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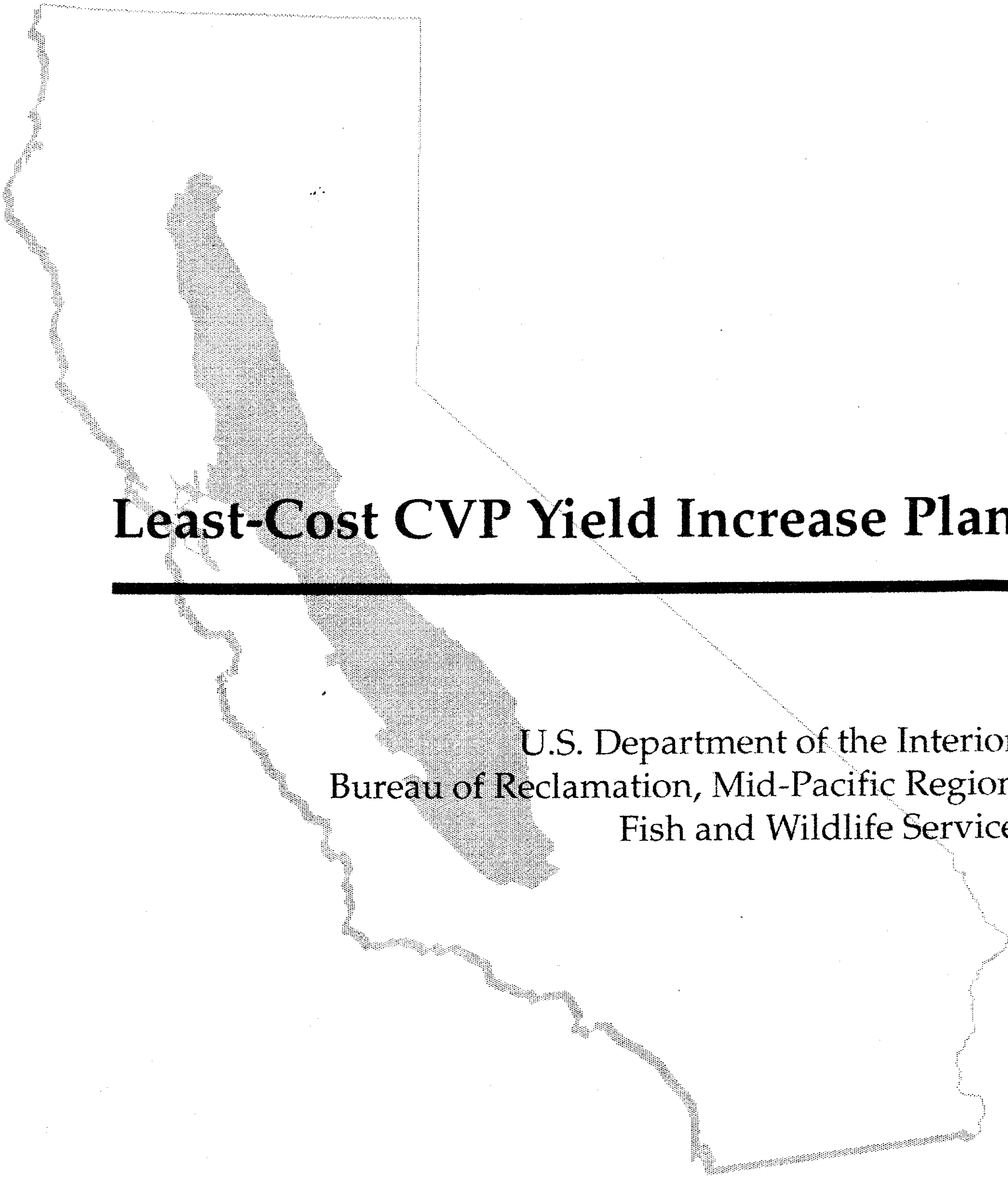

Least-Cost CVP Yield Increase Plan

U.S. Department of the Interior
Bureau of Reclamation, Mid-Pacific Region
Fish and Wildlife Service

October 1995

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Abstract

The *Least-Cost CVP Yield Increase Plan* (Yield Increase Plan) is a report to Congress describing possible actions to increase the yield of the Central Valley Project (CVP). The CVP is the largest water storage and delivery system in California.

Title 34 of Public Law 102-575—"The Central Valley Project Improvement Act" (CVPIA)—dedicates 800,000 acre-feet (af) annually of CVP yield for restoration of fish and wildlife habitats lost as a result of construction, operation, or maintenance of the CVP. This yield was previously available to CVP contractors, and these contractors may be adversely affected by its reallocation. The CVPIA also required preparation of a *Least-Cost CVP Yield Increase Plan* with the purpose of increasing the yield of the CVP by the amount dedicated to fish and wildlife purposes. The *Least-Cost CVP Yield Increase Plan* serves to address and help minimize adverse effects, if any, upon CVP contractors, and to assist the State of California in meeting its future water needs.

