultural and political. Local economic concerns sometimes result in political resistance to transfers. Water transfers might be facilitated if water purveyors and local governments can recover all of their lost revenue and water transfer costs. Laws that facilitate temporary short-term transfers for post-1914 appropriative rights might be extended to pre-1914 rights.

- In the future, research and implementing rules may be needed to expand methods and locations by which real water savings can be made available for transfers; in particular, by non-irrigation and by on-farm conservation. Water transfers from non-irrigation of perennial crops such as irrigated hay, pasture and trees could be enabled by allowing growers to delay the re-establishment or re-planting of the crop.

- There is currently renewed interest in water transfers from in-Delta water users. A review of environmental benefits (such as reduced diversions) and costs (increased subsidence) is suggested.

- The recommendations of the SWRCB's Water Transfer Workgroup (2002) should be thoroughly reviewed and adopted where appropriate.

- Some environmental water uses such as wildlife refuges might participate in water transfer markets as a seller

- Water from out-of-State transfers might be economical for buyers and sellers when conveyance capacity is available. California should work with other Colorado River states to ensure that institutional and legal barriers to interstate transfers can be overcome.

- There are practical limits to water transfers that limit potential for efficiency improvements. In particular, there are conveyance limitations and substantial transactions costs involving measurement and external effects including injury to other water users. Recently, export limits under the Wanger decision combined with flow requirements have reduced the worth of Sacramento River transfers.

State Programs and Incentives

- All State grants for water use efficiency or supply development should require a finding of economic efficiency from the State perspective.

- State grants programs should provide funds to cover a share of costs based on non-local benefits only. This concept has been applied for WUE programs but should be extended to other grant programs as well.

- Water users are required to provide a statement of water diversion and use, but compliance rates are low, and water users in the Delta lowlands do not need to report (Water Code section 5101). This lack of data increases the potential for water use without a water right as well as error in water planning.

- Unauthorized water use may be inefficient from the State perspective. This inefficiency should help provide justification for enforcement.

- Groundwater overdraft conditions are likely to increase significantly relative to the recent past. It is not clear how State laws and policies might best be changed to avoid unnecessary future costs.

New Water Supplies

In the short run, water supplies have become scarcer with dry conditions and new Delta export constraints. In the long run, more supply or water use efficiency is needed to cope with expected growth, the possibility of more water dedicated to ecosystem purposes, aquifers that may be damaged by non-sustainable use, and climate change. The following water supply options, in consideration of all of their economic effects, are believed to be economically efficient from the State perspective now. Their scope and plans for mitigation and implementation may need additional development.

- Land retirement of drainage-impacted lands in the San Luis Unit can avoid financial and environmental costs of drainage and can improve the overall balance between water supply and demand in the Delta export area.

- Legislation and policies are needed to facilitate water transfers, including legislation to enable water transfers from land irrigated using riparian rights, legislation to further reduce impediments to short-term temporary transfers, and policies to expand and clarify agricultural practices that can provide water for transfers.

Modern water supply strategies inevitably involve multiple types of benefits and costs, and management for uncertainty suggests that local water supply portfolios should be diverse. It is hard to generalize about future water supply strategies that may be efficient, but two strategies may deserve more attention.

- In coastal urban regions, innovative methods for capture and use of stormwater. Technologies to capture and treat stormwater for water supply are becoming more economical as stormwater water quality standards increase. If stormwater must be retained and treated then the incremental cost to use it as water supply may be economical. Stormwater retention, treatment and distribution, porous pavement, and rainwater catchment systems and cisterns have potential to contribute water supply while reducing stormwater volume.

- Land management strategies to increase water retention in forested and agricultural areas. These strategies might include forest and grassland management and more intensive management of irrigation water such as pre-irrigation, non-traditional groundwater recharge, and soils modifications. Research is needed to establish potential benefits and land management incentive systems.

Need for Information

The following information is needed to better understand the potential magnitude of some potential efficiency improvements above.

- How much water use is occurring outside of valid water rights?

- How much acreage is irrigated under riparian rights, what is grown and where is it located?

- What are the values urban users place on changes in service from certain water-saving fixtures and appliances such as ultra-low flush toilets, high efficiency washing machines, and landscaping changes?

- How will the changing economy, especially rising oil costs, the declining dollar and the booming agricultural economy affect irrigated acreage, agricultural water use efficiency, groundwater overdraft, and water transfer costs?

The following information needs are case-specific

- How much do water prices differ from marginal opportunity and energy costs under the California perspective?

- How much conveyance capacity in the Delta, the Colorado River Aqueduct and elsewhere may be available to move water transfers?

Table ES-1. Summary of Findings and Recommendations. Economic Efficiency of Conservation and Pricing

No.	Finding	Recommendation	Next Steps
1	Generally, the economic framework for evaluating urban BMPs is appropriate, but some development in addition to 2. to 4. below is advised.	CUWCC should continue improvement of economic methods for urban BMPs as described by A&N Technical Services (2005)	Work with CUWCC to make sure recommended studies, public perception issues and new technology research are adequately addressed.
2	There may be inefficiencies because energy used to pump and convey water is not priced at its market value and some prices include fixed costs.	State should estimate efficient prices from the State economic perspective and use them in State economic analysis.	Detailed study of CVP and SWP energy use and pricing policies to reveal difference between actual price and efficient price.
3	Water pricing rate structures could be improved by more use of variable rates, tiered rates and connection fee conservation incentives.	Providers should develop and implement more efficient water pricing structures within constraints of Proposition 218.	1. Work with advisory groups and providers to develop analysis to determine potential for gains. 2. If justified, work with legislature to improve pricing legislation.
4	Urban water users are not adopting conservation technologies to the extent suggested by some economic studies.	Investigate the relative importance of reasons for low adoption rates including 1) uncounted end-user costs, 2) public perceptions, and 3) a lack of concern because water costs are small.	With CUWCC, develop an analysis to quantify factors and develop an approach to including these factors in marketing and BMP analysis.
5	Agricultural water conservation often provides public benefits, but local and private funding alone will not provide economically desirable levels of WUE.	The State should continue to fund the public share of agricultural WUE. More monitoring of benefits and cost-effectiveness may be helpful. More incentives for agricultural water planning and EWMP implementation should be developed.	Support continuation of DWR's WUE grant program, with linkages to state benefits. Identify and analyze specific monitoring and incentives improvements.
6	Pricing that encourages conservation requires good measurement. A detailed evaluation of agricultural water use measurement was provided by the Independent Panel on Appropriate Measurement of Agricultural Water Use	The State should implement the recommendations of the Independent Panel on Appropriate Measurement of Agricultural Water Use. (2003).	Review and prioritize recommendations and develop action list

Table ES-2. Summary of Findings and Recommendations. Economic Efficiency of Water Transfers and Supply Development

No.	Finding	Recommendation	Next Steps
7	There may be inefficiencies in water allocation because some water users can not fully participate in water markets.	If there is much potential, allow land irrigated under riparian rights to transfer water.	Analysis of riparians to deternine potential for improvement. If justified, change State law to allow transfers from riparian rights
8		Exempt one-year transfers from land irrigated under pre-1914 rights from CEQA	Change law to remove CEQA requirements for pre-1914 one-year transfers
9		Avoid relatively inefficient water use by unauthorized uses; can't be transferred	Enforce water rights
10		Develop policies to enable transfers of real water savings from agricultural conservation, fallowing of more crops, and other real water savings.	Continue research and implement policies to enable more agricultural water users to participate.
11		Recognize that inter-State transfers may become more important in the future	Work with other States to ensure that barriers can be overcome.
12		Consider potential institutional barriers because of County and local agency policies and politics	Work with locals to develop standards and improve broad-based sharing of transfer benefits and overcome barriers.
13		Recommendations provided by SWRCB Transfer Workgroup (2002)	Review and prioritize recommendations and develop action list
14	Some State grants programs have not required a finding of economic feasibility	Require State grants to demonstrate economic feasibility from the State perspective	Work with DWR and SWRCB to change policies
15	Some State grants programs could provide funds that are also covered by local benefits.	Require that local beneficiaries pay a cost share commensurate with local benefits.	Work with DWR and SWRCB to change policies
16	Land retirement in the San Luis Unit appears to be efficient in consideration of all benefits and costs	Facilitate implementation of land retirement alternative	Work with Reclamation to implement land retirement alternative
17	More capture and use of stormwater for water supply may be efficient in coastal regions where retention and treatment will be required anyway	Work with urban coastal stormwater agencies and water providers to develop and promote stormwater solutions that also increase real water supply	Review work in LA basin, develop and implement an analysis strategy to determine statewide potential.

Note: Water for ecosystem purposes and new surface storage and conveyance not considered.

1. Economic Efficiency and Water Allocation

This report identifies key issues related to the economic efficiency of water development, allocation and use in California and discusses general policy changes that might improve efficiency. The report does not address efficiency of water use for environmental or ecosystem purposes, and it does not address the economics of major surface storage or conveyance facilities. These issues are being addressed in different forums.

Efficiency of water use has never been more important in California. Everyone agrees that we should not waste our water but people have ideas about what is waste. What may be reasonable use for one person is waste to another. What objective criteria should be used to judge water use efficiency and reasonable use, and how does economics fit in?

- How can water use efficiency, water allocation and reasonable use be better linked conceptually and analytically?

