III. DETERMINATION OF GEOGRAPHIC ZONES

To facilitate estimation of water use efficiency improvements, zones have been created that group together geographic areas with similar characteristics. Specific zones have been developed for each of the three water use sectors: urban, agricultural, and diverted environmental.

The CALFED Bay-Delta Program's Programmatic EIR/EIS report is also being separated into geographic zones, but in this case, to facilitate the presentation of information. Because the PEIS/EIR includes many more issues than just water use efficiency, the water use efficiency zones were developed to fall within the PEIS/EIR zones.

Many efforts have been undertaken in the past to estimate the potential of water use efficiency improvements. Each of these have developed or presented information using a defined boundary. One of the more common boundaries is the Department of Water Resources' Planning Subareas (PSA). There are 44 PSA's that cover the entire state of California. Information at the PSA level is also readily available for use in this analysis and has been used for other investigative purposes such as for the Bureau of Reclamation's *Least-cost CVP Yield Increase Plan* (October 1995). For water use efficiency estimation purposes, grouping the PSA's into common zones was believed to provide the appropriate level of detail for a programmatic level analysis. PSA's have been grouped into the zones described below for each of the three water use categories.

Agricultural Zones

The agricultural approach to water use efficiency is focused on identifying and implementing improvements in local water use management and efficiency. This will include conservation of losses and changes in local management to gain multiple benefits from existing water supplies. Major differences in the potential resulting from efficiency improvements exists among regions of the state. For instance, conservation of "lost" water typically can only occur where water flows to salt sinks or unusable bodies of groundwater, which can occur in areas that export water from the Delta. Conservation potential would then further depend on soil, crop, climate, as well as other site-specific characteristics. On the other hand, changes in local water use management to possible achieve a secondary ecosystem benefit are more apt to occur in areas that directly divert water from natural streams and rivers. Because of these differences, it is appropriate to develop estimates that are locally specific. However, though differences exist, there is limited information to allow a full understanding of local variations. Therefore, the following grouping of PSA's was established to group areas that had regional similarities. PSA's are listed beneath each zone designation. Figure X represents a graphical view of the agricultural zones.

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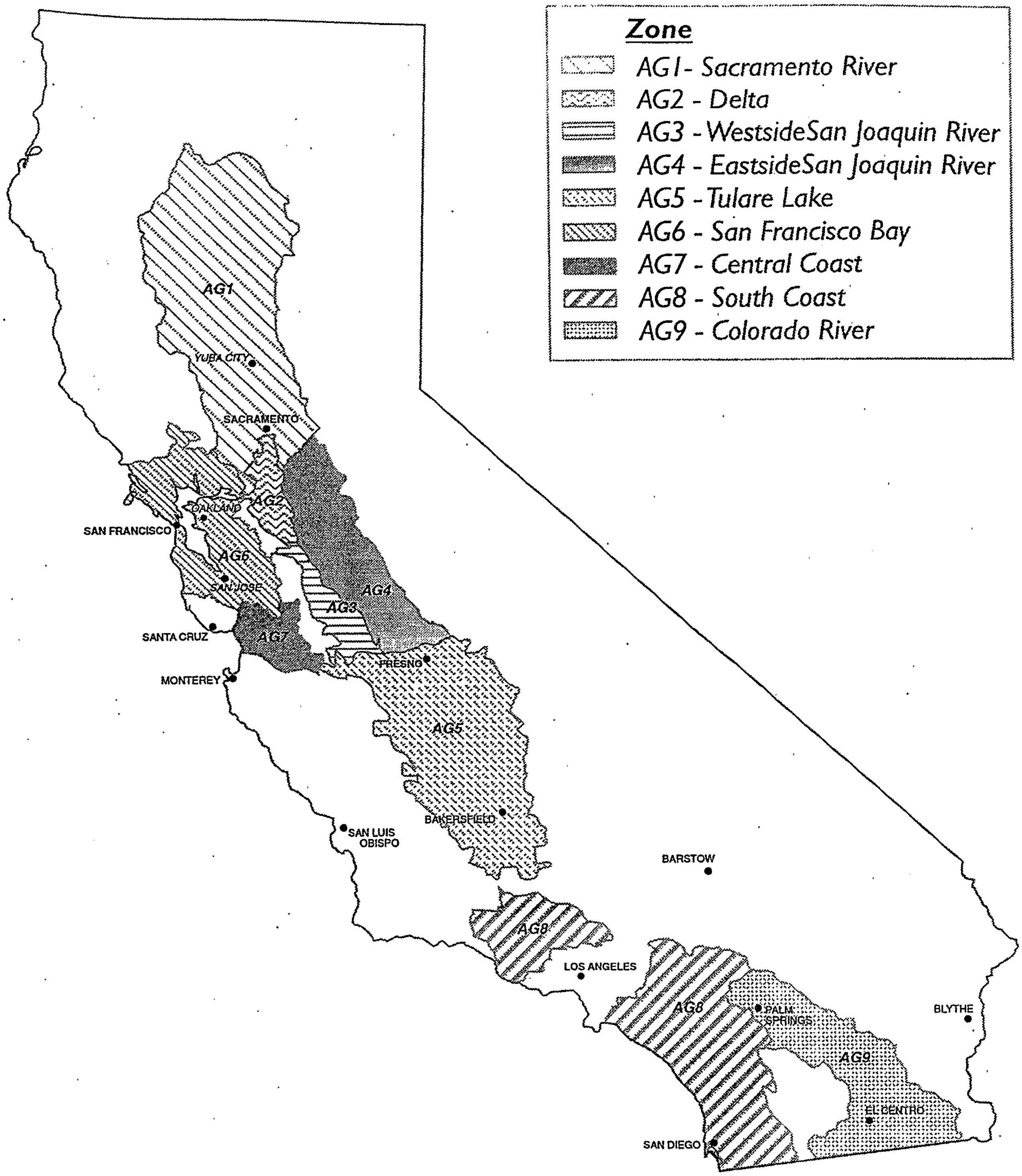

Figure X
Agricultural Regions

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E-010718

Zone AG1
Sacramento River Region
- Northwest Valley
- Northeast Valley
- Central Basin West
- Central Basin East

Zone AG2
Delta Region
- Delta Service Area (Sacramento HR)
- Delta Service Area (San Joaquin HR)

Zone AG3
Westside San Joaquin River Region
- Valley West Side

Zone AG4
Eastside San Joaquin River Region
- Eastern Valley Floor
- Valley East Side

Zone AG5
Tulare Lake Region
- San Luis West Side
- Kings-Kaweah-Tule Rivers
- Kern Valley Floor

Zone AG6
San Francisco Bay Region
- North Bay
- South Bay

Zone AG7
Central Coast Region
- Northern (portion connected to San Luis Reserv.)

Zone AG8
South Coast Region
- Santa Clara
- Santa Ana
- San Diego

Zone AG9
Colorado River Region
- Coachella
- Imperial Valley

By inspection, not all PSA's are included in the agricultural zones presented. PSA's not included were felt to have limited agricultural activity or were determined to be outside of the CALFED solution area. For instance, the Northern PSA under the Central Coast region has been included because of State Water Project agricultural deliveries to the southern Santa Clara Valley. The Southern PSA under the same region is not included because of agricultural water supplies do not originate from the Delta. Areas of the Imperial Valley have been included because potential conservation savings could be used to offset existing or future Delta demands of the South Coast region.

PSA's included under each zone were assumed to represented the majority of the agricultural production areas. For programmatic impact analysis purposes, this is believed to provide the necessary level of detail for determination of potential impacts. It can be assumed, however, that water use efficiency improvements in agricultural areas outside of the PSA's included above will be a necessary part of an overall Bay-Delta solution.

E-010719

Urban Zones

The urban approach to water use efficiency is focused on identifying and implementing conservation and water reuse measures. Conservation measures implemented in some regions will reduce water demands, saving water otherwise lost to saline sinks (e.g., the Pacific Ocean). Other regions may not truly save water but can reduce the cost of treatment and distribution and have secondary benefits to the environment. Because of the variation in conservation and reuse goals, urban areas have been separated into the same regional zones used for agricultural. Although the urban geographic zones may not differ from that used for agriculture, the PSA's within the zones will. For instance, conservation or reuse potential in the Sacramento River Region is mainly limited to the Central Basin East PSA. The South Coast Region includes a PSA aptly named "Metropolitan LA" which was excluded from the agricultural zone. The following grouping of PSA's was established to group areas that had regional similarities. PSA's are listed beneath each zone designation. Figure Y represents a graphical view of the urban zones.

Zone UR1
Sacramento River Region
- Central Basin East

Zone UR2
Eastside San Joaquin River Region
- Eastern Valley Floor
- Valley East Side

Zone UR3
Tulare Lake Region
- Kings-Kaweah-Tule Rivers
- Kern Valley Floor

Zone UR4
San Francisco Bay Region
- North Bay
- South Bay

Zone UR5
Central Coast Region
- Northern (portion connected to San Luis Reserv.)
- Southern (portion connected to Central Coast project)

Zone UR6
South Coast Region
- Santa Clara
- Metropolitan LA
- Santa Ana
- San Diego

Zone UR7
Colorado River Region
- Coachella
- Imperial Valley

Similar to the agricultural zones, not all PSA's are represented in the above designations. For instance, the Sacramento River Region is limited to the PSA containing the Sacramento metropolitan area. Other urban areas in the Sacramento Valley have much smaller population centers. Areas of the Imperial Valley have been included because potential conservation savings could be used to offset existing or future Delta demands of the South Coast region.

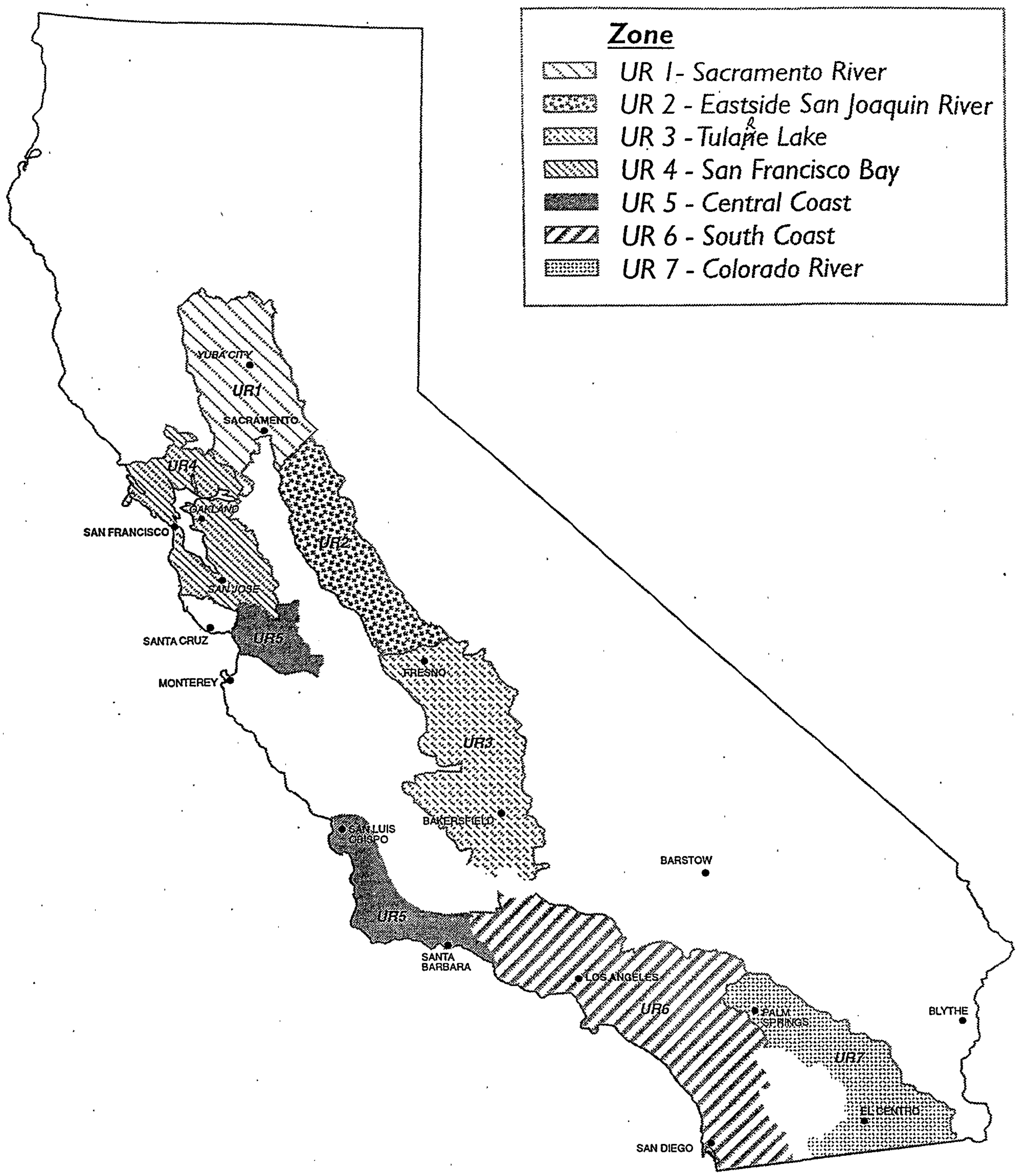

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Figure Y
Urban Regions

PSA's included under each zone were assumed to represented the majority of the populated urban areas that derive their water supplies from the Delta or its tributaries. For programmatic impact analysis purposes, this is believed to provide the necessary level of detail for determination of potential impacts. It can be assumed, however, that water use efficiency improvements in urban areas outside of the PSA's included above will be a necessary part of an overall Bay-Delta solution.

Diverted Environmental Zones

The water use efficiency approach also includes identifying and implementing water management and efficiency improvements in managed wetlands (e.g., refuges, wildlife areas). The majority of these exist within the confines of the Central Valley. Opportunities for conservation and improved water management are somewhat similar for each specific area, regardless of their location in the Valley. For that reason, it would make sense to group these areas together and look at their collective potential. However, because the Programmatic EIR/EIS report has separated geographic regions for presentation purposes, zones must also be established for efficiency potential of environmental diversions. The following zones have been created. Each zone lists the federal, state, or private wetland that has been included for estimating purposes. Figure Z graphically presents these zones.

Zone WR1
Sacramento River Region
- Sacramento NWR
- Delevan NWR
- Colusa NWR
- Sutter NWR
- Gray Lodge WA

Zone WR2
Delta Region

Zone WR3
San Joaquin River Region
- Kesterson NWR
- San Luis NWR
- Merced NWR
- Grasslands WD
- Volta WR

Zone WR4
Tulare Lake Region
- Pixley NWR
- Kern NWR
- Mendota WR

Zone WR5
San Francisco Bay Region
- Suisun Marsh

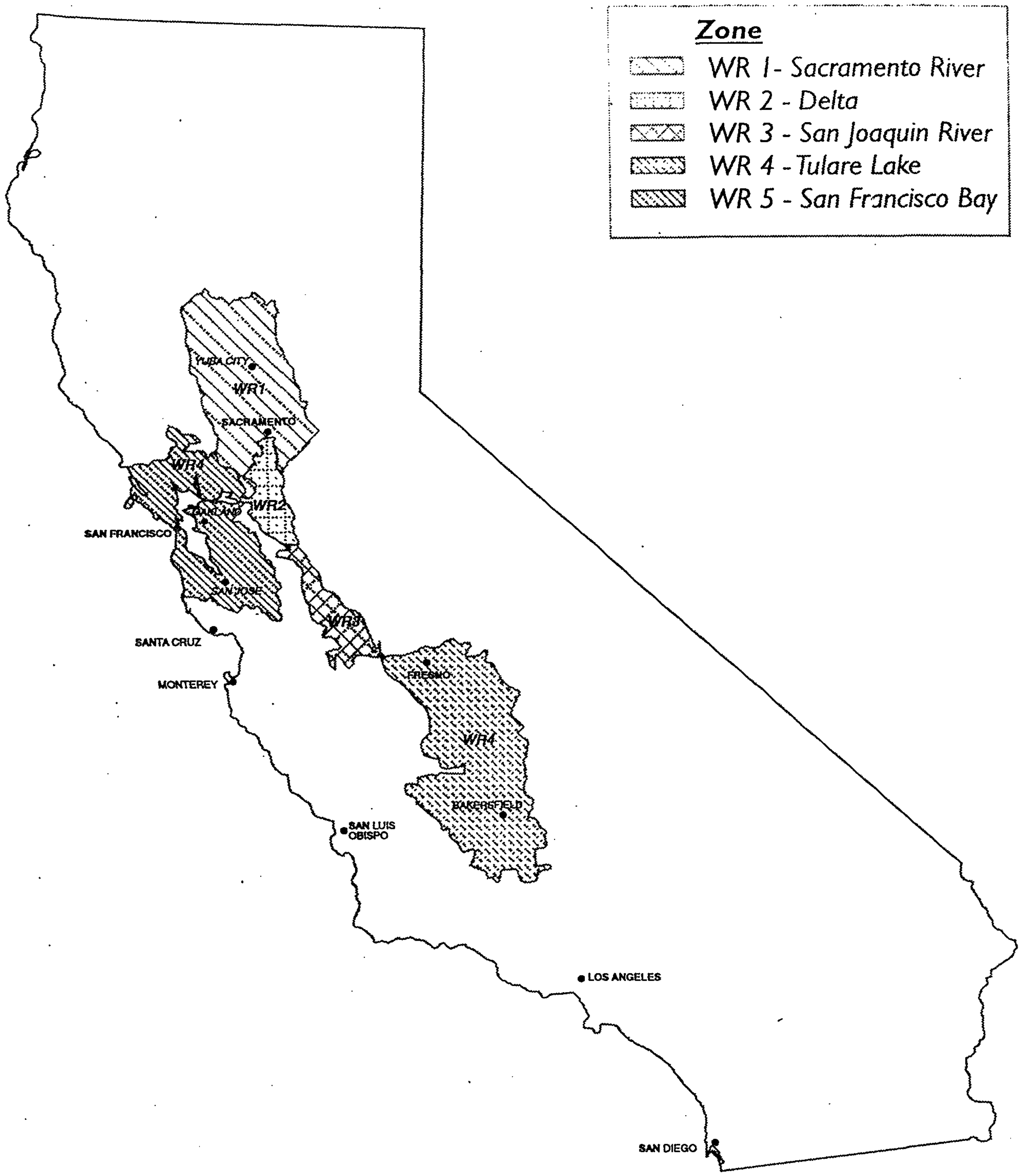

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Figure Z
Diverted Environmental Regions

E-010723

IV. AGRICULTURAL WATER USE MANAGEMENT AND EFFICIENCY IMPROVEMENTS

This section presents the basis and background for estimating potential water savings and identifies related impacts that may occur as result of the CALFED No Action alternative and as a result of the CALFED Water Use Efficiency Program, or CALFED alternative. The proposed CALFED approach to agricultural water use efficiency is focused on local identification and implementation of new measures, as well as expansion existing measures, to improve local agricultural water use management and efficiency. Local involvement is anticipated to further advance water management in California.