A Programmatic Environmental Impact Statement (PEIS) is being prepared to analyze possible adverse effects and other impacts and benefits of the CVPIA. If the PEIS identifies adverse impacts on CVP contractors, and if Congress determines that these impacts require mitigation, the yield increase options incorporated in the *Least-Cost CVP Yield Increase Plan* can be considered for implementation.

Implementation of the Yield Increase Plan would also narrow the gap between statewide future water demands and future water supplies as projected by the State Department of Water Resources.

The *Least-Cost CVP Yield Increase Plan* was developed with consideration of all reasonable options, including supply increase and demand reduction. In addition, the perspectives and viewpoints of various individuals and agencies affected by CVPIA were incorporated into the planning process.

Over one hundred yield increase options were identified within the general categories of land fallowing, conservation, modified operations, conjunctive use, water reuse, surface storage and conveyance, and other supply options. These options were characterized with regard to their annual cost, yield, environmental effects, social effects, time required for implementation, and associated institutional issues.

Options that did not have known unacceptable environmental or social impacts, and could be implemented in the required time frame (CVPIA requires that the plan be implementable by 2007) have been incorporated into the *Least-Cost CVP Yield Increase Plan*. They include purchase of water supplies from locally owned projects, purchase of water available from land fallowing, conjunctive use of surface water and groundwater, agricultural and urban conservation,

urban wastewater reuse, and one surface storage facility.

Figure A-1 summarizes the range of present costs and yield of these option categories.

As shown in **Figure A-1,** purchase of supplies from locally owned projects can provide up to 180,000 af of yield at relatively low present cost.

Conjunctive use of surface water and groundwater, particularly options involving active recharge of groundwater, can provide over 900,000 af of potential yield, also at relatively low present cost. Conjunctive use options would only be implemented after Groundwater Management Plans addressing interaction of surface water and groundwater and water rights issues are in place and environmental effects of stream diversions can be evaluated.

Land fallowing can provide as much as 1.2 million af of yield in the same cost range as conjunctive use options. Land fallowing was analyzed in four increments of about 300,000 af each. Water from land fallowing would be purchased from users of non-CVP surface water supplies. Land fallowing has the potential, however, to cause divisiveness, and adverse economic impacts and concerns in local communities. These impacts can be mitigated through temporary, rotational, and dispersed land fallowing practices, or by implementing only a portion of the total land fallowing yield identified. It should be implemented through local partnerships including government, agencies, interest groups, and the general public.

Urban wastewater reuse and agricultural and urban conservation options can provide over 600,000 af of yield but at higher cost. These options increase the efficiency of use of existing water supplies.

Surface storage and conveyance facilities, other than enlargement of Farmington Dam, are not included in the Yield Increase Plan primarily because of the time required for implementation and cost considerations. In addition, substantial concern regarding the environmental effects of these options exist. If others could accelerate implementation of surface storage facilities, they may be able to meet the timeframe criterion.

Recent developments indicate increased near-term competition for water in California, both for currently developed supplies and for future supply increases. Options available for inclusion in the plan have a cumulative yield of approximately 3 million af in order to account for the possible effects of this increased competition. These effects include increased costs for water purchases and loss of options to other developers or purchasers.

The summary array (**Figure A-1**) shows the present cost for available options. The marginal cost for implementing the first 800,000 af of yield increase is about $170 per af under present market conditions. The summary array also shows that, as competition increases and options are developed by others, the marginal cost for implementing the Yield Increase Plan with options that involve purchase of water could