Modern water supply and conservation decisions are complicated because they inevitably involve alternative opportunities for use of the water. Also, there are external effects on third party water users, water quality, energy and the environment, and there may be economic impacts. Water use will be inefficient in economic terms when prices do not consider opportunity costs and external effects. The correct price signals might be provided by water markets, but water markets are regulated and the environment is often unable to participate because it has a limited budget or property rights.

- How might pricing and markets be better applied to obtain more efficient water use?

Conceptually, economics allows for opportunity and external effects of water use to be considered using the common denominator of money. Indeed, public investment decisions for water resources have used economic criteria for decades and economics continues to play a central role in water supply and conservation decisions in California. In practice, however, the environmental costs and benefits of water use have been difficult to document.

- What are the practical limits for incorporating environmental benefits and costs of water use into economic efficiency measures and policies?

The second part of this paper reviews progress in applied efficiency analysis of water supply and conservation investments in the last decade and identifies some investments that deserve more detailed consideration. Practically all strategies for additional water supply have interactions with water quality, energy and the environment and these interactions must be counted in the efficiency judgment.

- What water supply strategies are likely to be most efficient given the close relationships between water supply and quality, energy and the environment?

Investment decisions require forecasting, but the future is highly uncertain. Some future conditions have a probability distribution that can be estimated with some certainty. For example, the historic hydrologic distribution is commonly used to represent the future, and the past can suggest a likely range of population growth in the future. For other future conditions, a lack of precedent means that no probability distribution can be applied. We can not quantify how climate change will affect the hydrologic distribution. We also do not know how environmental laws such as the Endangered Species Act (ESA) will affect allocations.

- How should risk and uncertainty affect the efficiency of water supply and related investments?

1.1 The Concept of Economic Efficiency

Economic efficiency is different from water use efficiency. Economic efficiency is about making people better off. A condition is economically efficient if no one can be made better off without making someone else worse off. Conversely, if someone can be made better off without making anyone else worse off, that would be an efficient change. A win-win situation is clearly economically efficient if no third party is made worse off.

Economic efficiency is different from technical efficiency. Technical efficiency means that the maximum amount of a good is being produced from the inputs being used to produce it, all else equal. That is, inputs are not being wasted. Cost efficiency goes a step further. Production is cost efficient if no more can be produced for the same or less cost. Technical efficiency is concerned with the physical production from a given amount of inputs, but cost efficiency allows comparison across different technical processes that may have different inputs. Cost, not the quantity of inputs, is the common denominator.

Economic efficiency requires technical efficiency and cost efficiency for production of a good, but it also allows comparison across different types of goods. This comparison occurs through individual preferences. In the market, individual preferences are expressed through the quantities bought at market prices. The basic result of market competition is that the efficient price of a good reflects, simultaneously, 1) the marginal (incremental) cost to produce it, and 2) the marginal rate that consumers will trade it with other goods.

Economic *perspective* defines whose benefits and costs are counted. The California perspective includes the benefits and costs of all Californians. It includes all the roles of Californians in the economy; as residents, workers, and business and property owners. . In general, this paper adopts the California perspective as the goal of our economic efficiency analysis. Individuals or firms make decisions according to their own economic perspective, but these decisions sometimes have effects on others. In the California perspective, these effects must be included.

Economic efficiency analysis counts benefits and costs. Other economic measures such as income, wages and salaries, value of output, or employment are not counted. Changes in the other economic measures may be associated with changes in costs and benefits, but they are not the same thing.

1.2 The Characteristics of Water (and Fish) as a Good

Water is different from most goods. The amount of surface water produced is highly variable and not determined by man. Water property rights systems evolved to accommodate this natural variability. Also, water is a fugitive resource. It tends to disperse and change form. It can be expensive to contain, control and measure. Water is also bulky. It has a low price per unit weight. These characteristics mean that the costs of storage and conveyance are often a large share of the ultimate cost of water. Conveying water uphill often requires large energy costs. With its natural supply variability and large conveyance costs, the value of water is largely determined by when and where it is.

Wild fish are perhaps the epitome of a fugitive resource. They are very difficult to observe in their natural state. Despite our efforts, it is difficult to understand how different factors contribute to their populations. The fugitive nature of fish means that the information needed to protect them is hard to come by.

The fact that water is a highly variable, bulky and fugitive resource does not cause it to be allocated inefficiently. Water developers and users try to overcome these characteristics in a cost-efficient manner as best they can. Still, these characteristics contribute to costs of water and its management in ways that profoundly affect economic efficiency.

Free trade of goods can be efficient when production and consumption affect producers and consumers only. In contrast, the use of water often has external effects, i.e., effects that extend beyond the boundaries of the water user. For example, the water had important values in its natural course, or water use degraded water quality, levels, or other water-related amenities. With external effects the resulting water use may not be efficient from the broader perspective of the State.

Historically, water was often diverted without regard for external effects. Now, external effects are regarded as very important. External effects on ecosystems and fish and wildlife have resulted in the rise of the public trust doctrine. External effects on local watersheds resulted in area of origin statutes. The public trust and reasonable use doctrines, and federal laws such as the Clean Water Act and the ESA have established competing claims for water in California. The importance of external effects has been expressed through reallocations by law (The Central Valley Project Improvement Act), by court decisions, and by environmental water markets. Both the State and federal governments participate as buyers. State funds are generally from California taxpayers while federal spending is primarily from Central Valley Project (CVP) water user fees.

State and federal governments have had a large role in water development, allocation and pricing. The states have the main responsibility for defining water rights and controlling water allocation. Private water users usually obtain water rights from the State, but these rights are conditional and the conditions often protect others from external effects. The federal role comes through federal water and flood control development, water quality laws, and the federal ESA among others.

It is appropriate to ask if the State and federal governments can be counted on to behave efficiently. Public water resource development and allocation does not always follow the public interest. Sometimes, public water supply developments have been inefficient, water has not been priced to encourage efficient water use, and federal or State policies have inhibited water transfers. Water transfers have been carefully regulated to avoid external effects, but are the regulations efficient?

1.3 Agricultural Water Measurement

Resource allocation is most likely to be efficient when all parties with an interest have access to reasonably accurate[2] information. Water rights holders; end users; buyers and sellers; government agencies in their role as purveyors, regulators or public trustees; third parties affected by decisions; and other groups with a private or public interest in water use and allocation – all of these can best pursue their interests with an understanding of the quantity, timing, and quality of water.

Standards and practices for agricultural water measurement vary widely across California. Water agencies delivering water for irrigation have developed their measurement and pricing practices based on the status and adequacy of their water right or contract, the physical layout and capability of their delivery systems, hydrologic characteristics of their delivery area, cropping pattern, and, of course, the economic costs and benefits of different measurement and pricing approaches.

The accuracy of water measurement and potential costs of improvements are closely tied to the type of water delivery system. Many open canal delivery systems use an instantaneous rate of flow measure times the duration of flow as the measure of volume. This type of measurement is inherently less accurate than water meters or other totalizing measurement devices. Achieving full benefit from more accurate measurement may require both improved farm gate delivery devices and district delivery system improvements that can support more accurate and controllable delivery to the gate. Maximum measurement accuracy generally would imply complete conversion from open canal to pressurized piping.

The type of water measurement selected by a district to measure water delivered to its customers is largely an economic decision. Increasing measurement accuracy is costly, so high accuracy is economical when the marginal value of water is high, either because the explicit price charged is high or because water must be rationed to growers. The Final Report of the Independent Panel on Appropriate Measurement of Agricultural Water Use. (2003) surveyed and estimated the costs of improving measurement accuracy of agricultural water diversions, farm gate deliveries, crop water use (evapotranspiration), return flows, and groundwater use. Farm gate deliveries are the most costly to improve to a high level of accuracy, ranging from $25-33 per acre per year on affected lands (i.e., farm fields that currently have low delivery accuracy).Again, this estimate varies by region and District – some Districts such as Westlands Water District already have piped and metered delivery to growers, reflecting the high marginal value of water in that area.

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[2] Both accuracy and precision are important for good measurement. For brevity, we will refer only to accuracy in the text.

Some purposes of agricultural water measurement are only partially achieved by more accurate farm gate delivery measurements. For water transfers and water use efficiency, the price or reward may be based on a reduction in consumptive use, not delivery, and additional costs are required for measurement of other factors to enable consumptive use calculations. The other factors may include return flows, percolation, or direct measures of consumptive use. Measurement of these factors is often expensive and even less reliable than measurement of deliveries.

Many of the likely components of California's water future will require greater measurement accuracy to implement .For example, savings from improved water use efficiency can only be assessed if accurate measurement baselines are available. An effective water transfer market requires that buyers, sellers, trustees of public values, and other affected third parties all have accurate measurement of the effects of transfers. As marginal values of water across the State rise over time, measurement accuracy will increase in value.

Measurement will enable better management of and efficiency in water use, but by itself is not likely to generate large efficiency gains. In other words, better measurement is necessary but not sufficient for generating large improvements in efficiency in use and allocation. In addition, improving measurement may not be cost-effective – it depends on the potential benefits that rely on better measurement to be realized. In some situations the benefit to the local farmer and district may be less than the total benefit when considering other public values of water. In these situations, public funding may be worth using to pay for part of the measurement cost.

1.4 Water Rights and Economic Efficiency

A water right is conditional right for use of water, normally for a specific type, time, point of diversion and amount of use. A full description of water rights, transfer legislation and related laws can be found in CDOJ (2007). Water is allocated among water users by a complex array of water rights, but also by a variety of federal and state laws, by allocation rules within service areas and districts, through water projects and infrastructure, and by water transfers and water pricing.