This section is intended to be used solely for Phase II impact analysis and is not intended to provide planning recommendations. The following information is included:

- Potential reductions in losses resulting from efficiency improvements, either as real water savings, or benefits to water supply reliability, water quality or the ecosystem,
- the cost associated with implementing agricultural efficiency improvements, and
- the potential impacts from efficiency improvements to various resource categories.

Summary of Findings

Improvements in on-farm and district level efficiency can result in the reduction of losses typically associated with the application of irrigation water to fields. Though the majority of loss reduction does not generate real water savings and cannot be reallocated to other beneficial uses, it can provide significant benefits to water quality and the ecosystem. Estimates are separated into two categories:

- estimated real water savings resulting from a reduction in irrecoverable losses, and
- estimated applied water reduction resulting from reduction in recoverable losses. (This category of loss reduction does not result in water that can be reallocated to other beneficial water supply uses.)

Based on the detailed assumptions and data described later, the estimates of cumulative loss reduction (for both real water savings as well as applied water reductions) are shown in Figures 4.1 and 4.2.

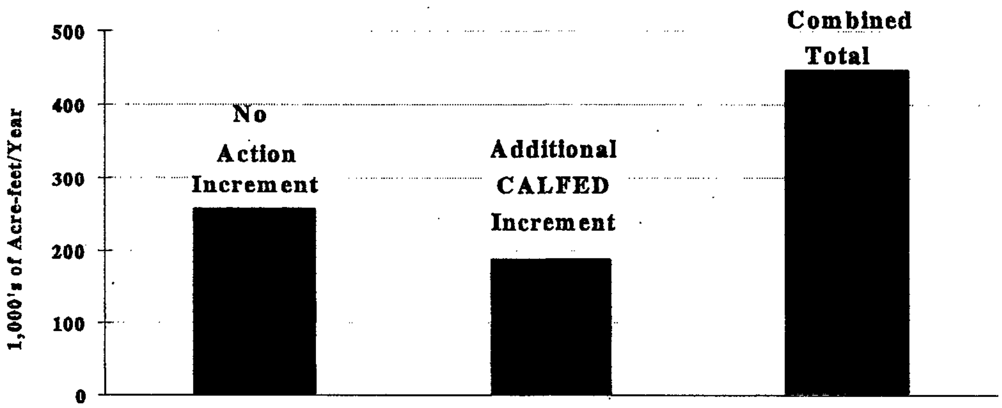

Figure 4.1 - Estimated Statewide Range of Real Water Savings
The incremental portion generated by CALFED is less than half of the total projected savings. This water can be reallocated to other beneficial uses.

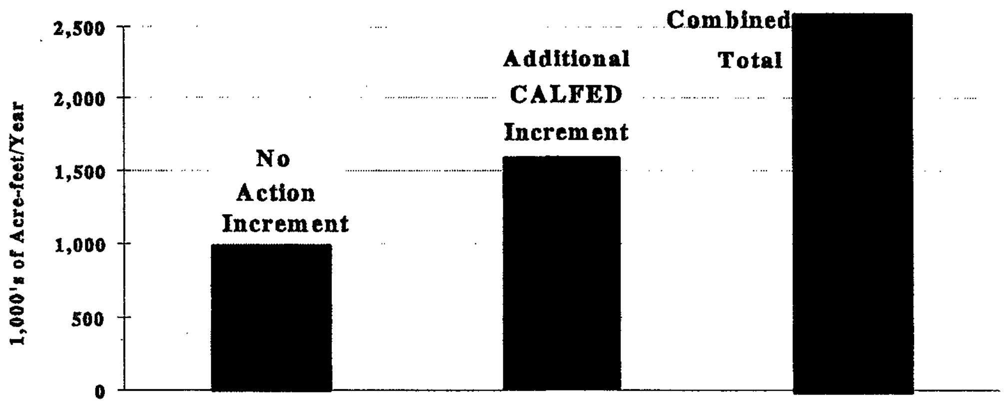

Figure 4.2 - Estimated Statewide Range of Applied Water Reduction
These reductions can provide water quality and ecosystem benefits. The reductions do not constitute a reallocable water supply.

Although the total potential loss reduction estimates shown here are sizable, it must be recognized that they assumes all agricultural water users within the CALFED solution area will achieve an 85 percent level of efficiency and irrigation system distribution uniformity will increase to between 80 and 90 percent. To achieve this will require increased levels of support and commitment from federal, state, and local agencies.

Costs associated with implementing improvements to achieve these loss reductions will vary case-by-case. Both on-farm and district spending are necessary in order to obtain the anticipated levels of improvement. Generally, the on-farm cost to reduce applied water ranges from $35 to $95 per acre-foot annually. District expenses can add an additional $5 to $12 per irrigated acre per year to the cost of improved efficiency. In contrast, the range of cost to generate real water savings from reductions in applied water is much greater because of the relationship of applied water reduction to real water savings (see Figure 4.3). Where real water savings do occur (as a result of reduced irrecoverable losses), the cost for real water savings is estimated to range from $80 up to $850 per acre-foot per year. A detailed discussion of cost is provided toward the end of this section.

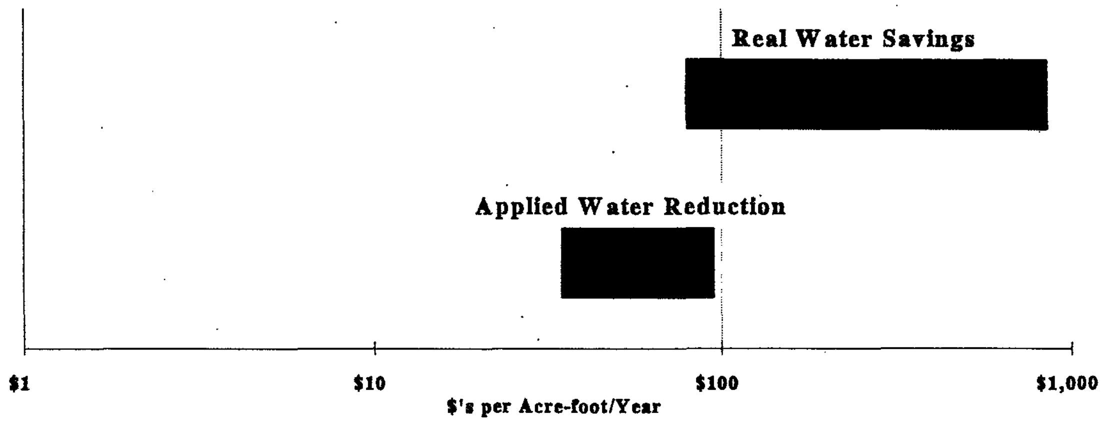

Figure 4.3 - Estimated Range of Cost to Improve On-farm Irrigation Efficiency
Generating real water savings can cost significantly more than reducing applied water

Section Overview

The remainder of this section provides a more detailed discussion on the basis used to estimate the potential reduction of losses. The section is subdivided into the following topics:

- General state-wide assumptions
- Specific state-wide assumptions - including the basis for projecting on-farm and district level efficiency improvements for the CALFED No Action alternative as well as those anticipated for the CALFED solution alternative.
- Irrecoverable versus recoverable losses - including differentiation of the two types of losses and the benefits that can be derived from each.
- Regional reduction estimates - including descriptions and assumptions for each agricultural zone and the resulting projection of loss reduction.
- Estimated cost of efficiency improvements - including cost information for each agricultural zone associated with implementing efficiency improvements.
- Anticipated impacts, beneficial and adverse, resulting from efficiency improvements

General State-wide Assumptions

Information presented in this section is for the sole purpose of identifying potential impacts, both beneficial and adverse, as part of the CALFED Bay-Delta Program Programmatic EIR/EIS. Neither the information nor the analysis is intended to be used for planning recommendations. Impacts associated with anticipated actions will be described in more general terms than may be presented in a site specific EIR. Therefore, information developed here, as a first-step in impact analysis, is based on broad assumptions. The general state-wide assumptions listed below guided the development of necessary information used during the analysis of impacts. Specific assumptions are described for each agricultural zone later in this section.

- It is assumed that irrigated agricultural acreage will not increase in the future. Therefore, increased water use efficiency in the agricultural sector is not assumed to result in increased irrigated acreage. State-wide, agricultural acreage is expected to decline as a result of Central Valley urbanization, loss of soil productivity, ecosystem restoration activities, land retirement, water transfers, as well as other factors (DWR, Bulletin 160-93). Estimates of loss reduction have been adjusted accordingly to account for this anticipated reduction by using acreage forecast made by DWR for 2020.

- Conservation of water that results in additional water supply is limited to the reduction in irrecoverable losses. These include losses to evaporation, evapotranspiration of non-agricultural plants, saline sinks, and poor-quality perched groundwater. Further discussion of this is included later. There are other changes in water and farm management that would reduce consumptive water use by agriculture, but these measures are not considered efficiency improvements and are not considered in this analysis. These measures include changes in crop mix, fallowing, and permanent land retirement.

- Conservation of water in areas where water returns to the hydrologic system in a usable form can potentially be credited with ecosystem or water quality benefits but typically not water supply benefits. Benefactors of existing methods of water application that may be adversely impacted when changes are made need to be taken into consideration when implementing efficiency measures. These include secondary agricultural users, multiple reuse, seasonal wetlands, and riparian habitat in drains. For instance, a measure to reduce diversions and associated fish entrainment impacts by implementing conservation measures may adversely impact habitat in a drainage course that currently survives off of the “excess” applied water.

- Water that is conserved (either by the supplier or the water user) is assumed to remain in the control of the supplier or water user for their discretionary use or reallocation.

This could include applying the "saved" water to additional under-irrigated lands, offsetting groundwater overdraft, or transferring to another benefactor, including the environment.

- It is not the intention of this effort to reanalyze estimates of water use efficiency improvements that have recently been developed by others. This effort has directly included or has been influenced by information developed or presented by the following:

  -Department of Water Resources (DWR). 1994a. "California Water Plan Update." Final Bulletin 160-93.
  -Department of Water Resources (DWR) - internal staff work developed as background and draft input data for Bulletin 160-98.
  -U.S. Department of Interior (DOI) - Bureau of Reclamation, Mid-Pacific Region and Fish and Wildlife Service. September 1995. "Demand Management - Technical Appendix #3 to the Least-Cost CVP Yield Increase Plan."
  -Pacific Institute. May 1995. "California Water 2020 - A Sustainable Vision."
  -San Joaquin Valley Drainage Program. September 1990. "A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley." Final Report.

Many factors are considered by growers when evaluating the merits of improving irrigation efficiency. The actual savings of water is only one of these factors. In many instances, it does not make economic sense to invest in improved levels of efficient use, because there is insufficient return on investment. In regions where water supplies are less reliable and usually more expensive, it becomes cost effective to improve management and irrigation techniques, to an extent. For a grower, the decision to spend capital will only be made if the capital will be returned over a relatively short period of time. Repayment may be in the form of reduced labor costs, reduced water costs, improved yields, etc. A water user will not decide to implement actions if their "bottom line" will be adversely affected. Social issues also play a role in the decision to implement new measures. For instance, many growers use untrained field laborers to irrigate rather than a specially trained irrigator. Also, the generational passing of knowledge (i.e., transfer of control from parent to child) can slow the acceptance of new technologies. For instance, a child may want to try new technics but may not want to challenge the way their parent operates, even if it can be improved upon. Though these issues exist and will be a factor in the rate of acceptance and implementation, they are not assumed to limit the values projected here.

Specific State-wide Assumptions

The assumptions listed here provide the specific basis for estimating loss reduction from improved efficiency. Estimates are based on determinations of:

- existing conditions,
- the CALFED No Action alternative which includes conditions expected with implementation of some on-farm improvements and some Efficient Water Management Practices (EWMPs) and,
- the CALFED solution alternative which includes projections of future conditions that could exist as a result of the CALFED Water Use Efficiency Common Program.

Technical assumptions presented below are categorized into the following:

- on-farm irrigation efficiency improvement
  - existing irrigation efficiency
  - projected irrigation efficiencies under the No Action Alternative
  - additional irrigation efficiency improvements as a result of the CALFED Program
- water delivery improvements by water suppliers
  - existing delivery inefficiencies
  - projected improvement under the No Action Alternative
  - additional improvement as a result of the CALFED Program

On-farm Irrigation Efficiency Improvement

On-farm irrigation efficiency is defined as the volume of irrigation water beneficially used divided by the volume of irrigation water applied (including the change in water stored in the soil). Beneficial uses include crop evapotranspiration, water harvested with the crop, salt removal (leaching), cultural practices, climate control, as well as other minor activities (Burt, etal.). Given these various elements and the difficulty in accurately measuring any one of them, it should be noted that irrigation efficiency is a gross measurement. Values derived are estimates based on best scientific data and should be viewed as a tool to help make management decisions. The data itself can easily be misinterpreted or incomplete, resulting in an estimate of efficiency that is not accurate. For instance, not including a crops uptake of irrigation water previously stored in the soil in the total applied water value can make efficiency appear higher than it actually is.

On-farm irrigation efficiency, in more practical terms, is a complex result of the type of irrigation system, the level of irrigation management, the amount of irrigation system maintenance, the method of delivery to the field, the timely availability of water, the climate, the soil, the crop, the irrigator, etc. Irrigation efficiency does not improve simply by changing one of these factors. In fact, some studies have shown that on-farm irrigation efficiency can become worse when, for example, a system type is changed but the management style is not. High levels of irrigation efficiency that are sometimes referred to by agriculture, by the public, and by policy makers can be very misleading since they may reflect regional or mis-calculated efficiencies and not necessarily true on-farm efficiency. In some instances, these high efficiency values actually mean that the crop is being under-irrigated (it is possible to use 100 percent of the applied water beneficially but still under-irrigate). This means reduced yields and the possibility of salt build-up in the soil.

The assumptions presented below for existing and projected on-farm irrigation efficiencies address these issues in more detail and describe the limits of what can be achieved while maintaining optimum agricultural production and a healthy soil environment.

Existing Irrigation Efficiency

Analysis of over 1,000 different field evaluations of on-farm irrigation systems show that state-wide on-farm irrigation efficiency (IE) averages 73 percent (DWR's data, UCD analysis). However, the value can vary significantly from farm-to-farm and basin-to-basin. For each agricultural zone discussed below, information derived from local irrigation system evaluations, farm advisors, local agencies, and other sources, provides an estimate of the average local on-farm irrigation efficiency. This is the baseline efficiency assumed for 1995 conditions. Based on this assumption, projections for improved efficiencies allow estimates to be made of potential reductions in irrigation related losses that may occur in the future.

Care must be taken to only include on-farm irrigation efficiency to eliminate confusion between on-farm and regional efficiency. Regional efficiency is derived from a combination of on-farm efficiencies and the level of regional water reuse, including reuse of deep percolation and tailwater runoff. It is erroneous to draw a comparison between regional efficiency and on-farm efficiency without considering regional reuse, a primary reason for higher regional efficiencies. For instance, water lost from one field as tailwater runoff or deep percolation, if water quality is not severely degraded, can be reused on another field for additional beneficial uses. The greater the level of reuse, regardless of the on-farm efficiency of any particular field, the higher the regional efficiency will tend to be.

Projected On-farm Irrigation Efficiencies under the No Action Alternative

Irrigation efficiency is anticipated to improve to between 73 and 80 percent as a result of existing trends in growers' irrigation systems and management. Efforts by federal, state, and local agencies over the past decade in research and education are also expected to continue to provide new understanding of plant/water/soil relationships which will further aid in improved water management. In addition, there has been a renewed focus on conservation and approval of new funding sources, such as Proposition 204, that will continue to influence efficiency improvements. As a result, for the CALFED No Action alternative, on-farm efficiency is projected to be higher than it is today. Estimates of what may occur are presented here to provide a differentiation between what is projected absent the CALFED Program, or No Action, and what additional improvements may result from the Program's Water Use Efficiency component. This difference will provide the basis for programmatic level impact analysis.

Because of variations from field-to-field and basin-to-basin, it may be useful to consider a range of efficiencies that are reasonably expected. Analysis shows that a range of efficiency between 73 percent and 80 percent is a reasonable target (DWR). (Efficiencies of 73 percent represent full irrigation for an entire field, 80 percent efficiency represents full irrigation on 7/8ths of the field and slight underirrigation on 1/8.) However, these levels of efficiency will require continuation of technical and financial assistance at levels that exist today, at a minimum.

One of the factors that limits projected on-farm efficiency to 80 percent is a factor called *distribution uniformity*. Distribution uniformity (DU) is the uniformity with which irrigation water is distributed to different areas in a field (Burt, etal.). Distribution uniformity is primarily affected by four main factors:

- system manufacturing (e.g., nozzle size, material durability, performance reliability),
- system design (e.g., number of emitters per tree, spacing of sprinklers, size and spacing of furrows),
- system maintenance (e.g, nozzle replacement, land grading, drip system chlorination), and
- system management (e.g., how well a grower operates the system in comparison to the needs of the crop)

Experts in the field of irrigation maintain that current hardware design and manufacturing technology, as well as typical system maintenance activities, limit the DU to around 0.8. The anticipated efficiency improvements under the No Action alternative assume that the majority of irrigators will be able to obtain this level of distribution uniformity. This is necessary to achieve average on-farm efficiencies between 73 and 80 percent. Because of the effect that DU can have on irrigation efficiency, increasing on farm efficiency to levels above 80 percent is unlikely without accompanying improvements in DU, especially if soil conditions are to be maintained for optimum crop production.