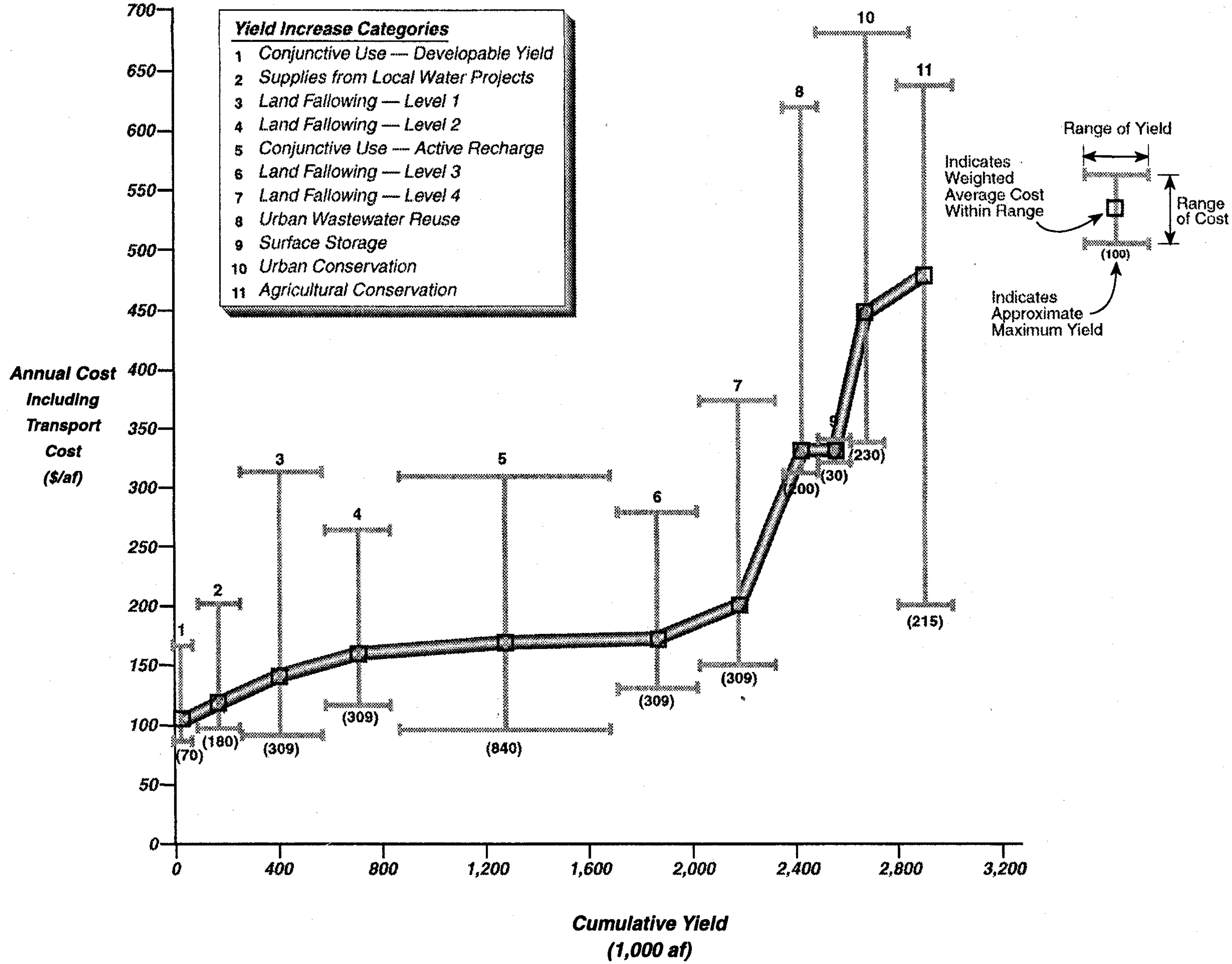


Figure A-1
Summary Array of Categories of Options That Make Up the Least-Cost CVP Yield Increase Plan

reach $650 to $700 per af. As competition increases, options not requiring purchase of water, such as conjunctive use, become relatively more attractive.

At some future date, Congress may authorize implementation of the Yield Increase Plan. At that time, it will be necessary to determine the current condition of the California water market and its impact on costs for purchasing water. It will also be necessary to determine which options have been acquired or developed by other water suppliers since this report was prepared. A refined set of options that serve to mitigate any adverse impacts as identified in the PEIS, and that are available at the time of authorization, would be determined.

Options involving water purchase should be coordinated with acquisition of CVPIA supplemental water and other federal programs that could result in the fallowing or retirement of farmland. Options that can be implemented with multiple purposes are more cost-effective than those implemented for environmental or yield increase purposes alone.

The CVPIA requires that recommendations on appropriate cost-sharing arrangements be included in the *Least-Cost CVP Yield Increase Plan*. Cost-sharing can include both the financing of the implementation of an option and annual cost. Possible participants in cost-sharing arrangements include federal, state, and local governments, and interest groups that realize a benefit from implementation of a particular option. Yield increase options implemented with multiple purposes can encourage cooperation and participation in innovative cost sharing arrangements.

Implementation of the Yield Increase Plan (the refined set of options) will require additional analyses, feasibility investigations, environmental documentation and permitting, possibly design and construction, and development of specific cost-sharing arrangements.

Contents

Section I
Introduction and Perspective

This report is intended as a guide for use by members of Congress and their constituents in considering possible actions to increase the yield of the Central Valley Project (CVP). The CVP is the largest water storage and delivery system in California.

The Bureau of Reclamation (Reclamation) and the Fish and Wildlife Service (Service) have prepared this report at the direction of the Secretary of the Interior under authority of Title 34 of Public Law 102-575.