Groundwater rights may not allocate groundwater at all. If a groundwater basin is not adjudicated, then overlying landowners are allowed to make reasonable use of groundwater underneath their land without regard for the condition of the aquifer. The cost that each user imposes on others is not priced and the expense of court proceedings required to halt overdraft can create an economic impediment to a common solution. If use exceeds recharge then overdraft occurs. Overdraft can be economically efficient, but it is not likely to be, and it is definitely not sustainable.

It is unlikely that a historical allocation of water will be efficient because relative economic values change. For example, the best location for residential or industrial growth may be far removed from irrigated land, and the values placed by the public on environmental amenities have changed. For an economist, the historical allocation of rights is not the main determination of efficiency. Rather, efficient markets and pricing are required to allocate water to its highest and best uses. Therefore, economic efficiency is concerned with the ability of water rights holders to transfer water, and with the extent to which prices can reflect alternative values for the water.

Opportunity cost is the net economic value of a resource in its next best use. For example, the opportunity cost of a crop-idling water transfer is the net revenue foregone from farming. If markets function well, then this opportunity cost is included in the "price" that the farmer pays for the water. For example, if the transfer price is $100, then a farmer gives up $100 when he uses the water for irrigation, and this is in addition to whatever price he pays the district. Furthermore, end users make efficient water conservation decisions because they weigh the water price against costs of conservation. Markets and prices, not water rights, are the key to efficiency. If markets do not function well, then neither the seller nor the buyer can face the correct price signals.

Given these considerations, some features of California water rights may contribute to inefficiency.

- A riparian right is generally nontransferable. A riparian owner can forebear water use and leave it in the stream, and recent legislation allows a riparian owner to dedicate water for environmental or recreational use. However, the very concept of a riparian right, that it must be used on the adjacent land, is at odds with economic efficiency. If riparian users can not market their water then they do not face opportunity costs.

- Water that is used without a valid water right can not be transferred so it can not internalize opportunity costs.

- Water districts control water transfer decisions but individual growers face the opportunity costs of farming. It is not clear that water districts always represent the best interests of farmers in water transfer markets.

- Groundwater use rights allow overdraft in some basins that is not sustainable and probably not efficient.

Environmental water rights and allocations have created a variety of new problems in the State. For most environmental water use, there is no way to determine if an allocation is economically efficient or not because two important types of information are not available; 1) the relationship between the water and the resource to be protected and 2) that between the resource to be protected and the values Californians place on them.

This all does not mean that efficiency of ecosystem allocations should not be considered. Technical efficiency and cost efficiency analysis might still be applied, but type 1) information will be required. Can water management be changed to provide the same level or more ecosystem restoration with less water? Can some other method such as habitat restoration provide the same ecosystem restoration for less cost? These questions may not by answerable for the Delta, but other important environmental water uses occur outside of the Delta.

1.5 Reasonable Use and Economics

This section provides a discussion of the meaning of “reasonable use” in California and demonstrates a connection to economic efficiency.

A constitutional amendment requiring all water use to be "reasonable and beneficial” was passed in 1928. Article 10 of the constitution reads

> “The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water. . . nothing herein contained shall be construed as depriving any riparian owner of the reasonable use of water of the stream to which the owner’s land is riparian under reasonable methods of diversion and use, or as depriving any appropriator of water to which the appropriator is lawfully entitled”

Reasonable use has been defined by statute, by SWRCB proceedings and by court decisions.

Some parts of the water code define reasonableness explicitly; for example, Section 13550 states that use of potable water for landscape irrigation is unreasonable when reclaimed water can be provided for the same or less cost, the reclaimed water will not be a detriment to public health, and the reclaimed water will not damage plant life, downstream water rights, or water quality.

The SWRCB and the state Supreme Court have considered reasonable use in some water rights proceedings. SWRCB decisions that found unreasonable use include:

- 966, maintenance of flow to keep streambed charged in summer so that water could be moved downstream in late fall.
- 1387, use of a leaking and high-consumption diversion facility.[3]
- 1460, a complete diversion by a flood control facility which could harm downstream natural areas including oak trees and wildlife habitat.
- 1463, filling a recreation lake in a drought (1977), later reversed by D-1469.
- 1600, in Imperial Irrigation District “the failure to implement additional water conservation measures at this time is unreasonable and constitutes a misuse of water.” This finding relied substantially on investigations conducted by DWR.

Decision 1224 shows how reasonable use might be judged by comparison to other similar water users. DWR had contended that use of water for rice irrigation was “excessive and wasteful” but the SWRCB found that water use was “in line with the type of irrigation experienced in other

[3] SWRCB, Digest of Selected Water Right Decisions of the California State Water Resources Control Board and its Predecessors. Revised and Updated to decision 1400.

rice growing areas" locally.[4] At the time, the average "gross duty" in the Colusa Basin areas was 10.5 afa, and in the Feather River area, 8.6 afa.

Section 100.5 of the Water Code states

> It is hereby declared to be the established policy of this state that conformity of a use, method of use, or method of diversion of water with local custom shall not be solely determinative of its reasonableness, but shall be considered as one factor to be weighed in the determination of the reasonableness of the use, method of use, or method of diversion of water, within the meaning of Section 2 of Article X of the California Constitution.

In one case, the Court ruled that water users may be required to "endure some inconvenience or to incur reasonable expenses" to achieve reasonable use.[5] In D-1600 "The determination of whether the cost of a particular conservation measure is reasonable must be made with respect to the resources available for financing water conservation efforts as well as the value of the water which would be conserved."[6]

In EDF v. EBMUD (1977) The California Supreme Court found that "what constitutes a reasonable water use is dependent upon not only the entire circumstances presented but varies as the current situation changes.[7] In Decision 1600 "the law requires an examination of the ascertainable facts concerning such water usage and an evaluation of such facts in view of the increasing need for water conservation in California."[8]

The history of legislation and decisions shows that reasonable use has been defined by regional standards, but other factors including the cost and value of water play a role. Reasonable use can and should change over time, and it changes with annual hydrologic conditions. The language also suggests that economics might be used explicitly to compare benefits and costs.

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[4] SWRCB. 1965. Decision D-1224. In the Matter of Applications 13681, 13682, 14919, 14920, 15551 and 15552 Held by Richvale Irrigation District on Behalf of Joint Water Districts. Adopted June 30.

[5] People ex rel. SWRCB v. Forni 54 Cal.App.3d 743, Cal. Rptr. 851 (1976)

[6] D-1600 p. 27.

[7] SWRCB. 1984. Imperial Irrigation District Alleged Waste and Unreasonable Use of Water. Order 84-12. Affirming Decision 1600 and Denying Petitions for Reconsideration. September.

[8] D-1600 p. 23.

2 Water Pricing

This section discusses water pricing issues in California and describes potential efficiency improvements related to pricing. Water pricing is concerned with prices charged by wholesale and retail water purveyors. In California, the State and federal governments are major water wholesalers through the SWP and the CVP. These and other facility owners and agencies sell water to other wholesalers who sell and distribute water to retailers and end users.

2.1 Water Pricing, Opportunity Costs and Cost Recovery

Water pricing is central to economic efficiency, and pricing and efficiency are closely related to water transfers and water use efficiency. In conventional economic theory, efficient pricing is closely associated with cost structure. Efficient water use requires that the price of water to end users equals the marginal (incremental) cost of providing that increment of supply. The price should include the variable cost of conveying, treating and developing that unit of supply. If the resource is scarce, then it also has an opportunity cost and the price should include that. Finally, if there are external costs or benefits, then the external cost should be included also. We use the term *total marginal cost* to mean the total variable incremental cost of water including external and opportunity costs.

Efficient water pricing requires that end users can face opportunity costs. The CBO finds that “Water prices, rather than incorporating the opportunity costs of a given use, more commonly reflect only the expenses associated with physically accessing and delivering the water.” Furthermore, “subsidies have reduced water prices paid by irrigators. . . Subsidies for water infrastructure and agricultural production encourage the use of water resources” (CBO, 2006).

The oft-heard argument that farmers should be charged more for water because of infrastructure subsidies may be over-rated from the California perspective, for three reasons. First, if individual water users can participate in transfer markets then the price of water they are charged need NOT include an additional opportunity cost. It is true that, if water users can not participate fully in transfer markets, then the water prices do not reflect all alternative opportunities and markets cannot obtain an efficient allocation. Legal and institutional constraints in transfer markets are discussed later.

Second, agricultural subsidy effects can be important for some California crops, rice and cotton in particular, but 1) some of the subsidy may be obtained whether or not the crop is produced, and 2) the national subsidy is a legitimate benefit from the perspective of California.

Third, capital cost recovery is a financial, not an efficiency, argument. The marginal costs that water users should pay for efficiency include current opportunity costs of the water, energy and other resources required to produce and deliver the water. The sunk costs of storage and conveyance capacity are irrelevant to efficiency.

On the other hand, the potential for future subsidies may encourage water resource development that is inefficient. The proper time to avoid infrastructure subsidies is before sinking the money into the infrastructure. Once the cost is sunk the wasteful investment can not be undone by pricing. Efficiency in water resource development is discussed later.