Additional Irrigation Efficiency Improvements as a Result of the CALFED Program

The CALFED Program's Water Use Efficiency component is expected to extend the level of on-farm efficiency improvement up to 85 percent. Necessary additional improvements will be facilitated by increased levels of technical, planning, and financial assistance, along with increased implementation of EWMPs by agricultural water suppliers (see discussion below under Water Supplier Improvements).

The assumption that allows on-farm efficiencies to increase above 80 percent requires that distribution uniformity (DU) increase to a range of 0.8 to 0.9 by 2020. Analysis of data indicates that an increase of DU to this range for example, can result in applied water reduction of 8 to 12 percent (e.g., about a 3 to 4 inch reduction in applied water on a crop like tomatoes) without any reduction in crop water requirement or any reduction in beneficial uses (DWR). Such improvements could occur through advances in design and manufacturing of pressurized hardware along with increase awareness and implementation of irrigation system maintenance. Figure 4-1 shows relationships between applied water, irrigation efficiency, and improved distribution uniformities. Note that, as the figure demonstrates, reduction in applied water occurs without reduction in beneficial uses (such as crop consumptive use, leaching, and climate control) simply as a result of increased distribution uniformity.

This improvement can occur as a result of combined efforts to improve manufacturing processes and system designs, and efforts by irrigators in improving maintenance and management practices for irrigation systems. It is reasonable to expect these improvements can occur because of increased awareness and necessity for higher efficiency resulting from the CALFED Bay-Delta Program and response by the irrigation industry.

With a higher potential DU, on-farm irrigation efficiencies of 85 percent can be assumed for each agricultural zone. However, it must be recognized that this is a maximum level for maintaining optimum crop production. Average efficiencies would be expected to range from the current statewide average of 73 percent up to a maximum 85 percent. For comparison purposes, it is assumed:

- the maximum on-farm irrigation efficiency projected for the No Action alternative is estimated at 80 percent.
- the maximum on-farm irrigation efficiency projected for a CALFED alternative is estimated at 85 percent.

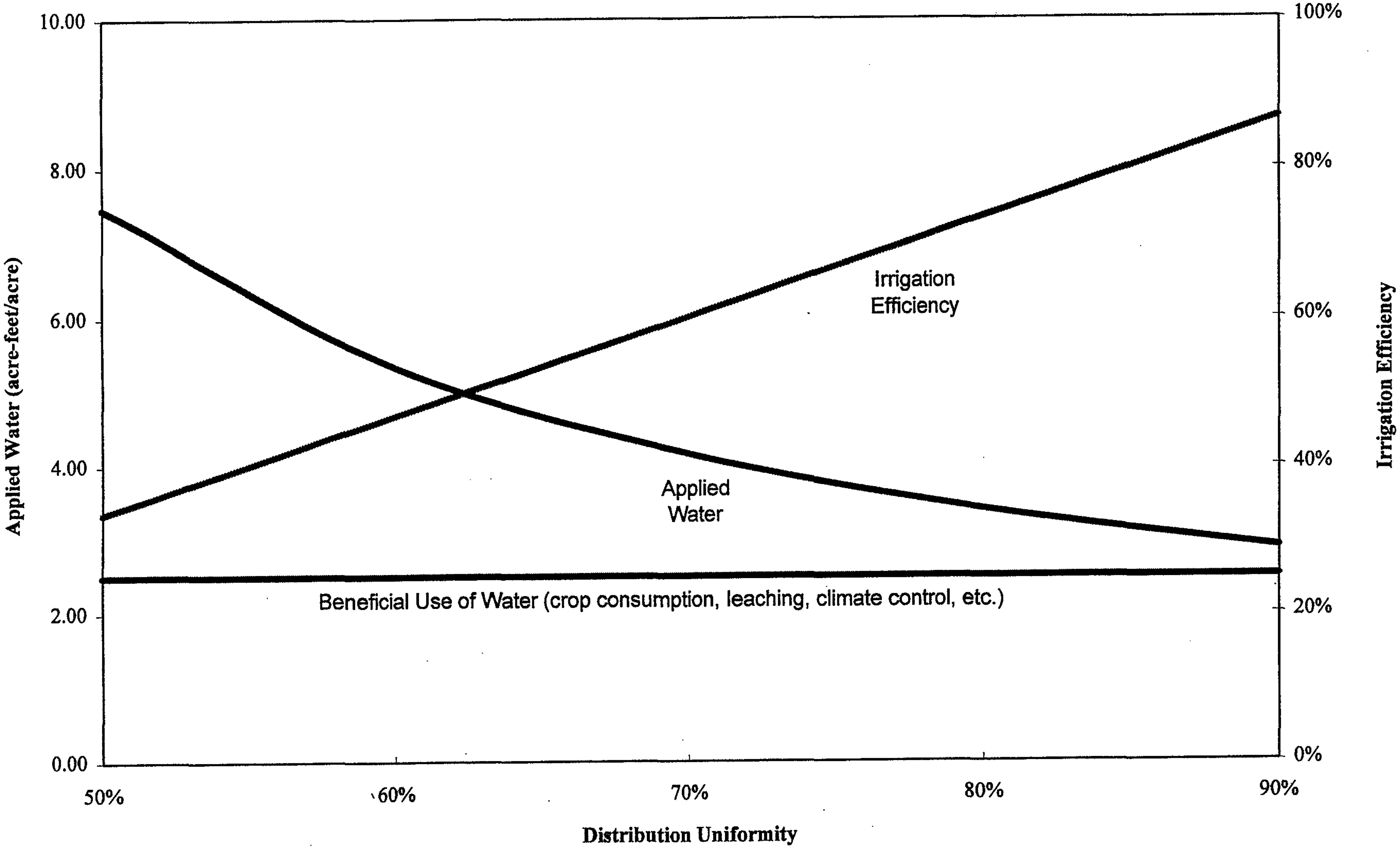

Figure 4-4

Effect of Improved Distribution Uniformity on Potential Seasonal Irrigation Efficiency and Applied Water

Improvements in distribution uniformity can result in increased efficiency and decreased applied water while still meeting beneficial crop needs.

Figure courtesy of DWR

CALFED Bay-Delta Program
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Water Delivery Improvements by Water Suppliers

The majority of water applied to fields is obtained from water districts, which obtain most of their water from surface diversions (DWR, 1994a). Surface water supplies are actively distributed and delivered to fields and farms within a district's service area. This has been the primary job of the water district for many years. Only recently, has the job of the district begun to change from that of only water delivery to a role of water supply management. It can be noted that districts that typically have limited water supplies and/or high water costs have already taken on the role of water management. Other districts, especially those with ample supplies, still maintain the "delivery only" paradigm. The CALFED Program's Water Use Efficiency component will increase the availability of planning assistance, technical assistance, and funding so that more districts can expand their role to include water supply management, not just delivery.

Distribution of large quantities of surface water is inherently difficult and challenging. In contrast to urban water deliveries, most agricultural water supplies are not pressurized or available "on-demand". (Research to provide "on-demand" supplies is underway but is currently cost-prohibitive). Instead, large networks of pipelines or open canals rely on gravity to distribute the water. Some of the water districts in California have new, more manageable systems, but many others have gravity systems originally constructed during the early part of this century. Many of these existing water delivery systems need to be upgraded to improve the ability of the district to meet more sophisticated needs of their customers, the end user.

Existing Delivery Inefficiencies

Like on-farm systems, district delivery inefficiencies are a result of the type of system, the availability of water, the climatological conditions, the management, and the maintenance. Losses incurred while delivering water result primarily from four sources:

- conveyance seepage,
- canal spillage,
- gate leakage, and
- conveyance consumption.

Conveyance seepage originates from water supplier channels and reservoirs whose seepage flows directly to groundwater bodies. Canal spillage includes discharges from district end points and drainage courses and can flow to either surface or groundwater bodies. Gate leakage is water that leaks through the last gate or check structure of a water supply channel. The location of the last gate can vary along the channel with daily demands. Gate leakage is typically small and, as such, usually seeps through channel bottoms into groundwater bodies or evaporates. Conveyance consumption represents consumptive uses of water along supply channels and reservoirs including evaporation from water surfaces and evapotranspiration of riparian and bank vegetation (DOI, 1995).

Estimates of existing losses resulting from inefficiencies are presented later for each agricultural zone. Values are based upon information from the *Least-Cost CVP Yield Increase Plan* (DOI, 1995) and its supporting appendices. These estimates of existing conditions are used to estimate the potential for reduction in these losses.

Projected Improvement under the No Action Alternative

Recent efforts by agricultural water suppliers, environmental interest groups, and other interested parties have resulted in the development of the *Memorandum of Understanding Regarding Efficient Water Management Practices by Agricultural Water Suppliers in California*. This MOU is designed to create a constructive working relationship between these groups and to establish a dynamic list of efficient water management practices (EWMPs) for implementation by water suppliers. The goal is to voluntarily achieve more efficient water management than currently exists.

It is anticipated that many agricultural water suppliers will sign the MOU and complete the planning requirements. However, implementation levels of EWMPs may occur below the maximum potential. This is based, in part, on resource limitations (both dollars and people) currently experienced by most districts and lack of interest in participating by some water suppliers. The CALFED Water Use Efficiency component includes planning and technical assistance, as well as additional funding, designed to address these shortcomings.

With the MOU being finalized at the start of 1997, already more than 28 water suppliers representing over 2.8 million acres have signed. However, there are over 9 million acres of irrigated lands in California, though some of which is not part of any district. Current signatories represent about 30 percent of this total. Assuming that two to three times more water suppliers sign the MOU by 2020, maybe 50 percent of the total will be included, around 4 to 5 million acres.

For purposes of the No Action alternative, it is estimated that voluntary efforts by suppliers representing about 50 percent of the land will result in attaining 60 percent of the water supplier improvements estimated in the *Least-Cost CVP Yield Increase Plan* (DOI, 1995) and its supporting appendices. This should represent a modest level of planning, adoption and implementation of efficiency measures consistent with the anticipated level of participation in the MOU. Yet, this does not assume that all signatories will achieve implementation of all that is feasible and cost-effective.

Additional Improvements as a Result of the CALFED Program

The Program's Water Use Efficiency component is anticipated to provide the assistance necessary to gain higher levels of EWMP implementation and by more agricultural water districts. Incentives, coupled with regulatory triggers, will encourage more districts to properly examine the benefits of the EWMPs and implement those that are cost-effective. It is assumed that such measures will result in a significant majority of the water suppliers planning, adopting, and implementing feasible, cost-effective efficiency measures.

Estimates of the potential reduction in existing losses are presented later for each agricultural zone. For purposes of impact analysis, estimates of loss reduction under the CALFED alternative are based upon attainment of the majority of remaining improvements identified in the *Least-Cost CVP Yield Increase Plan* (DOI, 1995) and its supporting appendices (i.e., remaining improvements above those achieved under No Action).

It is important to recognize, though, that these estimates are for the sole purpose of programmatic level impact analysis and should not be used for any planning purposes.

Irrecoverable vs. Recoverable Losses

With the exception of a negligible amount of water required for plant metabolic processes (about 1 percent of the water absorbed by plants), agricultural applied water can be accounted for by the demand elements presented in Figure 4-5. The "consumptive" elements (ET_{crop}, on-farm evaporation, and conveyance consumption) are lost to the atmosphere and can only be recovered through the hydrologic process. Thus, these elements are not considered humanly recoverable.

Tailwater, deep percolation, conveyance seepage, canal spill, and gate leakage flow either to surface or groundwater bodies and may be recoverable. In theory, all losses are recoverable. In practice, however, losses that flow to very deep aquifers or excessively degraded water bodies may not be recoverable because of prohibitively expensive energy requirements (i.e., they become irrecoverable). Determining recoverability varies with location and time as well as other factors (DOI, 1995).

Distinguishing between irrecoverable and recoverable losses is typically based solely on water quality considerations. This assumes that all losses to usable water bodies can be economically recovered. Principal water bodies that are regarded as irrecoverable include saline, perched groundwater underlying irrigated land on the west side of the San Joaquin Valley, the Salton Sea, which receives drainage from Coachella and Imperial Valleys, and the ocean.

Real water savings can only be achieved by reducing irrecoverable losses because they are truly lost from the system. Water is considered "saved" when these losses are reduced. Recoverable losses, on the other hand, often constitute a supply to the downstream user. Downstream uses can include groundwater recharge, agricultural and urban water use, and environmental uses, including wetlands, riparian corridors, and instream flows. Often, recoverable losses are used many times over by many downstream beneficiaries. To reduce these losses would deplete such supplies with no net gain in the total water supply. They do, however, provide significant opportunities to contribute to the achievement of other CALFED objectives such as:

- improve instream and groundwater quality through reduced deep percolation or runoff of water laden with residual agricultural chemicals, sediments, and naturally occurring toxicities,
- reduce temperature impacts resulting from resident time of water on fields prior to runoff returning to surface waters,
- reduce entrainment impacts to aquatic species as a result of reduced diversions, and
- reduce impacts on aquatic species, especially anadromous fish, through minor modifications in diversion timing and possibly provide in-basin benefits through subsequent modifications in the timing of reservoir releases.

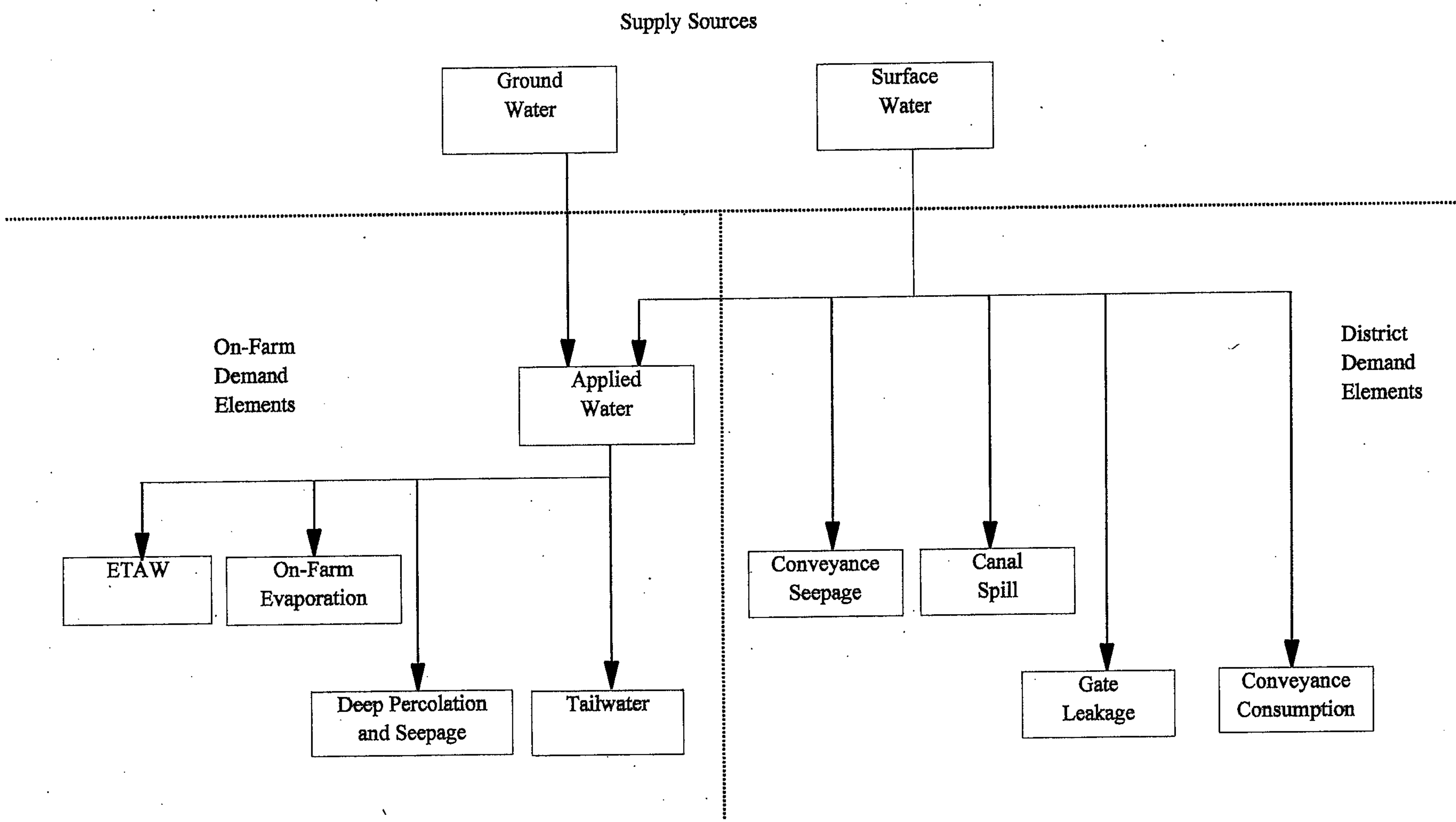

Figure courtesy of the Bureau of Reclamation - Mid Pacific Region from the *Demand Management Technical Appendix #3* to the *Least-Cost CVP Yield Increase Plan*

CALFED Bay-Delta Program
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Figure 4-5

Demand Elements

Water supplied to agricultural fields can result in one of several demand elements. The efficiency of delivery and application systems dictates how much goes to each element.

In general, the same water use efficiency measures are implemented to reduce recoverable losses as are used for reducing irrecoverable losses. The only purpose for separating the two is because of their difference in ability to generate water supplies that can be reallocated. Recoverable losses are available for subsequent in-basin use, and may provide environmental benefits. Reallocation of recoverable losses to out-of-basin uses could result in impacts to other diverters or the environment. This is described in more detail below under *Hydrologic Interconnections*.