Energy price subsidies are very relevant to the efficiency of water prices. There may be inefficiencies because the price being charged water users for energy is too low. An acre-foot of water delivered to Southern California requires over 2,200 kWh and close to 4,000 kWh for delivery to some districts (CEC 2008). The SWP practices time-of-day and time-of-week operations to minimize power costs. It is unknown whether SWP or other water charges approximately reflect energy opportunity costs, or not. Cohen et. al (2004) suggest that CVP water users obtain higher energy subsidies than the SWP. Energy subsidy issues may also be important where water districts generate and provide power for irrigation purposes at below-market costs and the irrigated land can not fully participate in water and energy markets.

Some water prices include capital recovery and other fixed costs. These costs do not change with the quantity of water used and they can not be avoided by using less water. Where water prices include a fixed cost component there is potential for water prices to be too high from an efficiency perspective. To be efficient, the fixed costs might be recovered by a lump-sum payment that does not vary with the amount of water use.

If water prices do not reflect the opportunity cost of power but they do include fixed costs there is potential for the two to cancel each other out. This potential should be included in any efficiency analysis.

2.2 The Water Pricing Problem with Multiple Revenue Mechanisms

Water suppliers have many goals and problems in rate-setting, including cost recovery, revenue stability, political and administrative feasibility, and fairness and equity. From the water agency perspective, the most important goal of pricing is to recover costs. Water suppliers are often public agencies or regulated public utilities and price is required to be close to the average cost of providing water. Mercer and Morgan (1986) found that municipal water districts had low rates of return, and low average water prices were the primary reason. In this study, water prices did not recover even the average cost of supplying water, much less the marginal or opportunity cost.

If price was the only revenue mechanism available, and if revenue had to be close to costs, then price might not be close to the marginal cost of water and water use would not be efficient.[9] However, several revenue mechanisms are usually available to water suppliers including volumetric pricing, service charges and connection fees. With multiple revenue mechanisms, there is more potential to design rates to accommodate multiple goals including cost recovery, equity and efficiency. In particular, volumetric pricing can be used to recover variable costs while encouraging efficiency in use, connection fees can be used to recover capacity costs while encouraging efficient development including conservation technology, and monthly service charges or credits can be used to recover average costs including overhead.

[9] Marginal costs and average costs are usually compared over a range of quantities. They are rarely the same amount per unit unless there are no fixed costs and the marginal cost is constant over quantity.

2.3 Tiered Water Rates

In water, marginal cost pricing is often implemented through tiered or block rate structures. When quantity of water used reached a specified point the price increases and remains at that price until the next tier is reached, and so on.

Volumetric pricing is the minimum standard for urban water users. In 2006, 195 urban water agencies reported that 80 percent of their revenue was derived from volumetric charges (CUWCC, 2006). Black and Veatch (2006) report that volumetric pricing was used by 90.5 and 95.6 percent of respondents in 2001 and 2006, respectively. Tiered water pricing is increasing, but was still not used by most respondents. From 2001 to 2006, use of tiered rates increased from 38.4 to 43.3 percent of respondents. Tiered rates were used by most respondents in most Central Coast and most Bay Area counties, but uniform rates were still most common in most central valley, southern inland and in some south coast (Los Angeles) counties. In other south coast counties (Orange and San Diego), non-tier rates were still used by about half of respondents. In April 2008 Assembly Bill 2882, designed to encourage public agencies to adopt conservation rate structures, passed by a large margin (Woodland Daily Democrat 2008).

In urban water, end users normally can not transfer their water supply, so efficient marginal cost pricing requires that the volumetric price include the opportunity costs of the last unit of water provided. This opportunity cost might be the cost of the last increment of water supply purchased. Clearly, this opportunity cost varies from year to year, so the efficient prices might also vary from year to year. Variable prices as a component of drought conservation programs might also help to maintain revenues even as water use declines.

Few agricultural water districts in California charge growers using tiered water prices. All CVP water service contractors will, upon renewal of their contract with the U.S. Bureau of Reclamation, pay for water according to a tiered water pricing structure defined in the Central Valley Project Improvement Act of 1992. This Act does not, however, require the contractors (mostly public water agencies) to use a tiered, volumetric price for irrigation water they sell to growers.

2.4 Connection Fees and Capacity Costs

A reasonable efficiency argument can be made that the marginal capacity costs of urban growth should be recovered by the connection fee, not by water rates. The potential demand for new water supply capacity is created by the water using capacity of the new development. Arguably, it is unfair to burden existing residential users with the capacity costs of new supplies through water rates because they did not create the need for the new supplies.

The use of connection fees in California follows a pattern similar to that for tiered rates. Nearly all water suppliers in the Bay Area have significant connection fees, often about $5,000 per unit but in some communities up to $25,000. About 29 percent of cities in the 2006 survey had no connection fee (Black and Veatch 2006). Most cities or agencies in Los Angeles County have no connection fees at all, and the average fee is less; this could be because there is limited room for growth. Private water companies “typically do not charge a connection charge.”

Efficiency theory suggests that the size of a connection fee should vary with the potential demand created by the home. Connection fees might vary based on the number of bedrooms, or some other proxy for sheer size, but also with the potential demand from landscape irrigation, appliances, and bathroom fixtures. Connection fees could provide a price signal for developers regarding water-efficient design. Efficient connection fees could be a viable substitute for growth limiting policies. One author found that these policies can slow construction and drive up home prices while “water impact fees do not appear to significantly slow housing growth” (Hanak 2008). It might be efficient to allow homes to avoid the connection fees if they can provide their water supply from other sources.

2.5 The Limits of Water Pricing

There are a number of problems that limit the potential for volumetric water pricing to provide incentive for efficient water use. The costs of measurement for agricultural water were discussed in Section 1.

For many types of urban water use there is a principal-agent problem. The persons who control the amount of water use are not the same ones who pay the bill. This problem occurs in rental properties, in short-term accommodations such as hotels, and in some businesses such as health clubs. In rental properties, it is not clear that making tenants pay water bills would be efficient. With little incentive to maintain permanent landscape features, the amount of water use might be inefficiently low.

Some studies have shown that residential water users have limited knowledge of their rate structures and other factors that affect their water bills (Jordan, 1999). Complex water bills, an inability to read meters and the fact that water is purchased in bulk rather than in discrete units may contribute. However, Olmstead et al (2005) find that “households facing block prices are more sensitive to price increases than households facing uniform marginal prices.”

Proposition 218 may be an impediment to efficient water pricing where opportunity costs or external costs are not borne by water agencies. Proposition 218 and subsequent court opinions require that water agency fees and costs must not exceed the cost of serving a parcel (Schofield, 2008). If water costs to the agency do not include opportunity costs then water prices can not be designed to include them. External costs are, almost by definition, not paid by the water agency, so Proposition 218 could require that prices are too low for economic efficiency purposes. Also, Proposition 218 clearly places a burden on the water agency to calculate water charges that do not exceed the cost of service. Efficient water pricing could be inhibited by the burden of proof required by the Proposition.

This does not mean that Proposition 218 requires prices to be inefficiently low. Fees and charges can include costs of recovering capital. From the efficiency perspective some of these costs are sunk costs so they should not be included in the price of water. For efficiency such costs should be recovered through non-price revenue mechanisms.

Court opinion has also found that Proposition 218 applies to all water fees and charges except connection fees. However, there is an important implication for connection fees. Logically, the incremental cost of a connection can not be recovered through fees and charges to other parcels. Therefore, the incremental costs recovered by connection fees should probably include water supply capacity costs required to serve the property. This capacity requirement might be estimated under an assumption that other parcels' supply reliability must be maintained.

2.6 Pros and Cons of Policy Changes

There appears to be a limited but growing relationship between water pricing and efficiency concerns in California. Efficient water prices should include water opportunity costs provided either as the opportunity to transfer water or directly as part of the price. There are still some legal and institutional barriers to transfers so some prices faced by water users are not efficient. In some cases, water price increments to reflect external costs or opportunity costs would be efficient. Positive incentives are needed to help water users adopt efficient price structures.

In many regions, a large share of the cost of water is the cost of energy required to convey the water. Water prices should include the opportunity cost of energy required to convey it. Usually this opportunity cost can be estimated from market power rates.

The extreme natural variability of water supplies means that the marginal costs and opportunity costs of water use change often. For efficiency, water prices should change as hydrologic and other supply conditions change. The extent to which prices are used to allocate water according to supply conditions is not known. Variable volumetric pricing – prices that change each season – might be used more to obtain more efficient water use. Efficiency gains could be offset by the costs of implementing variable pricing.

Connection fees could play an important role in more efficient pricing. Fees should be based on the incremental cost of developing new supply capacity and should vary based on the amount of water supply capacity required by each home. Homes that include water saving design and technologies should have lower connection fees.

Variable volumetric pricing, connection fees and tiered water pricing for urban supplies could be used more to obtain more efficient development and water use. The potential for complex rate structures to provide incentives for efficiency while achieving other goals has not been fully explored. Better methods of allocating marginal supply costs between volumetric charges and connection fees are needed. More research is needed to determine a basis and methods for optimal combinations of connection fees and variable tiered rates.

The potential for efficient volumetric pricing for agricultural water in some areas is limited by measurement costs. Also, measuring delivery is often not the same as measuring water consumption. In some cases, the costs of measurement could exceed potential efficiency gains.

The potential value of conservation rate structures may be limited by the quality of information provided to water users and the costs of understanding and using the information. More information on the level of understanding of water users and methods to improve customer information might be worthwhile.