As previously stated, it is assumed that on-farm efficiency may improve to 80 percent under a No Action alternative, given current trends and significant technical and financial input. This is assumed to increase up to 85 percent under the CALFED alternative resulting in total reductions in losses between 8 and 12 percent of applied water.

Though the reduction in applied water can seem significant, the benefit to water quality or the ecosystem is not necessarily one-for-one. For instance, an 8 to 12 percent reduction in applied water does not imply that the same percentage improvement in water quality would result. Results could be greater or less, depending on local circumstances. For instance, applied water reductions may be assumed to be spread throughout an irrigation season while water quality impacts that accompany the irrigation may be concentrated in particular days or months or under particular flow conditions. The benefit of reducing applied water may have only minimal benefits during certain periods but more significant benefits during other periods.

It is assumed that implementing efficiency improvements will not result in redirected impacts to the water user or water supplier. For instance, an efficiency measure would not be implemented to reduce applied water if the water user saw production costs increase but received no direct benefit. However, the influence of outside interests to offset local impacts such that there is a "win-win" situation is assumed to occur when appropriate. Outside participation in planning, funding and implementation can help make efficiency measures locally cost-effective when they otherwise might not be. Benefits are also assumed to be shared when costs are shared, whether gained by the water user, the water supplier, or the environment.

Hydrologic Interconnections

The primary reason that the reduction of recoverable losses does not generate a water supply for reallocation is because of the complex hydrologic interconnections that occur between surface water, groundwater, stream flows, and losses associated with irrigation. Figure 4-6 illustrates a generic "existing condition" for some areas of the Central Valley. Figures 4-6 and 4-7 are used as the basis for a discussion regarding hydrologic interconnections.

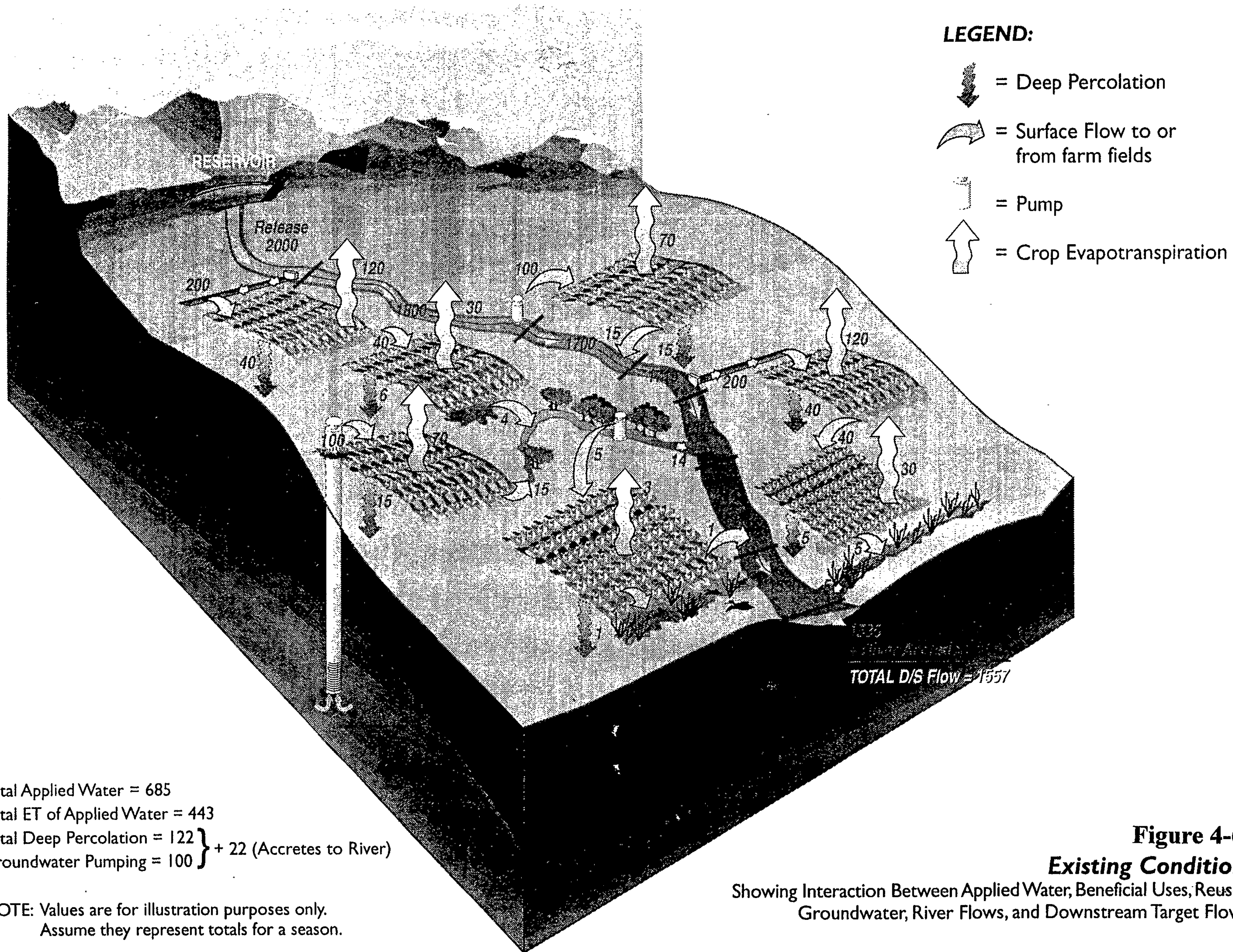
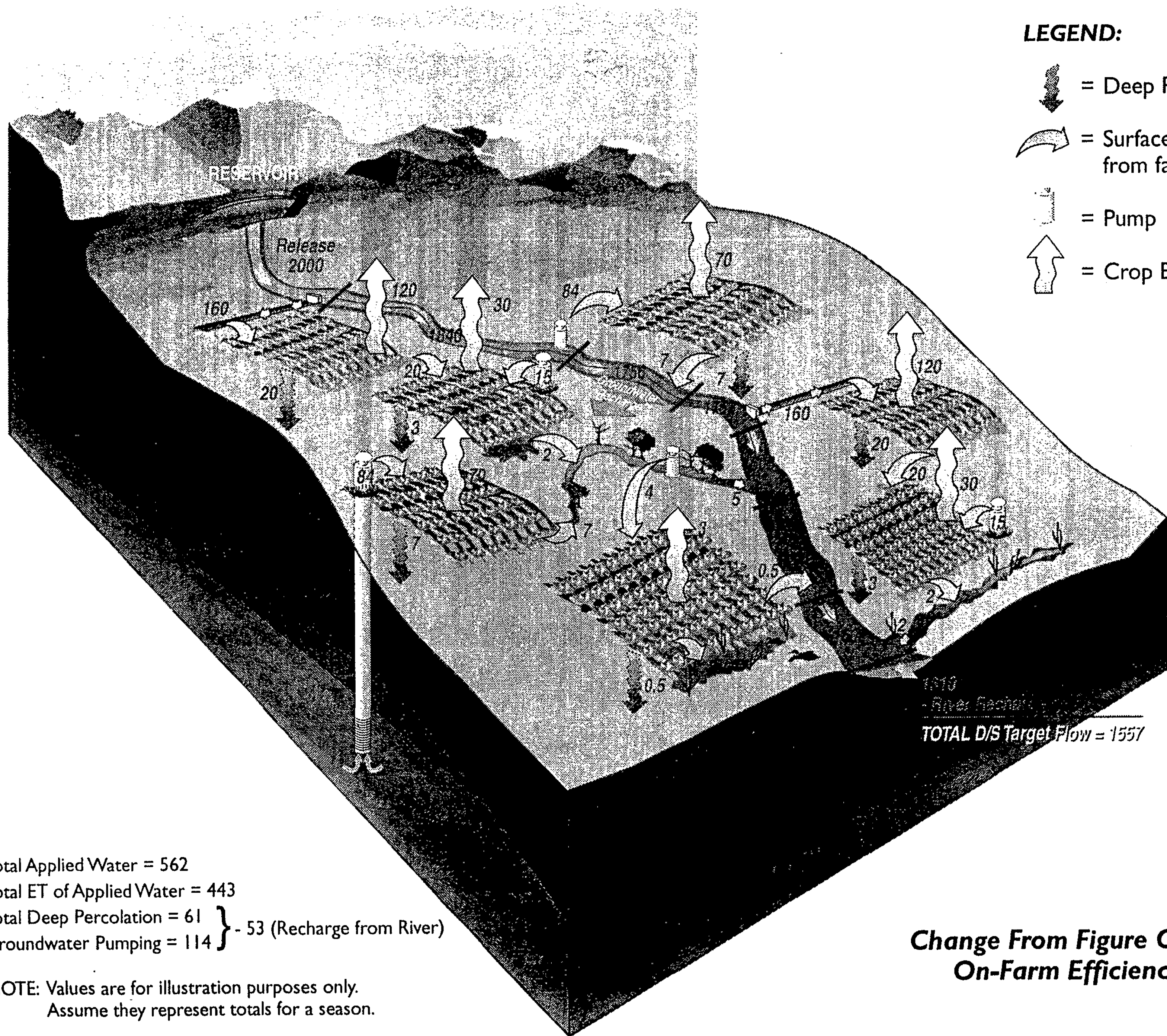


Figure 4-6
Existing Condition
Showing Interaction Between Applied Water, Beneficial Uses, Reuse, Groundwater, River Flows, and Downstream Target Flow.



Total Applied Water = 562
Total ET of Applied Water = 443
Total Deep Percolation = 61 } - 53 (Recharge from River)
Groundwater Pumping = 114 }

NOTE: Values are for illustration purposes only.
Assume they represent totals for a season.

Figure 4-7
Change From Figure C Resulting From On-Farm Efficiency Improvements

In general, if efficiency is improved, indirect use of "losses" will decline, but direct use of water will increase. Therefore, the basin's hydrology remains relatively stable. To most simply present this principle on the accompanying figures, several assumptions are made, including:

- crop evapotranspiration does not change (i.e., no crop modifications or land fallowing),
- cumulative target flows downstream remain constant for a given period of time (i.e., February through September cumulative demands do not change regardless of upstream activities), and
- long-term groundwater levels remain in balanced conditions.

These assumptions are reasonable, especially for basins such as the Sacramento Valley and agricultural areas along the eastern side of the Central Valley. For instance, it is quite likely that growers could improve on-farm irrigation efficiency but not change the types of crops grown. In addition, seasonal downstream demands usually remain fairly constant regardless of what occurs upstream since they are driven by Delta outflow and export demands. Also, groundwater and surface water interaction is governed by rules of hydrology. When groundwater elevations are lower than river elevation, a river typically will recharge groundwater. Conversely, groundwater will add to a river's flow when it is higher than the river elevation, referred to as accretion.

The interaction between ground and surface water, however, can be slow depending on the local geologic and hydrologic conditions. Delays of days, weeks, months or even years can erroneously be interpreted as water savings when in fact there are none. If the false savings are redirected out of a basin, overdraft of the groundwater resources and loss of instream flows can result. In areas that are not experiencing overdraft, the natural process of give and take usually can maintain a relative balance. For illustration purposes, this balance is assumed to occur within the same season, though multi-year benefits could sometimes be gained (i.e., through conjunctive use projects), but possibly at the risk of reducing water supplies for other purposes, including high winter flows flowing out to the sea.

As shown on Figure 4-6, releases are made from a reservoir to meet local diversions, instream uses and downstream target demands. The fields in the area obtain water for crop needs by various methods including delivery via a canal diversion, direct river diversion, direct diversion from drainage, and groundwater pumping. As illustrated with the various flow arrows and accompanying quantities (units are not necessary for this example but could be assumed as 1,000's of acre-feet), "losses" resulting from over-application of water go to either surface runoff or deep percolation. In addition to natural recharge, the deep percolation acts to recharge the aquifer. Surface runoff either returns directly to the river, to the river via a drainage course, or to another field. A simple water accounting is shown along the river as diversions remove water, and surface runoff returns water. In this example, a balance between deep percolation and groundwater pumping creates a slight surplus of deep percolation. It is assumed that this additional groundwater actually results in river accretion (groundwater naturally flowing back into the river) by the end of this hypothetical stream reach.

Figure 4-7, by contrast, assumes that on-farm efficiency improvements are implemented, resulting in decreased river diversions. Crop demands do not change. The reduced diversions could be interpreted as "real" water savings. However, reduced diversions really are the result of decreased deep percolation and decreased surface runoff- water that was being indirectly used for other existing beneficial uses. To continue to meet crop needs, fields that depended on surface runoff for their supplies have now added new wells. The result is that indirect reuse that was occurring in Figure 4-6 from surface runoff and deep percolation now occurs through increased direct groundwater pumping.

Increased pumping, coupled with decreased deep percolation results in lower groundwater levels. When this happens, the river will naturally allow more water to recharge into the ground in an attempt to maintain the balance. With natural balancing and the need to maintain downstream target quantities, the seasonal reservoir releases remain the same as occurred under existing condition. No net decrease in seasonal water use has occurred.

What does change is the seasonal management of water. For instance, the seasonal quantity of water instream is higher in Figure 4-7 than under existing conditions, and surface return flows as well as direct stream diversions have been reduced. Indirect use has been changed to manageable, direct use.

The focus should be placed on the benefit from each unit of water not on the unit of water itself. Changing to more manageable direct use can provide benefits desired by CALFED. When comparing the two figures, the reduced diversions can reduce aquatic species entrainment, and reduced return flows can result in better instream water quality, though maybe impacting drainage habitat at the same time. In addition, the increased instream flows can be re-regulated and released from reservoirs to correspond to fishery or other aquatic habitat needs (e.g., fish attraction or out-migration flows) rather than for irrigation demands. This is not a water supply that can be reallocated out-of-basin, however.

These important benefits can be gained through efficiency improvements with no adverse impact to local users. However, local users may not be able to justify the cost of implementing efficiency measures when compared to the local benefit they may see. Thus, outside assistance may be necessary to help realize the more regional or global benefits from improved local water use management and efficiency.

There are a number of different scenarios other than what is shown on Figure 4-7 that could be developed to show how hydrologic elements are interconnected. For instance, it could be envisioned that instead of increased groundwater pumping, a new surface water link could be directly routed to the fields from the river or from an existing canal diversion. This may help groundwater levels remain high and reduce river recharge but increase total diversions. Or, a new diversion could be constructed downstream and water pumped back upslope to each of the fields with existing river diversions abandoned. This may reduce diversion impacts from a particular sensitive reach of the stream, but not change total diversions. Each of these scenarios would create different benefits and impacts. For instance, pumping water back upslope would require more energy compared to using a gravity based system. The array of possibilities underscores the importance to analyze each opportunity individually. What works well in one location may be detrimental in another.

Identifying A Greater Purpose Requires a Basin-wide View

It is important to note that in some instances water associated with irrecoverable losses serves a greater purpose and conservation of the losses could be detrimental. For instance, agricultural drainage flow in the Imperial Valley currently flows to the Salton Sea. As stated above, these flows are considered irrecoverable losses because of their unavoidable degraded quality, in this case, as a result of leaching salts from the soil profile. However, they serve an important role in providing necessary dilution water for toxic drainage inflow from other sources, such as the New River, flowing to the Salton Sea from Mexico. In addition, they actually provide enough freshwater to help maintain lake salinity and elevation levels.

Another example of irrecoverable losses providing a necessary benefit is in the Salinas Valley. This area is currently experiencing sea water intrusion into inland areas. The result is contamination of groundwater and associated wells with salty ocean water. Deep percolation resulting from inefficiencies actually helps maintain high groundwater levels that act to hold back the intrusion of sea water.

The reason for stating these two examples is to highlight that all aspects of a basin's hydrology need to be taken into consideration as part of on-farm and district level improvements. What is saved for one purpose may be lost to another. Analysis should be undertaken using basin-wide approaches that look for net benefits.

Regional Reduction Estimates

Estimates of the results of efficiency improvements are presented here for each of the agricultural zones defined previously in Section III, *Determination of Geographical Zones*. The values presented are only intended to provide input for purposes of a programmatic level impact analysis. These are estimated goals, not required targets, and should not be used for planning purposes. Estimates of potential reduction in losses from on-farm and district-level efficiency improvements are presented under one of two categories:

- Estimated Real Water Savings for Reallocation to Other Water Supply Uses
  - existing conditions (on-farm, district)
  - No Action conditions (on-farm, district)
  - CALFED conditions (on-farm, district)

- Estimated Applied Water Reduction for Multiple Benefits
  - existing conditions
  - No Action conditions
  - CALFED conditions

Estimated real water savings (reduced irrecoverable losses) can be viewed as a source of water that can be reallocated to other purpose such as improved local agricultural supply reliability, offsetting of local groundwater overdraft, or a transfer to other beneficial water supply uses, including the environment. Estimated applied water reductions do not generate a reallocable supply, but do provide other benefits desired by the CALFED Program.

As stated, water use efficiency improvements can result in reduction in applied water of 8 to 12 percent. Potential applied water reductions are included here for eight of the nine agricultural zones. Reductions in the Colorado River Region would not directly translate to water quality or ecosystem benefits in the Bay-Delta watershed, and are therefore not included. Similarly, reduction of losses in the zones that import water from the Bay-Delta but are not tributary to the Delta (South Coast, Central Coast, and San Francisco Bay regions) can only provide an ecosystem benefit through reductions in diversions or modified diversion timing. They cannot benefit water quality because irrigation return flows do not re-enter the Delta watershed. Other export areas whose irrigation return flows do re-enter the watershed can provide water quality as well as ecosystem benefits to the Delta.

AG1 - Sacramento River

Overview

The Sacramento River region is defined by the Sacramento Valley, from Sacramento north to Redding. The area is predominantly in agriculture but many growing communities are within its boundary, including the greater metropolitan areas of Sacramento. All rivers that flow into the valley are carried by the Sacramento River southward to the Sacramento-San Joaquin Delta. Here, surface flows head west to the Pacific Ocean. With abundant surface and groundwater resources, agriculture in this region experiences few water shortages. Water users in the Sacramento Valley have some of the oldest rights to surface water, with some dating back to the gold rush era. Agricultural water use comprises about 58 percent of the region's total water use.

Typically, losses associated with agricultural water use in this region tend to return to the system of rivers, streams, and aquifers. Reuse of these losses is widely practiced. The region does not have significant irrecoverable losses, although water quality degradation does occur. Much of the region's groundwater resources are recharged by annual over-irrigation and deep percolation of applied water. This water is pumped by many of the areas agricultural lands that are irrigated solely with groundwater. In addition, tailwater from fields typically returns to streams and becomes part of the instream flow diverted for another farm, wetland, or city somewhere downstream.

Agricultural production is anticipated to remain constant into the future with no major decreases resulting from urbanization.

Agricultural Information

Types of crops grown:	rice, trees, tomatoes, corn, sugar beets, some truck crops, alfalfa and pasture.
Irrigated Land:	approx. 1,700,000 acres
Types of irrigation systems in use:	About 70% of the area is under surface irrigation (e.g., furrow or border). Drip/micro systems are more prevalent on trees.
Existing average on-farm irrigation efficiencies:	73%, as estimated by DWR
Average applied water:	approx. 6,500,000 acre-feet annually

Source of Water:

-groundwater, about 1/4 of the supply.
-surface water from the Sacramento, Feather, and American Rivers and various tributaries. Surface water is diverted at multiple points, both by individuals and by water districts. Water is stored in numerous reservoirs and released based mostly on agricultural demands.
-reuse of losses is an important feature in this area with all deep percolation and tailwater runoff being recovered and reused for some beneficial use.

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

As discussed above, the Sacramento River region is characterized as only having recoverable losses. Therefore, the Sacramento River region has no potential water savings that can be reallocated to other beneficial water supply uses. It is true, however, that potential exists to improve efficiencies for other purposes, namely improved water quality, changed timing of flow releases, and reduced fishery impacts. These are covered below under *Estimated Applied Water Reduction for Multiple Benefits*.

Estimated Applied Water Reduction for Multiple Benefits

Values shown in the table below are estimated reduction in applied water as a result of on-farm efficiency improvements that reduce recoverable losses. These reductions have the ability to benefit water quality, flow timing, and the ecosystem.

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
Sacramento	6,500	200-310	320-470	520-780

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only water quality and ecosystem benefits.

AG2 - Delta

Overview

The Delta region is characterized by a maze of tributaries, sloughs, and islands encompassing 738,000 acres. Lying at the confluence of California's two largest rivers, the Sacramento and the San Joaquin, it is a haven for plants and wildlife. Islands, protected from Delta waters by an extensive levee system, are used primarily for irrigated agriculture. The vast majority of the 500,000 acres of irrigated land in the Delta derive their water supply directly by diverting water from the adjacent tributaries, rivers and sloughs. Agricultural land use is anticipated to decline in the future as a result of other CALFED ecosystem restoration activities.

The Delta region is bounded on the north by the metropolitan area of Sacramento, and on the south by the city of Tracy. The west is bounded by Chipps Island near the true confluence of the Sacramento and San Joaquin Rivers. There is very little urban land use in the Delta. There are, however, a few small farming communities.

Local Delta water use is protected by a number of measures, such as the Delta Protection Act, the Watershed Protection Law, and water rights. Most water users have the right to divert water for beneficial uses on their land under the riparian water rights doctrine. Water diverted and applied to fields, but not consumed typically is collected in drains and pumped back into the Delta waterways. Because of this recycling of losses, the potential to generate actual water savings available for reallocation to other beneficial uses is non-existent.

Agricultural Information

Types of crops grown:	tomatoes, corn, sugar beets, some truck crops, alfalfa and pasture.
Irrigated Land:	approx. 500,000 acres
Types of irrigation systems in use:	Most of the area is under surface irrigation (e.g., furrow or border). Some use of hand-move sprinklers also occurs, but primarily for pre-irrigation and germination.
Existing average on-farm irrigation efficiencies:	73 percent, as estimated by DWR
Average applied water:	approx. 1,300,000 acre-feet annually

Source of Water: -groundwater, very limited use.
-surface water is pumped directly from the Delta waterways.
-reuse of losses is an important feature in this area with tailwater runoff being pumped off each island back into Delta waterways.

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

As discussed above, the Delta region is characterized as having only recoverable losses. Therefore, the region has no potential water savings that can be reallocated to other water supply uses. It is true, however, that potential exists to improve efficiencies for other purposes, namely improved water quality, and reduced fishery impacts. Since most Delta water users have riparian water rights, there is no ability to modify timing of flow releases as a result of efficiency improvements. Efficiency improvements resulting in reduced diversions could only result in water quality or fishery related benefits. These are covered in more detail under *Estimated Applied Water Reduction for Multiple Benefit* below.

Estimated Applied Water Reduction for Multiple Benefits

Values shown in the table below are estimated reduction in applied water as a result of on-farm efficiency improvements that reduce recoverable losses. These reductions have the ability to benefit water quality, flow timing, and the ecosystem.

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
Delta	1,300	40-60	60-90	100-150

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only water quality and ecosystem benefits.

AG3 - Westside San Joaquin River

Overview

The Westside San Joaquin River region is bounded by Tracy on the north, the farming town of Mendota to the south and the San Joaquin River to the east. Agriculture is the predominant feature in this region with only a handful of small farming communities. Other than the San Joaquin River running along the eastern border, there are no major rivers that provide surface water to the region. Most of the region's agriculture is supported by water exported through the California Aqueduct and the Delta Mendota Canal. These two canals are predominant features that run south through this region. Agricultural acreage is not anticipated to decline much in this area, other than what may result from higher water costs, some urbanization, and limited land retirement.

Toward the southern end of this region, referred to as the Grasslands area, agricultural drainage has become an increasing problem. Combinations of salts, imported by the canals, and naturally occurring trace minerals, such as selenium, have generated concern with drainage from agricultural fields. Some of this drainage results in deep percolation to shallow groundwater. This in turn has caused degradation of the shallow groundwater, limiting potential reuse. Several studies have been completed or are underway to find solutions to the drainage problems, including efforts by the CALFED Program. It is anticipated that these efforts will result in source control measures and possibly some land retirement. The source control measures will include improvements in on-farm irrigation efficiency, as well as other measures.

Agricultural Information

Types of crops grown:	tomatoes, corn, sugar beets, some truck crops, trees, vines, grain, pasture and alfalfa.
Irrigated Land:	approx. 430,000 acres
Types of irrigation systems in use:	Most of the area is under surface irrigation (e.g., furrow or border). Hand move sprinklers are being used in combination with surface systems. Micro/drip systems are increasing in use for some row crops, such as peppers and tomatoes, and on trees.
Existing average on-farm irrigation efficiencies:	73 percent, as estimated by DWR

Average applied water: approx. 1,400,000 acre-feet annually

Source of Water:

-groundwater is used extensively in the northern part of the region but is limited because of degradation in the southern portion.
-surface water is delivered primarily via the California Aqueduct or Delta Mendota Canal. Some surface water is delivered in exchange for San Joaquin River water.
-reuse of surface losses occurs regularly. Deep percolation, if not lost to degraded groundwater, is also reused.

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

	Existing Irrecoverable Loss (1,000 af)	Projected Reduction under No Action (1,000 af)	Additional Reduction under CALFED (1,000 af)	Total Reduction (1,000 af)	Remaining Future Irrecoverable Loss (1,000 af)
On-farm	30-40	3-5	20-30	23-35	5-7
District	20-25	5-10	10-15	15-25	0-5
Total	50-65	8-15	30-45	40-60	5-15

Estimated Applied Water Reduction for Multiple Benefits

Values shown in the table below are estimated reduction in applied water as a result of on-farm efficiency improvements that reduce recoverable losses. These reductions have the ability to benefit water quality, flow timing, and the ecosystem.

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
West SJR	1,400	25-45	40-70	65-115

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only water quality and ecosystem benefits.

AG4 - Eastside San Joaquin River

Overview

The Eastside San Joaquin River region encompasses the area from the San Joaquin River near Fresno north to the Cosumnes River, and from the eastern foothills to San Joaquin River as it travels up the valley to the Delta. This area is predominantly agricultural but includes the metropolitan areas of Stockton, Modesto, and Merced along with numerous other communities. Several rivers originating in the Sierra Nevada flow out of the mountains and west into the San Joaquin River (as it travels through the center of the valley). These include the Merced, Tuolumne, Stanislaus, and Mokelumne Rivers as well as other small tributaries. Natural flows and excellent water quality have provided ample supplies to the agricultural users on the eastside of the valley.

Losses associated with applied water typically recharge groundwater or return to surface waterways. Either way, they are available again for other beneficial uses. Irrecoverable losses are almost non-existent. However, some degradation of shallow groundwater does occur as a result of deep percolation of salts and trace elements. This primarily occurs in the southern portion of this region and at the bottom of the valley trough.

Many of the local water districts have very firm water rights dating back to the turn of the century. Some water is imported into the region via the Madera Canal. This water is diverted from the San Joaquin at Millerton Lake and routed north to irrigate lands in Madera County. Otherwise, there are no major out-of-basin deliveries of water (as occurs in export regions). Agricultural acreage is anticipated to decline slightly in this region as a result of increased urbanization.

Agricultural Information

Types of crops grown:	tomatoes, corn, sugar beets, some truck crops, trees, vines, alfalfa and pasture.
Irrigated Land:	approx. 1,270,000 acres
Types of irrigation systems in use:	Most of the area is under surface irrigation (e.g., furrow or border). Micro/drip systems are increasing in use for trees and vines.
Existing average on-farm irrigation efficiencies:	73 percent, as estimated by DWR
Average applied water:	approx. 4,000,000 acre-feet annually

Source of Water:

-groundwater, used for < 1/4 of the water supply needs. An overdraft of approx. 200,000 acre-feet occurs annually, primarily in San Joaquin and Madera counties.
-surface water originates in the Sierra Nevada and is of high quality. It is used for the majority of irrigation needs.
-reuse of losses is an important feature in this area with most losses either recharging the groundwater or returning to surface waterways.

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

As discussed above, the Eastside San Joaquin River region is characterized as primarily having recoverable losses. The region has very limited potential water savings that can be reallocated to other beneficial water supply uses.

	Existing Irrecoverable Loss (1,000 af)	Projected Reduction under No Action (1,000 af)	Additional Reduction under CALFED (1,000 af)	Total Reduction (1,000 af)	Remaining Future Irrecoverable Loss (1,000 af)
On-farm	4-6	1-3	1-2	2-5	1-2
District	1-2	0-1	0-1	0-2	0-1
Total	5-8	1-4	1-3	2-7	1-3

Estimated Applied Water Reduction for Multiple Benefits

Values shown in the table below are estimated reduction in applied water as a result of on-farm efficiency improvements that reduce recoverable losses. These reductions have the ability to benefit water quality, flow timing, and the ecosystem.

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
East SJR	4,000	125-190	190-285	315-475

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only water quality and ecosystem benefits.

AG5 - Tulare Lake Basin Sub-Area

Overview

The Tulare Lake region includes the southern San Joaquin Valley from the southern limit of the San Joaquin River watershed to the base of the Tehachapi Mountains. The area is predominantly agricultural, but many small agricultural communities as well as the rapidly growing cities of Fresno and Bakersfield are located here. The Kings, Kaweah, Tule, and Kern Rivers flow into this region from the east. All of the rivers terminate in the valley floor, and do not drain to the ocean except in extremely wet years. This means there is also no outlet for drainage flows originating on-farm. This area is a closed basin.

Because most of the source water is of very high quality, both surface and subsurface agricultural drainage is extensively reused, except along the western slope of the basin. In fact, artificial recharge of groundwater basins, known as groundwater banking, occurs in many areas of the Tulare Lake basin. This practice is likely to increase in future years as combined management of surface and groundwater sources becomes more essential.

Though, because of the closed-in nature of the basin, salinity build-up in the soils does occur. As water is reused and natural salts present in the irrigation water are leached from the soil, the drainage water does become increasingly salty. Several evaporation ponds have been constructed in portions of the basin to collect and evaporate this saltier drainwater. Drainage problems tend to occur only along the western slope of the basin and around the historic Tulare Lake bed. It is in these areas the conservation of irrecoverable losses has some potential.

Irrigated agriculture accounts for about 95 percent of the water use in the region. In the future, it is anticipated that increased urbanization, and increasingly high costs for water could reduce the variety and acreage of crops being produced, and thus, the amount of agricultural water use (DWR, 1994a).

Agricultural Information

Types of crops grown:	Cotton, trees, row crops, truck crops, vines. Double cropping of some crops also occurs.
Irrigated Land:	approx. 3,200,000 acres
Types of irrigation systems in use:	About 70 percent of the area is under surface irrigation (e.g., furrow). Drip/micro systems are more prevalent on trees and vines but are also being used on some row crops.

Existing average on-farm irrigation efficiencies:	75 percent as estimated by DWR
Average applied water:	approx. 9,300,000 acre-feet annually
Source of Water:	-groundwater, including a 500,000 to 600,000 acre-foot annual overdraft. -surface water from Kings, Kaweah, Tule, and Kern Rivers and imported supplies from the Friant-Kern system and the California Aqueduct. -reuse of losses is an important feature in this area with more than 75 percent of deep percolation being recovered and reused.

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

	Existing Irrecoverable Loss (1,000 af)	Projected Reduction under No Action (1,000 af)	Additional Reduction under CALFED (1,000 af)	Total Reduction (1,000 af)	Remaining Future Irrecoverable Loss (1,000 af)
On-farm	75-85	15-20	20-25	35-45	35-40
District	20-30	5-10	5-10	10-20	10-10
Total	95-115	20-30	25-35	45-65	45-50

Special Conditions:

Overall, potential savings shown above may intuitively seem low. But as a result of the drought in the late 1980's and early 1990's, the 1994 Bay-Delta Accord, and numerous other elements affecting water supply reliability and cost, irrigation efficiency has further improved, especially in the last 5 years. This has reduced the opportunity for savings that previously existed. For instance, previous estimates showed opportunity for 90,000 acre-feet of real water savings in the Tulare Basin hydrologic region. The No Action condition now reflects a potential of only about 25,000 acre-feet. The values shown under *Existing Conditions* also reflects the reduced potential. Additionally, most of the savings accompanying the improvements have been reallocated within the local districts to meet existing unmet demands.

Estimated Applied Water Reduction for Multiple Benefits

Values shown in the table below are estimated reduction in applied water as a result of on-farm efficiency improvements that reduce recoverable losses. These reductions have the ability to benefit water quality, flow timing, and the ecosystem.

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
Tulare	9,300	300-400	400-600	700-1,000

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only water quality and ecosystem benefits.

AG6 - San Francisco Bay

Overview

The San Francisco Bay region is primarily urban with very little agricultural acreage. A 1990 land use survey shows only about 60,000 acres of agriculture in the region (DWR, 1994a). This is a 60 percent reduction in 40 years. Agriculture only uses about 1 percent of the entire region's net water demand (80 percent of net demand is for environmental flows). Agricultural production generally is located on the outskirts of the urban areas and in isolated valleys, such as the Napa, Sonoma, and Livermore valleys. More than half of the agricultural acreage is for wine grapes. It is anticipated that a small portion of the existing irrigated land will be lost to urbanization. However, the ability to grow vines in areas never before irrigated will add new acreage and result in little or no net change.

Because of the location of most of the agriculture, losses associated with irrigation are recaptured through deep percolation or surface runoff to streams and waterways. The region does not have irrecoverable losses associated with irrigated agriculture (urban use is discussed in a separate section).

Agricultural Information

Types of crops grown:	Predominantly vineyards with some truck crops and fruit trees.
Irrigated Land:	approx. 60,000 acres

Types of irrigation systems in use:	Mostly pressurized systems using drip/micro or sprinklers.
Existing average on-farm irrigation efficiencies:	73 percent, as estimated by DWR
Average applied water:	approx. 90,000 acre-feet annually
Source of Water:	-groundwater is a key source for agriculture. -surface water is generated locally as well as imported from various areas, including directly from the Sierra Nevada and from the Delta. -reuse is an important feature in this area. Losses typically recharge groundwater, so there is no irrecoverable water (associated with agricultural use).

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

As discussed above, the San Francisco region is characterized as having only recoverable losses (associated with agricultural use). Therefore, the region has no potential water savings from agriculture that can be reallocated to other beneficial water supply uses. It is true, however, that potential exists to improve efficiencies for other purposes, namely improved water quality, change the timing of diversions, and reduced fishery impacts. These are covered in more detail under *Estimated Applied Water Reduction for Multiple Benefit* below.

Estimated Applied Water Reduction for Multiple Benefits

Values shown in the table below are estimated reduction in applied water as a result of on-farm efficiency improvements that reduce recoverable losses. These reductions have the ability to benefit flow timing, and the ecosystem, but not water quality. Any return flows that may degrade the quality of the receiving water is typically downstream of the Delta.

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
San Francisco	90	3-4	4-6	7-10

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only ecosystem benefits.

AG7 - Central Coast

Overview

The Central Coast region encompasses land on the western side of the coastal mountains that is hydraulically connected to the Bay-Delta region. This includes southern portions of the Santa Clara Valley and San Benito County. Most of the agricultural water supplies are generated within the region. However, about 50,000 acre-feet of Delta waters are exported annually to this region through the San Felipe Unit of the Central Valley Project. Exported water is delivered both to agricultural and urban users in San Benito and Santa Clara counties. The San Benito River also provides surface water to agriculture in the area. The San Benito River joins with the Pajaro River and flows through the agricultural areas around Watsonville then on to the ocean.

Some of the coastal area around Watsonville is experiencing sea water intrusion as a result of groundwater overdraft. To combat this, a proposed extension of the San Felipe pipeline may bring additional Delta waters to the Watsonville area.