Incentives created by water prices are also limited by principal agent problems. Information regarding the extent of this problem in California is needed, and targeted water use efficiency investments may be justified.

3 Water Use Efficiency Programs

This section explores economic efficiency in water conservation in the context of water supplier initiatives and State incentives.

Water use economic efficiency is closely related to water pricing. In theory, if water prices reflect total marginal costs, then water users should adjust their use and their adoption of conservation measures to efficient levels. From the proceeding discussion, water prices may not be "right" for efficiency because

- Utilities practice average cost pricing and have other, non-efficiency goals
- External costs and/or opportunity costs of water or energy are not reflected in the price (i.e., water prices are not right from the California perspective)
- Some water users do not pay the price for the water they use.

These provide some economic rationale for utility or public water use efficiency programs. Much of the economic analysis conducted for water use efficiency programs can be viewed as attempts to overcome these problems.

3.1 Summary of Existing California Water Use Efficiency Programs

The 1983 Urban Water Management Planning Act and the 1986 Agricultural Water Management Planning laid the foundation for the statewide urban and agricultural water use efficiency programs of today. California law and institutions that consider water use efficiency economics in conservation program and investment decisions are well-developed.

Table 3-1 provides a summary of these programs.

3.1.1 Agricultural Water Use Efficiency

Prior to the CALFED Water Use Efficiency program, agricultural water conservation had been viewed primarily as a water supply management tool. Conserved water was only considered useful if it led to so-called "real water savings" defined as a reduction in irrecoverable losses (water evaporating or flowing to salt sinks). The CALFED program significantly expanded the definition of Water Use Efficiency to include any reduction in agricultural losses that contributed to a Quantifiable Objective. Quantifiable Objectives included water quantity and reliability (i.e., "real water") objectives plus many in-stream flow and quality objectives. For example, agricultural water conservation can be shown to be beneficial and in the State's interest if it leaves water in a critical stretch of stream, even if that water would not have been irrecoverably lost.

Table 3-1.
Characteristics of Water Use Efficiency Programs in California

	Municipal	**Agricultural**
Basis	Urban Water Management Planning Act, 1991 MOU	Efficient Water Management Practices Act of 1990, AB 3616, Water Code Sec. 10900, 1999 MOU
Advisory Group	CUWCC	AWMC
Name of Practices	Best Management Practices (BMPs)	Efficient Water Management Practices
Practices Required of All Signatores	Prepare and adopt a Water Conservation Plan. Conservation coordinator is a BMP Good faith effort to implement fourteen conservation BMPs below, Including: Cooperating with other water suppliers and other relevant entities whenever possible and legal to promote BMPS. Use of legal authorities and administrative prerogatives as necessary and reasonable. If a BMP is not within legal authority, encouraging timely implementation by other entities that have legal authority, including financial incentives Encourage the removal of institutional barriers such as local ordinances, administrative policies or legislation. Optimizing savings from BMPs.	Prepare and adopt a Water Management Plan. Designate a Water Conservation Coordinator. Where appropriate, improve communication and cooperation among water suppliers, water users and other agencies. Evaluate the need, if any, for changes in policies of the institutions to which the water supplier is subject. Support the availability of water management services to water users. Evaluate and improve supplier pump efficiency.
Practices to Implement Subject to Economic Analysis	1: Water survey programs for single-family and multi-family residential customers. 2: Residential plumbing retrofit 3: System water audits, leak detection and repair 4: Metering with commodity rates for all new connections and retrofit of existing 5: Large landscape programs and incentives 6: High-efficiency washing machine rebate programs 7: Public information programs 8: School education programs 9: Conservation programs for cii accounts 9a: CII ULFT water savings 10: Wholesale agency assistance programs 11: Conservation pricing 12: Conservation coordinator 13: Water waste prohibition 14: Residential ULFT replacement programs	Facilitate 1) alternative land use for problem drainage lands, 2) use of recycled water that meets health and safety criteria, no harm to crops or soils and would otherwise not be reused, 3) financing of capital improvements for on-farm irrigation systems and 4) voluntary water transfers that do not unreasonably affect the water user, water supplier, the environment, or third parties. 5. Line or pipe ditches and canals. 6. Increase flexibility in water ordering. 7. Construct and operate spill and tailwater recovery systems. 8. Optimize conjunctive use of surface and groundwater. 9. Automate canal structures. Detailed Analysis: 1. Water measurement and water use report. 2. Pricing or other incentives.
Economic Principles	Net water savings estimates may be required for local and State perspectives State and local perspective analyses required. Local perspective includes environmental? BMP implementation not required if full B/C shows that either perspective fails B/C test	Definition of water conservation is reduction in irrecoverable losses or contribution to other CALFED quantifiable objectives Water supplier perspective required No implementation unless economic and other feasibility tests pass No B/C for 1 through 4 or if infeasible

The economic efficiency of water use is not the same thing as irrigation efficiency. Although definitions vary, the most standard definition of irrigation efficiency is the ratio of the evapotranspiration of applied water (ETAW) divided by applied water (AW). This ratio is sometimes called the seasonal application efficiency. Even at the field application level of analysis, this definition does not capture all of the value and uses of water. Water running off of one field is often reused on other fields or farms. Water is also used for salt leaching, frost protection, and other cultivation purposes. Water is also applied to farmland in some cases to percolate and recharge groundwater. Often a single irrigation event on a field may serve more than one of these purposes.

The economic efficiency of on-farm water use is measured from the grower's perspective by comparing the marginal cost of the water (again, either the explicit price paid or the shadow price implied by a rationed allocation) to the marginal value of its use in producing a crop. The District or basin perspective must account for conveyance losses and reuse. The State's perspective of economic efficiency is likely to diverge from the grower's and the District's when, for example, there are significant external costs such as public trust values lost as a result of diverting and using the water on-farm. These losses are largely external costs to the grower but important to others in the State. An explicit goal of CALFED's Water Use Efficiency Grant program was to internalize these external costs by providing State money to subsidize conservation, both on-farm and in the districts' delivery systems.

The Memorandum of Understanding Regarding Efficient Water Management Practices by Agricultural Water Suppliers in California lists a set of practices that signatories should or could implement. Currently about forty agricultural water supply districts have signed the Agricultural MOU. Water measurement and volumetric (including tiered) water pricing changes are included on the list of practices that would be subject to a benefit-cost analysis.

Recent legislation and initiatives have explicitly included economics in their definitions of what level of water use efficiency should be achieved. Water Code Section 10902 states

> "Efficient water management practices" means reasonable and economically justifiable programs to improve the delivery and use of water used for agricultural purposes.

Section 10904(a) provides that DWR "shall offer assistance to agricultural water suppliers to implement efficient water management practices to improve the efficiency of water use." The Agricultural Water Management Planning Program provides technical, financial and administrative assistance to the Agricultural Water Management Council and to the water districts throughout the State to develop Water Management Plans and to help implement cost-effective Efficient Water Management Practices (EWMPs) (DWR 2008).

CALFED's Water Use Efficiency Comprehensive Evaluation (2004) estimated that agricultural water conservation can make a significant contribution to the State's future water management. In this regard the Comprehensive Evaluation echoed other estimates such as that in California Water 2030 (Pacific Institute, 2005). However, the amount and location of agricultural conservation that may be cost-effective depends on the cost of other supply and management options (such as new storage and conveyance, conjunctive use, or water reclamation and reuse).

It also depends on how well the external costs of agricultural water use are incorporated into water pricing and allocation.

3.1.2 Urban Water Use Efficiency

A Memorandum of Understanding (MOU) was signed by nearly 100 urban water agencies and environmental groups in December, 1991. Since then the California Urban Water Conservation Council (CUWCC) has grown to almost 400 members. Those signing the MOU pledge to develop and implement fourteen comprehensive conservation Best Management Practices (BMPs) (CUWCC, 2007).

Exhibit 3 of the MOU provides Principles to Guide the Performance of BMP Economic (Cost Effectiveness) Analyses. The cost-effectiveness of a conservation measure is measured using two different accounting perspectives. First, total benefits and costs include environmental, retail customer and other water and wastewater provider costs. Financial incentives received by water suppliers or by retail customers are not included. Next, water supplier plus environmental benefits and costs are compared. This perspective includes financial incentives paid from or to the water provider and environmental benefits and costs.

A signatory water supplier is exempt from the implementation of specific BMPs for as long as the supplier substantiates, for each reporting period that based upon then prevailing local conditions, that one or more of the following findings applies:

(a) A full cost-benefit analysis demonstrates that either the program (i) would not be cost-effective overall . . . ; OR (ii) would not be cost-effective to the individual water supplier even after the water supplier has made a good faith effort to share costs with other program beneficiaries.
(b) Adequate funds are not and cannot reasonably be made available. . . .or
(c) Implementation of the BMP is (i) not within the legal authority of the water supplier; and the water supplier has made a good faith effort to work with others who have the authority or could get institutional barriers removed.

Detailed guidelines have been developed for evaluating conservation practices (A & N Technical Services, Inc. 1996) and updates have been developed, most recently in 2005. (A & N Technical Services, Inc. 2005) CUWCC frequently updates their analysis of BMPs and Potential BMPs.

CUWCC reports expected water savings for those BMPs that require water savings measurement. Table 3-2 shows estimated savings from 2000 to 2007. Estimated water savings have been declining since 2004. The reason for this is unknown.