Agricultural acreage in the upslope portions of the Santa Clara Valley and around Watsonville is anticipated to decline slightly in the future as a result of increased urbanization and increasingly high water costs.

Agricultural Information

Types of crops grown:	Truck crops, strawberries, artichokes, fruit trees and vines.
Irrigated Land:	approx. 100,000 acres
Types of irrigation systems in use:	Mostly pressurized systems using drip/micro or sprinklers. Some furrow irrigation still occurs.
Existing average on-farm irrigation efficiencies:	73%, as estimated by DWR
Average applied water:	approx. 200,000 acre-feet annually
Source of Water:	-groundwater is a main source of water for many truck crop fields, except in areas experiencing sea water intrusion. Overdraft conditions exist in some areas of the region. -imported water delivered from the San Felipe

Unit. Other surface water originates in the San Benito River.
-reuse is an important feature in this area. Losses typically recharge groundwater, but in some coastal area, deep percolation is "lost" to degraded groundwater.

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

	Existing Irrecoverable Loss (1,000 af)	Projected Reduction under No Action (1,000 af)	Additional Reduction under CALFED (1,000 af)	Total Reduction (1,000 af)	Remaining Future Irrecoverable Loss (1,000 af)
On-farm	4-6	1-3	1-2	2-5	1-2
District	0-2	0-1	0-1	0-2	0
Total	4-7	1-4	1-3	2-6	1-2

Estimated Applied Water Reduction for Multiple Benefits

Values shown in the table below are estimated reduction in applied water as a result of on-farm efficiency improvements that reduce recoverable losses. These reductions have the ability to benefit flow timing, and the ecosystem, but not water quality. Any return flows that may degrade the quality of the receiving water is not tributary to the Delta.

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
Central Coast	200	4-8	6-12	10-20

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only ecosystem benefits.

AG8 - South Coast

Overview

The South Coast Region lies south of the Tehachapi Mountains and extends to the California border with Mexico. It is home for more than 50 percent of the state's population but only 7 percent of the state's total land area. Rivers and streams that originate in this region flow toward the Pacific Ocean. The climate is Mediterranean-like, with warm and dry summers followed by mild and wet winters. Of the region's 11,000 square-mile area, only around 300,000 acres are currently used for irrigated agriculture. The agricultural net water demand accounts for only about 15 percent of total net water demand in the region. It is projected that the region will increase from a 1990 population of 16 million to over 25 million by 2020. Urbanization of agricultural land is expected to be most pronounced in this region. It is projected that by year 2020 irrigated crop acreage will decline to about 184,000 acres, a 42 percent reduction (DWR, 1994a). Some areas within the region may experience even greater reduction with more than 2/3 of the irrigated land going out of production. Reductions in irrigated land, coupled with existing high levels of efficiency and only marginal irrecoverable losses, will result in little water savings potential through increased efficiency. These factors are reflected in the projections below.

Agricultural Information

Types of crops grown:	Primarily citrus, olives, and avocados (over 50% of the irrigated land). Vineyards, nursery products, and row crops, make up another 40%.
Irrigated Land:	approx. 300,000 acres
Types of irrigation systems in use:	Pressurized systems such as sprinklers, micro-sprays, and drip are widely used for the permanent tree and vine crops. Water delivery systems are mainly pipeline, and in some cases, extensions of municipal systems.
Existing average on-farm irrigation efficiencies:	76%, as estimated by DWR
Average applied water:	approx. 700,000 acre-feet annually
Source of Water:	-groundwater; supplying about a third of the total demand. -imported water delivered from the Colorado River

and from the SWP; limited local surface supplies are also available.
-reuse; the region is greatly increasing its recycling programs, some of which look to deliver treated urban wastewater to agricultural areas.

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

	Existing Irrecoverable Loss (1,000 af)	Projected Reduction under No Action * (1,000 af)	Additional Reduction under CALFED (1,000 af)	Total Reduction (1,000 af)	Remaining Future Irrecoverable Loss (1,000 af)
On-farm	6-7	1-2	1-2	2-4	3-4
District	1-2	0-1	0	0-1	0-1
Total	7-9	1-3	1-2	2-5	4-5

* Note: projected reductions account for loss of over 40% of agricultural land to urbanization based on DWR data (DWR, 1994a).

Estimated Applied Water Reduction for Multiple Benefits

Values shown in the table below are estimated reduction in applied water as a result of on-farm efficiency improvements that reduce recoverable losses. These reductions have the ability to benefit flow timing, and the ecosystem, but not water quality. Any return flows that may degrade the quality of the receiving water is not tributary to the Delta.

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
South Coast	700	20-30	30-50	50-80

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only ecosystem benefits.

AG9 - Colorado River

Overview

The Colorado Region includes a large area of the State's southeastern corner with about 650,000 acres of irrigated land. It mainly includes the agriculturally rich Coachella and Imperial Valleys. The Salton Sea, located between the two valleys, is a prominent feature of this area. The Sea is currently fed by rainfall from the surrounding desert mountains and by agricultural surface drainage from the two valleys. Rainfall in the mountains also recharges the groundwater aquifers that underlie the region. Because of constant evaporation coupled with the rainfall runoff and agricultural drainage, which contain naturally occurring salts, the salinity of the Salton Sea continues to increase. It is now more saline than the Pacific Ocean. However, agricultural drainage is also considered to play a vital role in supplying relatively fresh water supplies to the sea to maintain water levels and dilute salinity and other toxicities that flow to the sea. By year 2020, an estimated 10,000 acre-feet of water will be needed annually to maintain a stable water level in the Salton Sea. Efforts to reduce the agricultural losses that flow to the Sea must consider this fact. Several plans to conserve water in the area while stabilizing the sea's salinity and water levels have been developed by the Salton Sea Task Force, chaired by the State Resources Agency. However, these plans would incur substantial cost (DWR, 1994a).

Agricultural Information

Types of crops grown:	Row crops such as cotton, grain, sugar beets ,corn alfalfa, other truck crops. Alfalfa constitutes about 34 percent of irrigated acreage. About 7 percent of irrigated land (50,000 acres) is vineyard and citrus. Double cropping also occurs.
Irrigated Land:	approx. 650,000 acres with 100,000 acres additional resulting from double cropping
Types of irrigation systems in use:	Majority of the area is under surface irrigation (e.g., furrow). Sprinkler and drip/micro systems are more prevalent on trees and vines.
Existing average on-farm irrigation efficiencies:	76%, as estimated by DWR
Average applied water:	approx. 3,600,000 acre-feet annually

Source of Water:

-groundwater, including an overdraft of approx. 75,000 acre-feet annually (although not all attributable to agriculture - the resort areas in Coachella Valley also use a significant amount of groundwater resources)
-surface water is delivered from the Colorado River via the All American Canal. A small amount of SWP water is also delivered to Coachella Valley via an exchange agreement that exchanges Colorado River water for Delta export water.
-reuse of losses is an important feature and is increasing through the adoption of on-farm tailwater recovery systems and district-wide improvements, especially in the Imperial Valley. Most of the Imperial Valley is underlaid with tile drains that collect deep percolation and route the "excess" to surface drains where it co-mingles with surface runoff.

Estimated Real Water Savings for Reallocation to Other Water Supply Uses

	Existing Irrecoverable Loss (1,000 af)	Projected Reduction under No Action (1,000 af)	Additional Reduction under CALFED (1,000 af)	Total Reduction (1,000 af)	Remaining Future Irrecoverable Loss (1,000 af)
On-farm	160-185	40-60	30-50	70-110	75-90
District	200-225	125-150	35-55	160-205	20-40
Total	360-410	165-210	65-105	230-315	95-130

Special Conditions:

The Imperial Valley and most of the Coachella Valley may have a limited role to play in a CALFED Bay-Delta solution. Since water used in this area is primarily imported from the Colorado River, reduction in losses will not directly affect the Bay-Delta watershed. However, the potential exists to use real water savings to offset existing or future demands of southern California, a primary exporter of Bay-Delta waters. To the extent that this can occur, a benefit may be realized in the Bay-Delta watershed. If conserved water is used by southern California, but not in a manner to reduce existing or future Bay-Delta exports, then no benefit can be claimed by the CALFED Program. This is the most probable outcome, since California already diverts more than it's allocation of Colorado River water entitlement.

Efforts by other states with entitlement to Colorado River water, including Arizona, Colorado, and Utah, may soon force California to reduce its total diversion from the Colorado. Today, agriculture uses about 3.8 million acre-feet annually of Colorado River. Urban uses, delivered to southern California via the Colorado Aqueduct, account for an additional 1.3 million acre-feet. California's entitlement, though, is only 4.4 million acre-feet annually, approximately 800,000 acre-feet less than existing diversions. The urban demands of southern California met by the Colorado River, delivered via the Colorado Aqueduct, would most likely remain at the levels seen today, or 1.3 million acre-feet. Therefore, reduction would probably occur through reducing agriculture's use of California's entitlement in order to reach the 4.4 million acre-foot limitation.

This has started to occur already with near completion of the Metropolitan Water District's transfer agreement with Imperial Irrigation District. This landmark agreement will result in just over 100,000 acre-feet annually being transferred from agricultural uses in the Imperial Valley to urban uses in southern California. The water is generated through conservation and efficiency improvements. The transferred quantity will be conveyed via the existing Colorado Aqueduct which already runs at capacity. In essence, this is a method of reducing California's overall use of Colorado River water to its required entitlement but maintaining full use of the Colorado Aqueduct to deliver water to urban areas.

Recently, new conveyance facilities from the Imperial Valley to the San Diego area have been proposed as part of another agricultural to urban water transfer. Political pressure from the other Colorado River states with entitlement may limit the potential for such new facilities. Limiting conveyance capacity to that available in existing facilities can provide some assurance to other states that California will reduce its use of Colorado River water down to its required entitlement. New conveyance facilities could be perceived as allowing continuation of diversion above entitled quantities.

The estimated real water savings potential shown above includes the potential of 200,000 acre-feet that may be transferred to the San Diego area under the proposed water transfer agreement. In addition, effects of the Imperial Irrigation District/Metropolitan Water District water transfer have already been accounted for in the No Action estimates. For example, previous estimates by DWR of the real water savings potential were 273,000 acre-feet (DWR, 1994), nearly 100,000 acre-feet higher than the potential shown under No Action. This assumes that the transfer is part of the existing conditions.

Estimated Applied Water Reduction for Multiple Benefits

Because the source of water used in this region originates in the Colorado River and not the Sacramento-San Joaquin River Delta, the ability for applied water reductions to generate water quality, timing, or ecosystem benefits in the Delta do not exist. Therefore, no estimates of applied water reduction were developed for this region.

Summary of Estimated Real Water Savings

The following is a summary table presenting the total estimated reduction in irrecoverable losses for the agricultural zones discussed above. It is assumed that water associated with these reductions could be reallocated to other beneficial water supply uses. However, the values shown are only for purposes of programmatic impact analysis and not goals or targets of the component.

Table 4.1 - Estimated Real Water Savings

	Existing Irrecoverable Loss (1,000 af)	Projected Reduction under No Action (1,000 af)	Additional Reduction under CALFED (1,000 af)	Total Reduction (1,000 af)	Remaining Future Irrecoverable Loss (1,000 af)
Sacramento	0	0	0	0	0
Delta	0	0	0	0	0
West SJR	50-65	8-15	30-45	40-60	5-15
East SJR	5-8	1-4	1-3	2-7	1-3
Tulare	95-115	20-30	25-35	45-65	45-50
San Francisco	0	0	0	0	0
Central Coast	4-7	1-4	1-3	2-6	1-2
South Coast	7-9	1-3	1-2	2-5	4-5
Colorado	360-410	165-210	65-105	230-315	95-130
Total	520-615	195-265	125-195	320-460	155-200

Although the total potential reduction associated with irrecoverable losses could amount to 400,000 acre-feet, it must be recognized that this assumes all agricultural water users will achieve the 85 percent level of efficiency and distribution uniformity will increase to between 80 and 90 percent, an attainable situation. But, to achieve this will require significant local and agency resources.

It should also be noted that the additional potential generated by a CALFED water use efficiency program is less than half of the total shown (e.g., only about 150,000 acre-feet of nearly 400,000). This assumes that existing trends will continue to provide improved efficiency regardless of the outcome of the CALFED Bay-Delta Program. In addition, about half of the CALFED increment is from the Colorado Region, which may or may not provide any Bay-Delta benefit. Costs associated with attaining the estimated real water savings are discussed later in this section.

Summary of Estimated Applied Water Reduction for Multiple Benefits

The following is a summary table presenting the total estimated reduction in applied water losses for the agricultural zones discussed above. It is assumed that water associated with these reductions can not be reallocated to other water supply uses. The savings, though, can have water quality, timing, and ecosystem benefits. Values shown are only for purposes of programmatic impact analysis and not goals or targets of the component.

Table 4.2 - Estimated Applied Water Reductions at 85% On-farm Irrigation Efficiency

	Average Existing Applied Water (1,000 af/yr)	Projected Applied Water Reduction for No Action (1,000 af/yr)	Incremental Applied Water Reduction for CALFED (1,000 af/yr)	Total Applied Water Reduction * (1,000 af/yr)
Sacramento	6,500	200-310	320-470	520-780
Delta	1,300	40-60	60-90	100-150
West SJR	1,400	25-45	40-70	65-115
East SJR	4,000	125-190	190-285	315-475
Tulare	9,300	300-400	400-600	700-1,000
San Francisco	90	3-4	4-6	7-10
Central Coast	200	4-8	6-12	10-20
South Coast	700	20-30	30-50	50-80
	Total	700-1,000	900-1,600	1,600-2,600

* Note: Totals have been adjusted to exclude any estimated irrecoverable losses presented previously. These estimated reductions do not create an increased water supply, only water quality and ecosystem benefits.

The total potential for applied water reduction, including what is projected under the No Action condition, is approximately 2 million acre-feet annually. The CALFED water use efficiency component will help generate about half of this reduction. These reductions can only provide benefits to water quality, flow timing, and to the ecosystem. Though any benefits that can be derived are desirable, they may be minor and will require analysis to determine their cost-effectiveness.

Reductions do not provide a reallocable water supply benefit. Values also assumes achievement of 85 percent efficiency by all local users and water suppliers, requiring significant support from local, state and federal agencies.

Estimated Cost of Efficiency Improvements

Reducing recoverable and irrecoverable losses through improved efficiency will result in additional district operation costs as well as on-farm production costs. These increases originate from irrigation system upgrades, changes in management style, and increased operation and maintenance. Cost increases occur regardless of who pays or who benefits. Estimated costs presented in this document do not attempt to allocate the costs or to determine if implementation is cost-effective. Various methods of cost allocation will occur during impact analysis, a process which uses this information for input. Determination of the cost-effectiveness of various efficiency measures will not be estimated for purposes of the programmatic EIR/EIS, but will occur on a case-by-case basis during implementation phases.

Cost of Reducing Applied Water vs. Cost of Real Water Savings

Implementation of specific water delivery improvements, whether on-farm or at the district level, will cost relatively the same whether in the Sacramento Valley or around Bakersfield. This is because the cost of irrigation system hardware, skilled irrigation labor, or higher levels of management does not vary significantly throughout the state. What does vary is the associated reduction in losses. The percentage of applied water that results in recoverable and irrecoverable losses depends on the types of crops grown in a region, on-farm irrigation management, district water supply management and operation, the hydrologic conditions, the soils, and other physical and economic factors.

The cost to reduce applied water losses, regardless of whether recoverable or irrecoverable, can be described in terms of dollars per acre-foot per year. This value would include the capital cost of any system improvements, amortized over the life of the system, and increased costs of operation, maintenance, and management of the system, divided by the potential water savings (in acre-feet annually) that are anticipated to result from implementing the improvements. This value represents the cost to reduce total losses (irrecoverable and recoverable). The cost associated with real water savings (reduction in irrecoverable losses) will be at least as great as that for applied water reduction and in many cases, much greater, for reasons explained below.

In areas where irrecoverable losses have been identified, each acre-foot of applied water loss includes both recoverable and irrecoverable loss. The irrecoverable portion is generally a small percentage of the total, but in some cases it can approach 100 percent. The percentage will depend on the specific local conditions. Irrecoverable loss can be the result of either on-farm or district inefficiencies.

To illustrate this relationship, suppose a field is being irrigated at 75 percent efficiency, defined as the ET of applied water and water needed to maintain salt balance and other cultural practices, divided by applied water. Then 25 percent of applied water goes to losses. If losses (e.g., surface runoff and percolation to degraded groundwater) are split evenly between recoverable and irrecoverable and efficiency improvements equally reduce recoverable and irrecoverable losses, then a reduction by 1 acre-foot of applied water reduces irrecoverable loss by half that amount. Therefore, efficiency improvements that may cost $50 per acre-foot of applied water reduction actually cost $100 per acre-foot of real water savings (reduced irrecoverable loss).

Similarly, if irrecoverable loss accounts for only 20 percent of applied water savings, the actual (real) cost per acre-foot of real water savings would be five times greater, or $250 per acre-foot. The same example could also be made to describe this concept as it applies to district inefficiencies. However, in such an example, the field may be replaced with a set of delivery canals. Either way, some fraction of each acre-foot of loss is irrecoverable, but not necessarily the entire acre-foot.

The analysis below uses a range of irrecoverable loss from 10 percent to 50 percent of total loss, based on estimates of existing on-farm conditions developed by the Bureau of Reclamation (DOI, 1995). This translates to cost increases of 2 to 10 times the cost for applied water reduction.

Estimated On-farm Efficiency Improvement Costs

Cost estimates to increase on-farm irrigation efficiency are based on a study prepared for the Bureau of Reclamation "On-Farm Irrigation System Management", (Young, et al., 1994). This study estimates the costs and performance characteristics of many different irrigation systems for eight crop categories common in the Central Valley. Costs are based on different combinations of hardware, operational regimes, and management, and are expressed as dollars per acre per season. For a given crop, each irrigation system option is summarized by two main characteristics: the irrigation efficiency, and the cost per acre per season.

For each crop, a nonlinear curve was fitted using each cost versus efficiency combination as a data point. The fitted curves describe the trade-offs between cost and irrigation efficiency. These curves have been incorporated into a regional agricultural production model called the Central Valley Production Model (CVPM). CVPM also incorporates data on cropping patterns, water use, and costs by region.

Using CVPM, estimates were made of the cost to improve average on-farm irrigation efficiency from current, or baseline, levels to 80 percent, then again to 85 percent. The model increases efficiency by 1 percent increments until the desired level is reached. The cost shown represents the cumulative cost to move from a baseline efficiency to the 85 percent level.

The values are presented on a per acre-foot per year basis for regions in the Central Valley. Values for areas outside the Central Valley were extrapolated from the Central Valley data since the model is limited to the Central Valley.

Table 4.3 - Range of Costs to Achieve On-Farm Irrigation Efficiency of 85%

	Cost per Acre-foot of Applied Water Reduced ($/af/yr)	Irrecoverable Loss Identified (see Table 4.1)	Cost per Acre-foot of Irrecoverable Loss Saved[1] ($/af/yr)
Sacramento	50-60	none ident.	--
Delta	40-50	none ident.	--
West SJR	35-45	yes	80-400
East SJR	55-70	minimal	--
Tulare	75-95	yes	170-850
San Francisco	75-95[2]	none ident.	--
Central Coast	75-95 [2]	yes	170-850 [2]
South Coast	75-95 [2]	yes	170-850 [2]
Colorado	-- [3]	yes	170-850 [2]

Note: Each cost presented is the annual cost to move from a baseline efficiency to 85%.
1. Cost shown for reducing irrecoverable losses are based on assuming 10 to 50% of each acre-foot of applied water reduction is irrecoverable (i.e., costs are multiplied between 2 and 10 times the cost of applied water savings).
2. These values have been extrapolated from the Tulare region results.
3. Colorado region has no water quality or ecosystem benefits that can be translated to the Bay-Delta.

The cost shown above represents the cost incurred for implementing and maintaining improved efficiency measures. However, a small discount may be subtracted from the values because of the reduced application of water. Reduced applied water should result in reduced cost associated with the water supply (i.e., reduced groundwater pumping cost or surface water delivery cost). Because water supply costs vary for each region, the savings from reduced water costs will also vary. Cost reductions will also depend on which supply of water is reduced. If surface supplies are reduced, generally considered less expensive than groundwater, then the savings benefit is lower. If groundwater pumping is reduced, the cost savings are usually greater. In general, reduced surface supply costs can offset the efficiency costs shown above by $2-$10 per acre-foot per year. Assuming a mix of reduced groundwater and surface supplies, this offset can be up to $10-$30, with the higher dollar savings occurring in areas with already higher per acre-foot costs (e.g., Tulare). These estimates assume that water supplies' fixed costs are held constant.

Though most water users will gain a minor savings from reduced water supply costs, some will see a minor increase. Increases will most likely be experienced by water users who currently are dependent on the losses of others to supply their needs. As these losses are reduced, so is this indirect supply. To offset the loss in indirect water supplies, these users will have to obtain water directly, either through groundwater pumping or direct delivery from a water supplier. In either case, the cost to obtain direct delivery of water is usually greater than the cost of indirect use.

Estimated District Efficiency Improvement Costs

In addition to on-farm efficiency improvement costs to the growers as depicted on Table 3, there will be costs for on-farm improvements that districts or other local agencies may incur associated with necessary district or agency level improvements. Without support by the water suppliers and other water agencies such as DWR, high on-farm efficiency, if not impossible, can be much more difficult to achieve. In addition, districts will have significant costs for district level improvements such as lining canals, flexible water delivery systems, regulatory reservoirs, tail-water and spill-water recovery systems, etc. Estimates/projections of these costs for such improvements for different regions were made using information from local agencies, the Department of Water Resources, and data from the US Bureau of Reclamation. Because of the unique situation at each water district, it is difficult to generalize about the costs. However, estimates are presented here for purposes of aiding in the programmatic impact analysis. Costs shown for each region may vary greatly for each specific project.

Table 4.4 - Estimated District Efficiency Improvement Costs ($million/year)

	Cost to Support On-Farm Efficiency Improvements[1]	Cost For Improvements in District Water Delivery[2]	Total Cost to the Districts	Average Cost per Acre ($/yr)[4]
Sacramento	9	4.25	13.25	7.80
Delta	1	1.25	2.25	4.50
West SJR	4	1.08	5.08	11.80
East SJR	6	3.18	9.18	7.25
Tulare	13	8.00	21.0	6.60
San Francisco	0.3	0.15	0.45	7.50

Central Coast	1	0.25	1.25	12.50
South Coast	1	none[3]	1.0	3.30
Colorado	3	1.63	4.63	7.10

1. This may include more district personnel, increased operation and maintenance costs, use of CIMIS stations, hiring irrigation advisers, etc. The cost will vary regionally because of the different crops and irrigation system mixes that are inherent in each region.
2. Estimates are based on a $2.50 per acre per year cost for district level activities such as improved delivery system monitoring/measurement, canal lining, system automation, and regional tailwater recovery systems. This cost is assumed to occur every year but may be higher in some years than other.
3. No value is provided for South Coast because most agriculture in this area is already served by pressurized municipal type delivery systems. Additional improvement potential is limited.
4. Average cost per acre is the total district cost divided by the average irrigated acreage in each region (acreage values were presented previously under each zonal description).

Anticipated Impacts, Beneficial and Adverse, Resulting From the Agricultural Water Use Efficiency Component

Agricultural water use affects a wide array of state-wide factors. Efficiency and local water management improvements can have positive, negative, or no impact on these various factors. In many cases, the improvements can have multiple and contradicting impacts. The following information is provided as a brief description of the anticipated impact resulting from implementation of efficiency improvements. The descriptions are not intended to be complete discussions of anticipated impacts, but rather indicators of what, where, and to whom impacts may occur.

General Benefits of Water Use Efficiency Improvements

The on-farm irrigation efficiency and water delivery improvements discussed above will result in reductions in associated losses that could have the following potential benefits:

- To the grower
  - higher crop yield and quality
  - reduced cost of irrigation: labor, water, energy
  - reduced delivery costs
  - improved flexibility with irrigation management
  - water savings that can be reallocated to other fields, growers, or uses
- To the water supplier
  - reduced delivery system maintenance
  - improve reliability of surface deliveries to growers
  - water savings that can be reallocated to other growers or uses
- To others (including the environment)
  - improved surface water quality (reduced tailwater)
  - improved ground-water quality (reduced leaching of fertilizers, pesticides etc).
  - reduced diversions from canals, streams, rivers, and reservoirs
  - reduced fishery impacts from diversions
  - water savings that can be reallocated to other beneficial uses, including the environment

While all the benefits listed above are excellent reasons to implement water use efficiency improvements, some are believed to be of greater importance in the CALFED Bay-Delta process. The extent to which any efficiency measures are implemented will be dependent on local conditions.

Anticipated Beneficial and Adverse Impacts

Anticipated impacts are described below under resource categories used for the presentation of impacts in the Programmatic EIR/EIS.

Hydrology and Water Management

Water use efficiency improvements can affect water hydrology and management in many ways. In general, as discussed previously, it is anticipated that this CALFED component will help reduce applied water. In some cases, the reduced amount can be reallocated to other uses, in others it can simply create other water quality and ecosystem benefits. In general though, water use efficiency improvements should help improve water supply reliability by reducing the amount of water necessary to maintain current beneficial uses. Therefore, during periods of reduced supply, less impact should be experienced by growers since they can maintain current production levels with slightly less applied water. The water use efficiency component may impact surface water and groundwater in the following manner:

Surface water flow. Efficiency improvements can benefit surface water flow management in a variety of ways. These include reduced diversions, real water savings, and possibly modifying the timing of reservoir releases.

Reduced diversions do not create real water savings in the majority of cases. But, when real savings do occur, the reduction will generate water that can be reallocated to other uses. In such instances, there will be a water supply benefit to the user. This new supply may be used to offset existing shortages or groundwater overdrafts, or may be transferred to another beneficial use. It is assumed, though, that control of the saved water is left to the discretion of the user or water right holder. As identified earlier, there is limited potential for real water savings, so accordingly there will be limited benefits.

What becomes more important with loss reduction is the reduction in applied water. This reduction can have both positive and negative impacts to surface water management. Secondary water users or habitat areas that indirectly use surface losses will no longer have access to this supply. Instead, these beneficial uses may have to obtain their water supplies directly from other surface sources or be adversely impacted. For agricultural lands, this may mean that new diversion points are created on the river or new lands are annexed into existing water districts. New direct deliveries may adversely impact surface water management. In addition, habitat areas that benefited from the surface losses may incur adverse impacts which may require mitigation.

The beneficial impacts of reduced applied water are associated with potential reductions in stream diversions and changes in the timing of reservoir releases. Currently, some portion of surface diversions flow across fields, into drains, and back to surface water bodies. This sometime unnecessary flow detour can be reduced through efficiency improvements. The result could be more water available to a particular stretch of surface water, rather than being routed across fields and through drainage courses. This would benefit stream flows, maybe by increasing water levels for a longer period of time, or by helping keep water temperatures cooler. This would also benefit water quality, from reducing some of the contaminant loading that returns with the rerouted water supply.

One additional benefit could be from the ability to modify the operation of some upstream reservoirs. For instance, a 100 unit reduction in applied water that previously would have been released from the reservoir in June could possibly be held for release in September instead. Timing benefits may not be available beyond the same season, but could allow shifting of flow releases to benefit instream flows. Carryover of unused water in reservoirs may also be a benefit of reducing losses associated with applied water.

Efficiency improvements may also result in reduced deep percolation and subsequent groundwater recharge. This could result in increased recharge directly from rivers and streams, reducing instream flow at a downstream point. Such changes may force releases of additional water supplies to ensure downstream flow targets are maintained.

Groundwater. Efficiency improvements can also impact groundwater resources in a variety of ways. These include reduced groundwater pumping from existing wells, the possible installation of more wells and greater total use of groundwater, decreased recharge from deep percolation, and the potential for increased recharge from surface water bodies.

Efficiency improvements can result in reduced groundwater pumping at existing well locations because of reduced applied water. This is no different than the potential reductions in surface water diversions discussed previously. This is a positive impact. However, because of the reduced surface water losses that used to be indirectly used by others downstream, there may need to be more wells drilled to develop a replacement source. It is unknown to what extent secondary users will obtain surface or groundwater sources as replacement supplies. It is likely that most secondary users will turn to groundwater for a replacement source because of seemingly greater dependability and less regulatory requirements (compared with obtaining a surface supply). The increased pumping from new wells may be equal or greater than any savings from efficiency improvements associated with existing pumping. This may have adverse impacts on the safe yield of particular aquifers and possibly result in overdraft conditions and the loss of some aquifer capacity due to land subsidence.

In addition, some growers may switch from surface water sources to groundwater pumping to implement on-farm efficiency improvements. Current technology to deliver surface water to farms limits the flexibility of a grower to irrigate with some system types. For instance, some districts deliver water on a rotating basis where a grower may only receive water once a week or once every several days, but not necessarily always when needed. In such cases, a grower's attempt at efficiency improvements may be offset, causing a desire to find new, more flexible sources of water. Switching from surface to groundwater can increase flexibility and provide a cleaner source of water. Flexibility and clean water are two key elements for successful use of irrigation technologies such as micro-sprayers and drip. Some water districts in the Sacramento Valley are experiencing this switch to groundwater such that it is starting to adversely impact the district's revenue base.

Improved on-farm and district efficiency will result in decreased deep percolation of applied water. Though this savings can have other benefits, the deep percolation plays a vital role in recharging underlying aquifers in many areas. Many of the farms in the Sacramento Valley and San Joaquin Valley serve as vast, effective, economical groundwater recharge basins. Given the potential of greater groundwater pumping, decreases in recharge could further adversely impact groundwater levels and aquifer capacities. Many water districts, especially along the eastside of the San Joaquin Valley, depend on their delivery canals as recharge basins. During wet years, these canals are purposefully filled with water during the winter months to recharge the underlying aquifer. This operation acts as a method of water storage for use later in the season or during drier years. Canal lining could adversely impact their ability to conjunctively use groundwater and surface water supplies.

Decreased recharge from on-farm irrigation may result in lowering groundwater tables. Where groundwater and surface water are in balance, decreasing groundwater levels will lead to increasing recharge of surface water back into aquifers. In such cases, instream flows will be decreased, resulting in the need to release more water from upstream sources to account for river losses.

Vegetation and Wildlife, Including Special Status-Species

The interaction between efficiency improvements and vegetation and wildlife is a complex issue involving not only physical aspects but biological ones as well. As stated above, improved on-farm efficiency and the reduction of losses associated with applied water will significantly reduce the opportunity for indirect reuse by wildlife and habitat areas. There are numerous examples of seasonal wetlands, riparian corridors, and other habitats that have developed as a result of water losses leaving a field and traveling to another field or to a surface stream or drain. Collectively, these habitat areas have significant vegetative and wildlife value.

Reduction or elimination of losses that are reused by these habitat areas could adversely impact their survival. It is possible to directly deliver conserved water to these same areas as mitigation. If so, direct water supplies may have better water quality but may lack necessary sediments and nutrients delivered from field runoff that were used by the habitats.

Also, improved efficiency could result in changes in the types of crops grown in a region. For instance, a district may implement efficiency measures that result in a need to raise the price for water. For some growers, the higher price may force them to change crops to types that have more economic value, such as from rice to tomatoes. Though this impact may be limited by other factors, some areas of the Sacramento Valley are experiencing a shift in crop types as a result of increased water cost. To the extent that efficiency improvements further such shifts, there could be an adverse impact to waterfowl and other wildlife from the reduction in acreage of lands, such as rice fields, that are conducive to wildlife.

Mitigation may reduce such adverse impacts, but analysis should be made on a case-by-case basis to see if it is prudent to eliminate an existing habitat areas created by inefficiencies simply to create or enhance another habitat, but at greater cost.

Fisheries and Aquatic Ecosystems

Efficiency improvements can provide some direct benefits to fisheries and aquatic ecosystems. These include reduced diversion impacts, potential to modify diversion timing, and potential to modify flow releases from reservoirs.

To the extent that applied water reductions can actually reduce surface water diversions, there may be inherent reductions in entrainment and impingement impacts to fisheries and aquatic species. However, there is not a one-to-one correlation between applied water reductions and potential benefits. For instance, many agricultural diversions begin in mid-spring, peak in July and August, and are no longer necessary after September or October. This creates a general bell-shaped diversion pattern. Reductions in applied water would primarily be consistently spread throughout the diversion season. Entrainment impacts, however, may be most problematic during certain months or flow periods. Therefore, only a fraction of the applied water reduction will result in any entrainment reduction benefits. In general, however, any reduction in diversion will generate positive impacts to fisheries and aquatic species existing in the source stream, river, drain, or reservoir.

Efficiency improvements in some areas of the Central Valley may also allow for slight modifications in the timing of local diversions. These modifications may not be more than a delay of a few days or a week for a planned diversion such that maybe a pulse flow could be routed downstream to help fish species out-migrate. For instance, assume a small tributary with several minor (<2 cfs) diverters. The diverters collectively decide to allow a pulse flow to move downstream to help flush juvenile salmon to a larger river. Each diverter successively delays irrigation diversions until the pulse flow has passed their diversion location. This may cause a delay in irrigation of a few days or a week, but, if properly coordinated, could be possible. Delays in diversions on larger rivers or of larger diversions become increasingly less possible because of more complex instream flow regimes. The potential to modify diversion timing would have to be analyzed on a case-by-case basis, but has the potential to positively benefit fisheries and aquatic species.

Though most efficiency improvements do not generate water for reallocation to other purposes, as explained previously, there is ample opportunity to reduce losses associated with applied water for purposes of multiple benefits (though maybe not always locally cost-effective). One benefit is increased instream flow (see Hydrology and Water Management impact discussion). The increased instream cumulative flows can be timed for release so they provide additional instream fishery benefits. Water may stay instream for longer periods or for longer stream reaches generally having positive benefits. In addition, savings could be accumulated so that fishery benefits can be maximized.

Adverse impacts to fisheries and aquatic species can also occur as a result of efficiency improvements. Primarily, such impacts would be limited to streams and drainage that support aquatic life as a result of surface runoff and other inefficiencies. The reduction of these losses would directly reduce the source water in such areas, and thus could adversely impact the aquatic life. Many small creeks and drains that support aquatic life during the entire year only have water present in the summer and fall months as a result of agricultural inefficiencies. Reduction of this water source may result in drains and creeks drying up in the summer months, adversely impacting existing aquatic species, not to mention the vegetation and wildlife that are also part of the ecosystem.

Economics and Land Use

On-farm, district, and regional economics can be affected by improvements in water use efficiency. Some of the impacts are beneficial, others are not.

Land Use. Changes in land use may occur as a result of improvements in water use efficiency. In some instances, land may be removed from production because of increased costs and decreased profitability that may result from required efficiency improvements or increased district water charges (i.e., as part of tiered water pricing). If not profitable, land will typically not be used to produce agricultural commodities.

Efficiency improvements that result in greater water supply reliability but also higher annual cost may cause a shift in the types of crops grown. For instance, Westlands Water District has seen a 300% increase during the past two decades in the acreage of vegetable crops grown and an 80% decrease in wheat and barley. This is partly because of improved irrigation performance. Also, areas of the Sacramento Valley are converting from open row crops and rice to permanent crops, such as orchards, partly because of increased water supply costs.

Agricultural Economics. Both on-farm and district level economics can be impacted by efficiency improvements.