Energy costs are very important to the value of water use efficiency in southern California (Cohen et al, 2004). One analysis found that when electricity prices are low, water transfers are a cost-effective option but at higher prices, “conservation of electricity and water through installation of high efficiency clothes washers is the most effective option” (Dale, 2004).

Table 3-2.
Urban Net Water Savings, 2000 through 2008, Measured BMPs Only

Year	5: Large Landscape	9: CII ULFT	14: Resid. ULFT	All Others	Total
2000	22,626	22,617	39,202	9,283	93,728
2001	22,861	28,749	41,641	11,618	104,869
2002	24,137	32,708	43,616	14,246	114,707
2003	28,372	32,825	45,677	16,867	123,741
2004	30,385	43,674	47,689	19,318	141,066
2005	32,311	20,715	48,091	20,144	121,261
2006	34,700	25,601	47,792	21,060	129,153
2007	11,655	22,062	45,881	19,236	98,834
2008	10,490	19,855	44,045	17,759	92,149

Source: CUWCC, 2008

3.1.3 State Funding

DWR provides funding for agricultural and urban water use efficiency projects that are not locally cost effective and that provide water savings or in-stream flows that are beneficial to the Bay-Delta or the rest of the State (DWR 2008c). Applicants are required to quantify the local and Bay-Delta water use efficiency benefits and propose a local cost share proportional to the relative balance of local and Bay-Delta water use efficiency benefits.

The maximum State share and minimum local share are calculated as follows:

> Maximum State Share= (project capital cost) – (project local monetary benefits) + ten percent (project cost), and
>
> Minimum Local Share equals the project cost minus the state share.

Applicants are encouraged to provide more local share than the minimum calculated by the cost share formula. Disadvantaged communities may request reduction or waiver of the local cost share requirement.

If a project is locally cost effective, then it is eligible for funding only if the applicant can make a compelling case that the project would provide broad transferable benefits, overcome implementation barriers, and/or accelerate implementation. Locally cost effective projects are required to provide a minimum of 90 percent of local cost share, (i.e. only eligible for up to ten percent cost share from the State) because these projects are likely to be implemented even without State funding.

3.2 Pros and cons of policy changes

A number of key technical issues complicate measurements of urban cost and water savings. A & N Technical Services, Inc. (2005) lists these “areas that require additional future research”

- Savings decay over time
- “Free rider” and “spillover” effects
- Discount rates
- Natural replacement rates
- Device saturation rates
- The affects of key program design variables like timing, scale, and targeting
- The types and amounts of utility costs avoided by conservation programs
- Expressing program benefits in dollar terms

The Pacific Institute published two reports recently which have had an important influence on common perceptions about urban water conservation potential (Gleick et al. 2003, 2005). The 2005 publication recommended many actions related to water use efficiency be undertaken now. Some of these are reproduced in Table 3-3 below.

Table 3-3. Urban Water Use Efficiency Measures Recommended by Pacific Institute (2003)
Efforts to promote the use of water-efficient technologies and practices should be greatly expanded, in both the urban and agricultural sectors.
Set new water-efficiency standards for residential and commercial appliances, including toilets, washing machines, dishwashers, showers, and faucets.
Offer comprehensive rebates, including both energy and water rebates, for the purchase of water-efficient appliances.
Require water-efficient appliances to be “retrofit on resale” for existing homes.
Revise and expand “Best Management Practices” for urban and agricultural water agencies.
Make “Best Management Practices” mandatory and enforceable.
Expand development and deployment of efficient irrigation technologies and new crop types.
Educational programs on water use, and on the potential for water-use efficiency, should be expanded.
Label all appliances with efficiency ratings.
Expand water-efficiency information and evaluation programs in the Agricultural Extension Services and other agricultural outreach efforts.
Develop on-line data collection and dissemination networks to provide farmers with immediate meteorological and hydrological information on climate, soil conditions, and crop water needs. Better combined land and water planning is needed.
Demonstrate water-efficient housing designs before developments are approved.
Source: Pacific Institute 2003

The 2003 report begins with this statement

> The largest, least expensive, and most environmentally sound source of water to meet California’s future needs is the water currently being wasted in every sector of our economy.

And later

> Many credible studies and sources indicate that the marginal cost of new or expanded water supply in most, if not all, of California is greater than most of our estimates of the cost of conserved water.

The report estimates that 2.3 million acre-feet of urban water use in California could be saved with existing technology, and that about 85 percent of this “can be saved at costs below what it would cost to tap into new sources of supply.”

Chesnutt and Pekelney (2004) offer some analysis of the 2003 report.

“While the report presents a range of useful data and informative discussion, readers should be aware of some key limitations to the analysis, as follows.

- Not all of the report’s conclusions are supported by the data and analysis presented.
- The report does not address what changes in current laws, regulations, or institutions would be needed to effectively tap into these reservoirs.
- Some estimates of end use savings potential could be improved by using available empirical evidence from field studies.
- The economic analysis, while suggesting that investment in water use-efficiency may be cost-effective from a total resource, or societal perspective, does not consider the institutional constraints and transactional costs that guide utility investment decisions.“

These authors, while not fully expert in the methods used by the Pacific Institute or the BMP analysis required by Exhibit 3 of the urban conservation MOU, offer these comments.

- There are public perception issues which may be limiting the adoption of efficient conservation technologies. In particular, experiences with outdated technology may deter adoption. For many, water costs are a small fraction of all living costs so there is little incentive to consider the potential net benefits from water savings.

- The apparent cost-effectiveness of some urban conservation methods may be overstated because some lost benefits associated with urban conservation may be uncounted; for example, the convenience, speed and pleasure of a high-volume shower as compared to low-volume and the enjoyment some people get from high-water using landscape features. On the other hand, some may prefer low-volume showers, and high-efficiency clothes washers may clean clothes better than older models. A lack of acceptance by consumers often reflects real economic values that should not be ignored.

- For indoor water conservation features the net benefits of recycling the water should limit the potential economics of indoor conservation methods

- A large share of the variable cost of water in the south coast is energy. More detailed analysis of opportunity costs of energy used for water conveyance should be developed for use in water use efficiency economics studies.

4. Water Transfers

For economics, water transfer markets are the key to economic efficiency in water allocation. With robust water markets, water can move to its highest and best use, market prices compensate for and reflect opportunity costs, and the buyer and seller are both better off. The California water transfer market has grown markedly since the late 1980's. Water transfers among water users within districts are common, and transfers within the SWP and the CVP are fairly routine. More recently, the amount of water transfers for environmental purposes increased.

This section discusses key water transfer laws, policies and issues in California. The policy of the State is to encourage voluntary transfers and, over time, laws have changed to facilitate and protect reasonable water transfers. The 1992 federal Central Valley Project Improvement Act specifically authorized transfers of CVP water.

4.1 Water Transfer Law

California law differentiates transfers of groundwater, riparian rights and appropriative rights (SWRCB 1999). Groundwater rights, any underground water that is not part of a subterranean stream, are generally transferable so long as other landowners are not adversely affected. If the groundwater basin is adjudicated then local groundwater management plans must be followed. Most counties have ordinances that restrict the export of groundwater. Hanak (2005) finds that "local restrictions have significantly reduced" groundwater exports.

Regarding riparian rights

> Since they attach to the land, riparian rights cannot typically be transferred. However, water not taken under riparian rights can be appropriated. In addition, under Water Code section 1707, a riparian user may request the SWRCB to approve a change whereby the riparian use could be dedicated to instream uses" (SWRCB 1999).

Appropriative rights account for most of the potential water transfers in the State. Appropriative rights are characterized by a priority, and by an amount, time, type and place of use. Water transfers within a district or other service area are common precisely because, from the perspective of the district's right, none of these are changed. Transfers become increasingly rare as the duration increases, and as the time, type and/or place of use are changed.

For pre-1914 appropriative rights, water transfers are subject only to a finding of no injury to other legal water users, and the injured person must bring court action t halt the transfer. For post-1914 rights, water transfers require an application to the SWRCB and the application can be protested by an injured water user. Any transfer of post-1914 rights also cannot have an unreasonable effect on fish and wildlife, and two laws that consider economic impacts may apply.

Water Code section 382 provides authority for transfers of surplus water by local or regional agencies. If an agency utilizes this code section then the SWRCB may approve the transfer if it does not “unreasonably affect the overall economy of the area from which the water is being transferred.” Water Code section 1810 permits any public agency that owns a water conveyance facility to utilize unused conveyance capacity for transfers provided the use of the conveyance facility does not injure any legal user of water, unreasonably affect fish, wildlife or other instream beneficial uses and does not unreasonably affect the overall economy or the environment of the county from which the water is being transferred.

California law provides for an expedited process for post-1914 water transfers lasting one year or less. These temporary short-term transfers are generally limited to consumptive use and are exempt from CEQA. CEQA compliance is required for temporary long-term and permanent transfers, and other water users are given more latitude to protest based on potential injury. A 2008 proposed water transfer from Richvale Irrigation District, a pre-1914 rights holder, was recently stalled because of a CEQA-related suit.

The State has established guidelines for temporary transfers from the Central Valley (DWR 2002a, 2002b). In general, water can be made available by crop shifting and crop idling. Idling of some crops for water transfers have not yet been used. The crops that have not been idled for water transfers are pasture and alfalfa, because “water savings can not be easily verified,” and trees such as walnuts, almonds and prunes. Presumably, trees would not be killed to transfer water but re-establishment might be delayed (see below). Corn and silage crops, and cotton in the San Joaquin Valley, have also not been idled.

4.2 Economic and Technical Issues

Transactions costs of a water transfer are the negotiation, legal and administrative costs of a transfer that are above and beyond the transfer price. Transactions costs are often substantial relative to the cost of the water itself and they are often a significant impediment to transfers. The amount of transactions costs increases as the duration of the transfer increases. Two types of transactions costs are very important 1) the measurement of real water savings, and 2) other conditions to insure against injury. These two costs are closely related.

Real water savings from changes in agricultural practices are often hard or expensive to measure. There are measurement costs at the point of delivery, and there is usually no measurement of water leaving the field as runoff or as percolation. Often, the cropping pattern that would occur without the transfer cannot be known.

The practical difficulties and costs of determining injury can play an important role in limiting water transfers. State policy limits temporary water transfers to the amount consumed but the amount of water actually consumed by crops, or the fate of water not consumed, often cannot be accurately measured or measurement is prohibitively expensive. Development of better technical data for consideration in injury determinations might provide more certainty to water transfer quantification.

Political constraints appear to be a significant barrier to efficient transfers from some areas. Even though California law clearly protects water rights under legal transfers, representatives have concerns about a possible loss of water rights resulting from even a temporary change in place of use. It might be possible to change the California water code to strengthen protection of water rights during temporary transfers.

Third party economic concerns are a significant impediment to some transfers and may contribute to political constraints (Hanak 2003, 2005). In many cases potential economic efficiency gains should be enough to compensate third party losses. It may be difficult to distribute water transfer revenues to those persons who are adversely affected. Improved methods for calculating compensation and for distribution of compensation are needed.

Water districts typically control water rights and transfer decisions. This could result in a potential principal-agent problem. Water districts make transfer decisions but growers face the net benefit of their farming and irrigation decisions. If water districts do not allow transfers that are in the best economic interests of their members then an economic inefficiency results.

Under the Wanger decision, operations are being changed in ways that affect transfer markets. In 2008, temporary transfers from Sacramento River water users were not completed because water can not be exported until July, but about 40 percent of the water proposed for transfer had served double-duty in May and June by meeting instream flow requirements. This water could not be transferred because it could not be "backed up" into Shasta because it must be released for the instream flow requirement. Under Wanger, the efficiency of the May-June instream flow requirement takes on greater importance. Also, enforcement of water quality standards in the south Delta may affect the ability to convey and export transfers from the Sacramento Valley.

4.3 Pros and Cons of Policy Changes

The ability to transfer water is a pre-condition for efficient water use. Without the ability to transfer, water users can not face the opportunity costs of their water use. Many riparian rights on the Sacramento and San Joaquin Rivers have been replaced by contracts with the CVP and SWP. However, riparian rights still enable some of the water used for irrigation in the internal Delta and on some other rivers that enter the Delta. Changes to California water law are needed enable water transfers and to define the amount of water that can be transferred from land irrigated using riparian rights.

California law allows an expedited process for temporary short-term transfers based on consumptive use. So far, these transfers have been enabled using just a few methods; primarily crop shifting, crop idling and stored water. In the future, increases in real water values and changes in the location of need for water may justify other methods.

Alfalfa, other hay and pastures are normally re-established at regular intervals of anywhere from 3 to 10 years. Trees are re-established at much longer intervals. Farmers could be paid to delay re-establishment of trees and water savings could be transferred. Others have proposed that water could be transferred by non-irrigation of established alfalfa. Real water savings from agricultural conservation practices should be standardized. To assure lack of injury, real water savings estimates can be conservative.

There have been limited transfers from idling cotton. Cotton and corn are important crops south of Delta where the need for water is greatest. No serious proposals for temporary transfers involving cotton in the San Joaquin valley are known. There may be political constraints in some regions. Corn production often involves long-term relationships with dairies that might be disrupted by temporary transfers. There are legitimate concerns about air quality. A cover crop that uses less water than the cotton or corn may be required. Net savings per acre may be small, but the market should decide if such transfers are worthwhile. There has been more discussion recently about water transfers from within the Delta. Important issues involve potential for subsidence and water rights issues.

Most environmental water use is prescribed and inflexible. However, some environmental water uses such as wildlife refuges might participate in water transfer markets as a seller. Wildlife refuges in the central valley have a need for cash and resources other than water. They may have rights to more water than they need in some years and they may be able to produce water cost-effectively to substitute for surface water. If they can not market water they have limited incentive to develop cost-effective water supply options. Clearly, water transfers from refuges would require careful analysis to ensure that refuge resources benefit from the transfer.

California has significant capacity to convey water that originates out-of-State, most notably the Colorado River Aqueduct. Recent events on the Colorado River have resulted in the possibility of excess capacity in this facility. Water from out-of-State transfers might be economical for buyers and sellers when conveyance capacity is available. California should work with other Colorado River States to ensure that institutional and legal barriers to transfers can be overcome.

The SWRCB’s Water Transfer Workgroup (2002) provided a number of recommendations. Of these, at least three appear to be still valid.

4. Further consolidation of USBR/SWP places of use.
9. Prepare legislation to define rights to use of vacant aquifer space.
10. Define relative state/local authority over extraction and use of water previously stored in groundwater basins.
18. Improve the reliability and predictability of planned drought transfers

The Pacific Institute (2005) recommended that these actions related to measurement of water be undertaken to facilitate transfers:

- A statewide system of water data monitoring and exchange should be created, especially for water use.
- Collect and make publicly available comprehensive water-use data for all users.
- Design and implement comprehensive local groundwater monitoring and management programs statewide.

The costs of some of these actions could be very large. There is no guarantee that the benefits would be worth the costs. No comprehensive cost studies are available.

5. Water Supply and Conveyance Development

5.1 Efficiency Conditions for Investments

Public investments in water supply facilities in California and the nation have normally been subject to benefit-cost analysis to ensure that they are economically efficient. Despite rigorous economic criteria (USWRC, 1983) some studies have found that benefit-cost studies are often used to rationalize projects (Campen, 1986). Undoubtedly, benefit-cost analysis has served to screen out some obviously inefficient projects and is still a significant requirement for federal water supply projects.

5.2 Why Investments May be Inefficient

Even if a benefit-cost analysis is entirely unbiased, there are many reasons why the economics of an investment can turn out to be less favorable than planned. Over a planning horizon of 50 to 100 years, tastes and preferences, technology and relative prices will change in ways that can not be predicted. Under uncertainty, it is often advisable to invest in a portfolio of options rather than just one. Hanak (2007) reports on water planning approaches that inspect a portfolio of options including recycling, desalination, underground storage, conservation and water marketing. A diverse portfolio is well-established as a technique for managing uncertainty.

5.3 Pros and Cons of Policy Changes

DWR and the SWRCB have recently required grant and loan applicants to provide economic analysis of their projects. The resulting analysis has been used to score the proposals along with a number of other criteria. Those proposals with the highest total scores have been awarded funds. This approach results in the possibility that projects that are not economical might be funded. A low economics score might be offset by high scores in other areas, or there might simply be not enough economical projects to use all of the available funds. In the future, water bond legislation might be amended to require that the State require a finding of economic efficiency for any project it funds.

Some of the recent grant programs have offered potential funding for projects that have primarily private or local benefits. State grants programs should provide funds to cover a share of costs based on the non-local benefits only. These benefits might be water savings to be available for non-local uses, or public or environmental benefits. As discussed above, this concept has been applied for WUE programs but should be extended to other grant programs as well.

6. Water Rights Enforcement

Efficient enforcement requires that the marginal costs of enforcement equal its marginal benefits. Additional resources should be dedicated to enforcement until the additional benefit in terms of efficient water allocation is not worth the cost.

Also, efficient enforcement requires that penalties for non-compliance be sufficient to deter unauthorized use. The size of the penalty should be at least as large as the benefit of unauthorized use divided by the chance of having to pay the penalty. For example, if a farmer realizes a net benefit of $100 from some illegal use and he perceives that the chance of being fined is 10 percent, then a fine of at least $1000 ($100/.1) may be justified.

Section 1825 of the water code states that

> "It is the intent of the Legislature that the state should take vigorous action to enforce the terms and conditions of permits licenses, certifications, and registrations to appropriate water, to enforce state board orders and decisions, and to prevent the unlawful diversion of water."

CDOJ (2007) reports that the SWRCB recently had only 6 employees in enforcement group and 4 in the complaints unit. The SWRCB (2008) reports 82 enforcement staff and 95 compliance staff in all of the Regional Water Boards. One author finds that "due largely to budget cuts the State Board staff has decreased by nearly half over recent years" (Kirk 2007).

The SWRCB (2008) recommends these improvements, among others:

- Create procedural consistency in enforcement proceedings
- Prioritize enforcement actions to address the most serious threats to water quality
- Evaluate the impact of establishing minimum penalties for California Water Code violations

Unauthorized water use that would truly matter to the hydrologic system is primarily irrigation of lands that are not authorized for irrigation. Such water use may be inefficient because 1) the water user may be paying no price for it, 2) opportunity costs for use of the water can not be reflected in its price. Both of these factors mean that some unauthorized water use is probably devoted to relatively low-valued purposes and enforcement has potential to have benefits in excess of its costs.