In general, efficiency improvements have positive impacts on crop production such as higher yield, better yield quality, reduced deep percolation and drainage, and reduced cost associated with irrigation such as labor and water. The use of energy may or may not increase. Additionally, efficiency improves surface water and groundwater quality through reduced transport of fertilizers and pesticides away from the root zone. Efficiency improvements can also allow for better fertilizer management resulting in generally lower fertilizer inputs and less cost. However, no efficiency improvement will be implemented by growers if there is a negative impact to their ability to make a profit. Farming is a very capital intensive business. The up-front capital costs and risks associated with changing from comfortable and profitable irrigation practices are real and can limit the implementation of even cost-effective changes.

One benefit of improved efficiency is improved water supply reliability. This improvement can aid in securing loans and other financing necessary for annual crop production. For instance, if a grower cannot tell a lender that he is secure in receiving a particular quantity of water to grow his crop, the lender will be hesitant to loan money for crop production. As a result of significant regional efficiency improvements, there is increased likelihood of still growing a crop, even with a quantity of water less than historically available in the region. This improves the likelihood of obtaining necessary production financing.

District economics can be adversely impacted by both on-farm and district level efficiency improvements. All districts currently charge a rate for water and a rate to recover fixed operating and maintenance expenses. If less water is delivered because of efficiency improvements, fixed costs relative to water supplied will increase resulting in a need to pass along higher fixed costs to water users. In the event that district delivery facilities are also improved or new staff added, fixed costs may increase even more, resulting in further increases to be passed on to the water user. Depending on the ability to recapture fixed costs, district operating budgets may be adversely impacted from any and all efficiency improvements. To the extent growers switch from surface to groundwater supplies, further reduction in the ability to recapture fixed costs will occur. This is occurring in a few districts in the Central Valley already.

Regional economics. Regional economics are assumed to be defined as local community economies. Water use efficiency improvements can result in both beneficial and adverse impacts to these economies, otherwise thought of as "third-party" impacts: Impacts upon those that are not directly involved with an action.

Improved reliability resulting from efficiency improvements can help sustain agricultural productivity such that farming remains as a long-term portion of local economies. Without such long-term sustainability, agricultural lands may go out of production, having negative impacts on local economies as a result of lost revenue in the region.

However, at the same time, improved efficiency can reduce labor and other inputs such that there is less money expended to grow a crop. This can have adverse impacts on the unskilled labor pool and on businesses that provide agricultural inputs, such as fertilizer.

Power Production and Energy. Power production may be beneficially impacted as a result of efficiency improvements. The possibility exists, as discussed previously under Hydrology and Water Management impacts, to modify the timing of reservoir releases. Any modification would probably be primarily for environmental benefits, but there is the potential to increase power production and associated revenue. Of course, modifications in the timing of releases may also adversely impact the ability to generate power during peak periods.

Water Quality

Water use efficiency improvements may result in improved instream water quality, primarily in areas that receive agricultural runoff. Groundwater quality may also improve or at least experience reduced levels of degradation. The amount of water quality improvement that could occur will depend on local conditions, including contaminant loading, timing, and concentrations. In some regions, improved efficiency could result in adverse impacts to downstream water quality. Such impacts could occur in regions that depend on large amounts of runoff to generate streamflow. Decreased runoff may result in increased concentration of contaminants in the remaining flow such that beneficial uses downstream are impaired.

In general, decreasing the volume of return flows or deep percolation will decrease the amount of sediment, nutrients, or residual chemicals that are transported away from the field. Take a field, for instance, that currently loses topsoil with each irrigation. The sediment is transported into the receiving stream causing some degradation. If a tailwater recovery system or other method of reducing sediment in surface runoff is implemented, sediment transport off the field is reduced, thus reducing stream degradation. The same can be argued for most nutrients and residual chemicals. The less water that leaves the field (or combination of fields) the less likely the total loading will be as great. It is possible, however, that although total loading of contaminants is decreased, concentrations in the remaining water that still leaves the field may be greater. This phenomenon will need to be analyzed for various conditions under which it may occur.

The exception to generally improved water quality is that salts present in irrigation water still need to be leached from the soil. It is assumed that although total applied water is reduced, the amount of salts needing to be leached remains relatively the same. Therefore, the loading does not change much. Given less excess losses, there will be less water available to dilute salt loading that is leached. In areas where drainage is not an issue, this may present little immediate problem, although other long-term impacts on groundwater quality may occur. For drainage impacted areas and areas that need to remove subsurface drainage from fields, however, this can become an issue. For example, some agricultural lands along the westside of the San Joaquin Valley are underlain with tile drains. These drains collect deep percolation and leaching water, direct them to sumps, and allow subsurface drainage to be discharged to surface waters. To the extent that additional efficiency improvements can reduce deep percolation in excess of the need for adequate leaching, there may be less flow in the subsurface tile systems. However, the loading of salts may not decrease equivalent to the decreased deep percolation. This may result in increased concentrations in the remaining subsurface drainage. Safe discharge of the drainage may require more fresh water supplies for dilution than currently are used. This can have an adverse impact on water supplies, or if dilution water is not used, an adverse impact on the quality in the receiving water.

When surface water quality is improved as a result of less contamination from return flows, all water users will benefit. Urban and agricultural users that divert the water downstream of surface returns will see improved quality. In some cases, the improved quality of the source water can have a compounding effect on improving additional return flow quality. For instance, if water quality in the Delta Mendota Canal is improved for some contaminants, then return flows, even without efficiency improvements, of those receiving DMC water could also improve slightly, resulting in improved San Joaquin flows, which partially supply the DMC, and so on.

Raw water sources for urban drinking water could also be improved through efficiency improvements. Generally, decreased losses associated with applied water on Delta agricultural lands will result in less drainage water being pumped from islands back into Delta channels. This should result in less introduction of organic matter into Delta water, a problem for urban water treatment facilities.

Some portions of the aquatic environment are adversely impacted by return flows. This includes adverse impacts from temperature and turbidity. Water that is diverted from a surface stream, to be routed across a field, but then returned to the stream, whether beneficially being used or not, increases in temperature and picks up sediments. The return flow then adversely impacts the temperature of the receiving stream, adversely impacting some aquatic species. Reduction of this occurrence has the potential to improve temperature conditions in many streams.

Air Quality

On-farm and district level efficiency improvements can have both beneficial and adverse impacts to local and regional air quality.

On-farm improvements may result in reduced cultivation or field preparation activities which can result in reductions of particulate matter measuring 10 microns or less (referred to by the U.S. EPA as PM10) and vehicle emissions. Conversely, if increased water use efficiency is obtained through use of pressurized irrigation systems, increased emissions from pumping may occur. These emissions may be local if fossil fuels are used (e.g., diesel or natural gas) or regional if electricity is used. Temporary adverse effects to air quality may result from construction activities related to changes in on-farm irrigation systems (e.g., building tailwater ponds, trenching).

District water use efficiency improvements could have beneficial impacts to air quality if efficiency improvements reduce maintenance activities along delivery systems (i.e., fewer weed control efforts because of canal lining). However, the activities may also increase other maintenance or operational activities and adversely impact air quality (i.e., cleaning lined canals of sediment). Changes in delivery systems, including regulating reservoirs and other flexibility improvements, will increase the energy necessary for delivery. This could adversely affect air quality.

Reduction of vegetative growth, both agronomic crops and riparian vegetation, can result in increased soil and air temperatures. Heat from solar radiation that typically is moderated by plant evapotranspiration, including wetlands and other plant ecosystems surviving off current inefficiencies, would contribute directly to warming of the soil and ambient air. Increased air temperatures could result in increased evapotranspiration from remaining plants, thus possibly reducing the desired benefits.

The net effect of improved water use efficiency on local and regional air quality needs further analysis. However, generally it is assumed that the net combination of specific impacts does not have long-term adverse nor beneficial regional impacts.

Noise Pollution

Generally, efficiency improvements are not assumed to cause positive or negative impacts to existing levels of noise generated by the agricultural sector. Implementation of efficiency measures may have temporary negative impacts from increased installation activities, but at the same time there may be associated reductions in cultivation or other typical operation activities. The net effect may be unnoticeable.

Increased use of pumping plants, whether at the on-farm or district level, is not assumed to have adverse noise impacts. In most cases, pumping facilities, even those that are powered by fossil fuels, are remotely located in rural areas. In addition, most pumps do not create much noise pollution anyway. Technology has improved to the point where most pumps are quite. If they are heard, it may signal a problem with the pump.

To the extent that efficiency improvements reduce wetlands or riparian areas associated with existing losses, and to the extent that improvements act to induce crop changes or act as a disincentive to after harvest field flooding, waterfowl habitat may be decreased. This decrease can result in reductions in the level of recreational hunting that may occur, potentially having a beneficial impact on noise pollution from reductions in the number of gunshots.

Visual Resources

Inefficiency in the delivery or application of irrigation water has created many individual plant and wildlife habitats, such as wetlands, riparian groves, grassy areas, and canal-bank habitat. These inadvertent habitats often provide beautiful scenery and add to the aesthetics of the local area. In many cases, these areas also harbor various forms of wildlife, including waterfowl and song-birds. Wildlife can be an integral part of the aesthetics of an area. Improvements in efficiency typically target reducing the same water that supplies these areas. Reduction in the supply could adversely impact, even eliminate, such habitats and could adversely affect the local aesthetics.

Public Health and Environmental Hazards

Water use efficiency improvements may beneficially impact some aspects of public health. For instance, to the extent that efficiency improvements decrease residual wetland or seepage areas along delivery facilities or on farm fields, mosquito breeding and other vector habitat will be reduced. However, where this type of habitat currently exists is usually well displaced from human population areas. Therefore, further improvements may not be necessary.

Because many efficiency improvements will include construction activities, the risk of contamination from hazardous materials, such as lubricants, fuels, and other elements, may increase. In addition, long-term operation of pumping equipment included as part of some efficiency improvements, including new groundwater wells, increases the risk of long-term contamination to groundwater sources.

At the same time, reduced deep percolation could reduce transport of nutrients, such as nitrogen, into groundwater sources. This would benefit those who rely on groundwater sources for domestic uses. Several groundwater wells throughout the valley have been contaminated by agricultural related constituents, such as nitrogen, at levels that are deemed unsafe to drink. Concern has been raised by the State Water Resources Control Board regarding the potential for further pollution of domestic groundwater wells from down-migration of fertilizers and other constituents used during agricultural production. To the extent that efficiency improvements allow for better utilization by the crop of such potential contaminants and decrease the chances for deep percolation, there may be beneficially impacts to future groundwater resources.

In addition to the possiblity of reduced groundwater degradation, agricultural efficiency improvements can reduce the level of contaminants in surface waters that are of public concern. For instance, reduction in applied water on Delta farmland could result in reduced pumping of drainage water. This drainage water is typcially ladened with organic carbons, a major concern of public drinking water quality. Reducing drainage water could reduce the loading of organic carbons into surface waters of the Delta, the primary source for export water supplies.

In addition, areas along the westside of the San Joaquin Valley introduce selenium into surface waters. This constituent can also be harmful to public health if in high enough quantities. The reduction in runoff and deep percolation that flows to surface water could reduce selenium loading.

Recreational Resources

To the extent efficiency improvements reduce wetlands or riparian areas associated with existing losses, and to the extent that improvements act to induce crop changes or act as a disincentive to after harvest field flooding, waterfowl habitat may be decreased. This decrease could have adverse impacts on the availability of lands for recreational hunting or for bird watching.

At the same time, efficiency improvements may lead to reduced diversions, leaving more water for instream benefits. Instream benefits may include increased flow through a particular reach of stream for a particular year, changes in the timing of reservoir releases, and decreased diversion impacts on aquatic species. All of these may have a combined beneficial impact on the fisheries, and other recreational activities such as boating (both instream and on reservoirs) resulting in benefits to recreational and commercial fishing.

Geomorphology and Soils

Water use efficiency improvements potentially can significantly impact various aspects of geomorphology and soils.

Sediment Transport. On-farm improvements, such as tailwater recovery ponds or installation of pressurized systems (over gravity), can greatly reduce sediment transport from fields to streams and drains. Tailwater ponds allow sediment to settle and be contained on the field, though removal of it from the pond and placement back into the field is necessary. Pressurized systems typically do not generate surface runoff at rates that cause erosion and therefore, when properly designed and operated, do not create sediment transport problems. Sediment transport is not a significant issue in all agricultural areas, but does pose a problem in sandy or organic soils, such as occur in the Delta and areas of the San Joaquin Valley. In these areas, sediment in the runoff causes adverse impacts to receiving waters.

At the district level, some efficiency improvements, such as canal lining or particular canal gates, can reduce flow velocities and reduce or eliminate erosion. Though, erosion from delivery systems is not a major problem in most areas since velocities are already quite slow.

Soil salinity. Systematic under-irrigation should be avoided since it will lead to salinity build-up in the plant root zone. Salinity built-up will degrade the soil environment and adversely impact the soil's production ability. However, efficiency improvements are assumed to take into consideration salt leaching requirements to maintain the soil environment. Since leaching already occurs in most areas, efficiency improvements would not create any significant adverse nor beneficial impacts to long-term soil salinity.

Ground subsidence. On-farm efficiency improvements, especially drip and micro-irrigation systems, will result in increased reliance in groundwater sources. This is primarily because of the need for more frequent water delivery which most surface sources cannot meet. Increased groundwater pumping may also occur as a result of reductions in on-farm losses that previously supplied secondary users. Such secondary users who depended on this indirect source of surface water will most likely switch to groundwater as a replacement.

Efficiency improvements will also reduce deep percolation which, in many cases, acts to recharge groundwater sources. If this form of recharge is diminished and no other recharge occurs, groundwater levels will most likely decrease. This could occur even with no change in the existing level of groundwater pumping.

All of these actions combined may result in dropping groundwater levels and subsequent ground subsidence. Groundwater levels should be closely monitored and active recharge programs established to ensure this does not occur.

Land Use Changes

Water use efficiency improvements can aid in improving water supply reliability for the agricultural sector. Improved reliability may help keep land in production and out of urban development.

It is possible that efforts to improve water use efficiency may result in increased acreage being taken out of production (i.e., land fallowing). This land would most likely not be urbanized but would remain fallow agricultural land or become habitat. In either case, this could reduce the potential for erosion from these particular lands since they would not actively be farmed. Soil salinity, however, may increase, making reclamation of the lands more difficult if ever returned to agricultural use.

Utilities and Public Service

Water use efficiency improvements can create both beneficial and adverse impacts to utilities and public service needs.

Land Use. Improved agricultural water use efficiency could result in greater reliability of water supplies. This reliability could reduce the chances of land being urbanized since farming would still be viable. Less urbanization reduces the amount of public service facilities needed (i.e., infrastructure, police and fire services, utilities).

Energy Resources. A typical method of improving efficiency would include pressurization of water delivery systems (e.g., sprinklers, drip systems). Changing from use of a natural gravity system, such as furrows, to a more energy dependent method of irrigation will increase energy inputs needed to produce the same crop yield. This energy may be in the form of local fossil fuel powered equipment, such as a diesel pump, or electrical power generated in some other part of the region, state, or nation.

Efficiency improvements often have been associated with the advance in irrigation water delivery and application technology. Sprinklers, micro sprinklers, and drip irrigation systems are inherently energy intensive. The pressurized irrigation systems need energy to transport water for delivery to and over a given field. Operation of such systems is costly in terms of energy alone. During the drought, power utilities reported significant increases in energy use. This was primarily a result of many water users switching to groundwater. As stated previously, use of some irrigation technologies will result in more use of groundwater resources in place of surface water. Overall energy use may likely increase.

All pressurized systems also involve some sort of pipeline such as aluminum or plastic. These need to be manufactured. The manufacturing process requires use of a significant amounts of energy and other natural resources such as aluminum. Additionally, these systems need to be replaced, maybe every 10-20 years, which requires further resource inputs. Energy is also needed to dispose of old material.

Generally, conversion of gravity fed irrigation systems to pressurized and energy intensive irrigation systems will increase the need for energy and many other resources. It is possible to gain significant efficiency improvements, though, while still using gravity systems combined with limited low energy pumping, such as is needed with tailwater recovery systems.

Social Well-being

Water use efficiency improvements have the potential for beneficial and adverse impacts to social well-being, depending upon the element analyzed. For instance, improvements can help improve water supply reliability and thus viability of a particular agricultural area, but at the same time, there may be adverse impact to farm labor. The following discusses potential impacts.

Community Stability. During the drought of early 1990's, many communities faced reduced employment resulting from significant reduction in cropped acreage. Farm laborers were left jobless. To the extent that efficiency improvements can help improve water supply reliability, employment opportunities will be maintained. This should contribute to the stability of many local agricultural communities.

However, efficiency improvements can also have adverse impacts on farm labor. One benefit of improved irrigation efficiency that may be experienced by a grower is reduced labor, whether because of less cultivation or changes in how crops are irrigated. Pressurized irrigation systems can have the biggest impact. Typically, what used to be the job of several laborers, now can be replaced by just one. It is estimated that as technology advances, 30 percent less labor is needed to perform the same job. So, for every three laborers now employed, only two may be employed once efficiency measures are implemented. California already is a global leader in the number of people that can be provided for by the each employee. In some developing and third world countries, it may take more than 3 farmers just to feed 4 people. In California, one farmer can provide for more than 100 people.

Job opportunities will also be created by these efficiency improvements. As irrigation management improves, so must the knowledge of those irrigating or scheduling irrigations. This will result in the need for more skilled labor, at higher costs. In addition, the design and installation of new or improved on-farm or district water delivery systems will create more jobs for skilled laborers. It is conceivable that efficiency improvements, especially those that involve physical constructions will add to local employment for a long period of time.

Improved efficiencies often translate to higher crop yields and better quality of farm products. Such advances can increase on-farm direct income, benefiting the grower's net income. This often translates to a lditional economic activities. Increased income can also help the overall economy in total sales and purchase and increase tax revenues that strengthen vital functions such as schools, roads, and social and health services.

Food and Fiber Supply. Efficiency improvements can result in improved crop yields. Improvements in the yield per acre-foot of applied water, even with possible reduction in water supply, will result in greater production of food and fiber on the same land. As populations continue to increase, not only in the state, but in the nation and globally, highly efficient food production will become a greater asset. Improved irrigation can help position our farmers to provide for a growing global population.