The potential extent of unauthorized water use statewide is not clear. Therefore, the most that can be recommended at this juncture is better data collection and analysis. The amount of water that can be legally used under a water right is often not straight forward. For example, riparian users can not use water that was stored by someone else upstream, but the share of water in the river that the riparian might be entitled to is sometimes not clear.

Water users are required to provide a statement of water diversion and use, but compliance rates are low, and some water rights holders in the Delta do not need to report. This lack of data increases the difficulty and potential for error in water planning as well as enforcement.

7. Potentially Efficient Water Supply Development Options

The following water supply options, in consideration of all of their external effects and other benefits, are likely to be economically efficient now. This does not mean that they are completely feasible from an engineering or financial perspective. Their scope and plans for implementation are not part of this document.

7.1 Land Retirement of Drainage-Impacted Lands in the San Luis Unit

Significant areas of irrigated land in the western and southern San Joaquin Valley are affected by poor drainage conditions and natural contamination of shallow groundwater by Selenium. Without the installation of artificial drains to collect very saline shallow groundwater and prevent it from accumulating in the crop root zone, the productivity of these lands will continue to decline. A number of large studies have been conducted over the years to identify a safe, economical, and acceptable way to drain these lands. The San Joaquin Valley Drainage Program (1990), the San Luis Unit Drainage Plan (1991), the Westside Regional Drainage Plan (2003), and the San Luis Unit Drainage Feature Re-evaluation (2006) have all attempted to craft effective and affordable drainage solutions.

All of these studies have concluded that, to some extent, the removal of the most-affected lands from irrigation is part of the best solution. In the most recent study, the U.S. Bureau of Reclamation has identified its proposed plan for the San Luis Unit that includes nearly 200,000 acres of land retirement. Although Reclamation and the affected water districts and landowners continue to negotiate the final plan and how to pay for it, it seems likely that large areas of drainage-affected land will be fallowed and/or retired.

Although most of these lands would be very productive if they had good drainage, the combination of their drainage condition and the contamination by Selenium make artificial drainage collection, treatment, and disposal very expensive and environmentally hazardous. Retirement of, say, 100,000 acres would reduce the long-term quantity of water demanded in the Delta export region by 200-250,000 acre-feet per year.[10]

7.2 Groundwater Management

Some aquifers are being or will be depleted or damaged by non-sustainable use. Many of the State's most important aquifers are overdrafted. DWR (1998) estimated that groundwater overdraft was about 1.46 maf in 1995. Most of the overdraft was in the Tulare Lake region (0.82 maf) with substantial overdraft in the San Joaquin River region, the Central Coast, and the South Lahontan region. Overdraft conditions in these regions have likely been increasing with reduced Delta supplies.

Recent hydrologic and economic conditions are combining to suggest increased groundwater overdraft. Prices of most agricultural commodities are at record levels, and dry conditions and reduced Delta exports will encourage increased pumping. The ability of individual users to pump

[10] Note that this will not reduce demand for surface water by that amount – these areas are already subject to shortages in contract delivery.

groundwater at non-sustainable levels reduces their economic interest in developing more sustainable albeit more expensive supplies.

The economic costs of overdraft can include increased pumping depth and head, costs for improving wells and drilling new wells, water quality impacts, and eventually, loss of economic viability of groundwater supplies. Overdraft of groundwater can be economically efficient depending on current and future water values and discount rates, but overdraft is not sustainable. In general, increasing real water values over time suggest that overdraft may not be economically efficient now.

The State may want to consider policy changes which would identify areas where overdraft may contribute

7.3 Water Transfers from Riparian Lands

Current law does not allow transfers of water from riparian lands except for limited purposes. Legislation is needed to enable and quantify water transfers from riparian land. Some water users have riparian and appropriative rights; they might be able to transfer water based on their appropriative rights. Data on the amount of land irrigated with riparian rights only is not readily available.

The following water supply options deserve further study

7.4 In Coastal Regions, Methods for Capture and Use of Stormwater.

Stormwater is currently a major water quality issue in California. The SWRCB is responsible for administering the state's stormwater management program. Municipalities and county governments must comply with the requirements established by the regional boards. Some municipalities have their own, more stringent treatment requirements. Most programs require that stormwater be treated to the maximum extent practicable. Numeric treatment requirements are not currently used (Stormwater Authority 2008). There are established and proposed Total Maximum Daily Loads (TMDLs) which may result in additional compliance costs.

Water supply might be an important benefit that could help pay for projects and stormwater may represent a large potential water supply. The Planning and Conservation League estimates that the annual average stormwater runoff in the Los Angeles basin alone totals 550,000 acre-feet. Dallman and Peichota (2000) discuss multiple benefits from stormwater management in southern California. Benefits could include water conservation and reuse, reducing dependence on imported water, reduced flood damages, and recharging groundwater supplies.

Costs of stormwater programs can be substantial. Currier et al. (2005) found that current costs for a sample of California cities ranged from $18 to $46 per household per year, and estimates costs for the Los Angeles area for scenarios including wetlands and infiltration basins were $55 to $71 per household per year, more than the current level of effort ($18). A detailed analysis of benefits and costs is associated with these estimates (Devinny et. al., 2004). The total estimated cost of stormwater quality control for the Los Angeles Region using non-structural BMPs only was about $2.8 billion. The costs of two other strategies are estimated to be more, but the groundwater replenishment benefits of these strategies are estimated to be more than the cost increase. For one scenario the costs are completely covered by the water supply benefits. Results are reproduced in Table 7-1 below.

Table 7-1. Costs and Benefits of Stormwater Quality Control Strategies in the Los Angeles Region

	Billion $ Present Value		
Strategy	**Cost**	**Groundwater Replenishment Benefit**	**Total Benefit**
Non-Structural BMPs	$2.791	$0	$5.600
Wetlands and Infiltration Basins. Watershed area basis	$7.420	$7.200	$18.000
Wetlands and Infiltration Basins, Detention volume basis	$5.661	$7.200	$18.000
Source: Devinny, J. S., S. Kamieniecki, and M. Stenstrom. 2004. Alternative Approaches to Stormwater Quality Control.			

In some areas, runoff from irrigation is summer is a substantial contributor to water quality problems in near-shore ocean areas such as beaches, harbors and bays. Santa Monica has a stormwater recycling facility which will capture, treat and reuse summer stormwater flows.

Real water supply potential occurs where rainwater does not otherwise collect into usable surface or groundwater supplies. In the coastal regions, most stormwater is conveyed to local channels and discharged to the ocean. Some stormwater strategies might have other significant benefits. For example, stormwater storage might provide a significant benefit as an emergency water supply following earthquake.

The economics of utilization of stormwater for water supply improves as stormwater discharge quality standards increase. This situation is similar to that for recycled water. Increasingly stringent discharge and treatment requirements reduce the incremental cost required to attain water supply quality requirements. If stormwater must be retained and treated, then the incremental cost to use it as water supply may be economical.

The ability of local utilities to raise funds for stormwater improvements is limited by statues and initiatives such as proposition 218.[11] Water supply considerations could provide a significant source of funds to assist with stormwater problems. Some California water agencies are actively managing stormwater for water supply. In the Chino Basin, about 18,000 AF per year of stormwater recharge is anticipated (Wildermuth Environmental, 2007). Retention/Irrigation is a recognized BMP for stormwater management (CSQA, 2003a). “Retention/irrigation refers to the

[11] Before a local government can charge a new property-related fee Proposition 218 requires local officials to conduct detailed planning studies and take a vote. If a majority of the affected property owners or two-thirds of the electorate in the affected area do not approve the fee it may not be imposed.

capture of stormwater runoff in a holding pond and subsequent use of the captured volume for irrigation of landscape or natural pervious areas."

Roof runoff controls including cisterns are also a recognized BMP for California stormwater (CSQA 2003b). Water would normally be used for non-potable outdoor purposes. Cisterns have been used as water supply systems for centuries and the technologies are well-established. Above-ground roof collection systems or systems in hilly areas may be able to use gravity pressure for distribution. Significant amounts may be collected from large commercial/industrial buildings. Costs of storage space may the largest cost share, but space required for stormwater retention elsewhere might be reduced.

Cisterns and some other stormwater controls would involve private property. Therefore, private economic incentives may be required. These incentives could include forgiveness from stormwater parcel fees where such fees are in place.

Porous pavement, a technology that is now about 25 years old, allows stormwater to infiltrate into groundwater instead of collection and discharge as surface water. According to one source:

> The ideal location for porous pavement is in low traffic or overflow parking areas. In extremely dense urban areas porous pavement has been used successfully in redevelopment projects, since it treats and stores stormwater without consuming extra land. Porous pavement can also be used on individual sites where a parking lot is being resurfaced. Newer applications of porous pavement include uses on some highways to reduce hydroplaning. Porous pavement should be avoided where activities generate highly contaminated runoff. Areas of low soil permeability, seasonal high groundwater tables, and areas close to drinking water supply wells should also be avoided (Greenworks, 2008).

Economic costs relative to normal pavement are unknown. Regular maintenance costs for cleaning may be required. There are several known applications in California (CAPA 2008).

7.5 Land Management Practices

With climate change, California will face reduced storage through loss of spring and summer snowpack. Land management strategies to increase water retention in forested and agricultural areas might help. These strategies might include forest and grassland management and more intensive management of irrigation water such as pre-irrigation, non-traditional groundwater recharge, and soils modifications. Water supply accomplishments of land management strategies may be hard to document, but they could be substantial for programs that cover large acreage over an extended period of years.

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