Among its other provisions, Title 34—"The Central Valley Project Improvement Act" (CVPIA)—dedicates 800,000 acre-feet (af) of CVP yield annually for restoration of fish and wildlife habitats lost as a result of construction, operation, or maintenance of the CVP.

This yield was previously available, depending on water conditions in particular years, to CVP contractors, and these contractors may be adversely affected by its reallocation. A Programmatic Environmental Impact Statement (PEIS) is being prepared to analyze these effects and other impacts and benefits of the CVPIA.

The CVPIA also required preparation of a *Least-Cost CVP Yield Increase Plan* (Yield Increase Plan) with the purpose of increasing the yield of the CVP by the amount dedicated to fish and wildlife purposes. This plan serves to: 1) minimize adverse effects, if any, to existing CVP water contractors resulting from dedication of water to fish and wildlife, and 2) to assist the State of California in meeting its future water needs.

In This Section:

- Purpose of this report
- Glossary of key terms
- Overview of state's water projects

If the PEIS identifies adverse impacts on existing CVP water contractors, and if Congress determines that these impacts require mitigation, the yield increase options incorporated in the *Least-Cost CVP Yield Increase Plan* may be considered for implementation.

Implementation of the Yield Increase Plan would also serve to narrow the projected gap between statewide future water demands and future water needs. The State Department of Water Resources (DWR), in its California Water Plan Update (Bulletin 160-93), has identified a potential additional water supply need in 2020 of 7 to 9 million af under drought conditions and 3.7 to 5.7 million af under average conditions. DWR believes additional surface storage and conveyance facilities may be needed in the future to offset these shortages.

The Central Valley Project Improvement Act dedicates 800,000 acre-feet of CVP yield annually for fish, wildlife, and habitat restoration purposes

Some other agencies and organizations believe that future water needs could be met with existing supplies. As envisioned by Pacific Institute in

An Overview of California's Central Valley, the Central Valley Project, and State and Local Water Projects

The Central Valley

The Central Valley is a vast, oblong valley stretching through the interior of California, 400 miles north-to-south and about 50 miles east-to-west. It is home to most of the state's important agricultural areas, migratory waterfowl refuges, native anadromous fishery runs, and an increasing portion of the state's population.

Within the Central Valley are three major river basins: the Sacramento River and San Joaquin River, combining to form the 1,150-square-mile Sacramento San Joaquin Delta, are the two most prominent basins. The Tulare Lake basin lies at the southern end of the valley but has no outlet.

The valley's rich soils and Mediterranean climate provide ideal growing conditions for a variety of agricultural commodities, particularly in the San Joaquin basin. Major centers of urban growth also have occurred in the southern part of the state. But the availability of water decreases significantly as one travels from north to south. The upper Sacramento basin averages 23 inches of rain annually, while in the San Joaquin basin, annual rainfall averages only 9 inches. In order to address the difference in the location between supplies and needs, water supply projects have been built and are operated by federal, state, and local water agencies. **Figure I-1** shows major rivers, reservoirs, and conveyance facilities.

The Central Valley Project

The CVP is an extensive network of dams, reservoirs, power plants, canals, and related facilities supplying water to 20,000 farms, 2 million urban residents, and numerous wildlife refuges. In addition, it provides flood control, and water for navigation, recreation, water quality, salinity control, and fish and wildlife purposes. Authorized in the 1930s by the Rivers and Harbors Act, and managed by Reclamation, it includes 20 reservoirs totaling more than 11 million af in combined storage, and more than 500 miles of major canals and pipelines. The largest reservoir in the system, and in California, is 4.6-million-af Lake Shasta. Shasta and other CVP reservoirs provide nearly 30 percent of the total surface storage in California—and deliver about 7 million af annually to agricultural, urban, and wildlife uses.

State Water Project

The California State Water Project (SWP) is a water storage and delivery system of reservoirs, aqueducts, powerplants, and pumping plants. It extends for more than 600 miles—two-thirds the length of California. Authorized in 1951, it is the largest state-built, multipurpose water project in the country. Project functions include water supply, flood control, power generation, recreation, and fish and wildlife enhancement.

The SWP has contracts to supply more than 4 million af of water annually to 30 public agencies. Approximately 30 percent of this water is used to irrigate farmland, and 70 percent will be used to meet the needs of the state's growing population.

Local Water Projects

Local water projects were constructed and are operated by a wide variety of water and irrigation districts, agencies, municipalities, companies, and individuals. Initially, local projects consisted of direct stream diversions. When these proved inadequate during dry seasons, storage dams were built. The purpose of the majority of local water projects is to capture, store, and divert water within the same basin. However, as nearby sources were fully developed, urban areas began reaching out to more distant sources (e.g., San Francisco diverting from Tuolumne River). In addition to urban and agricultural purposes, some local projects were developed solely for electric power generation.

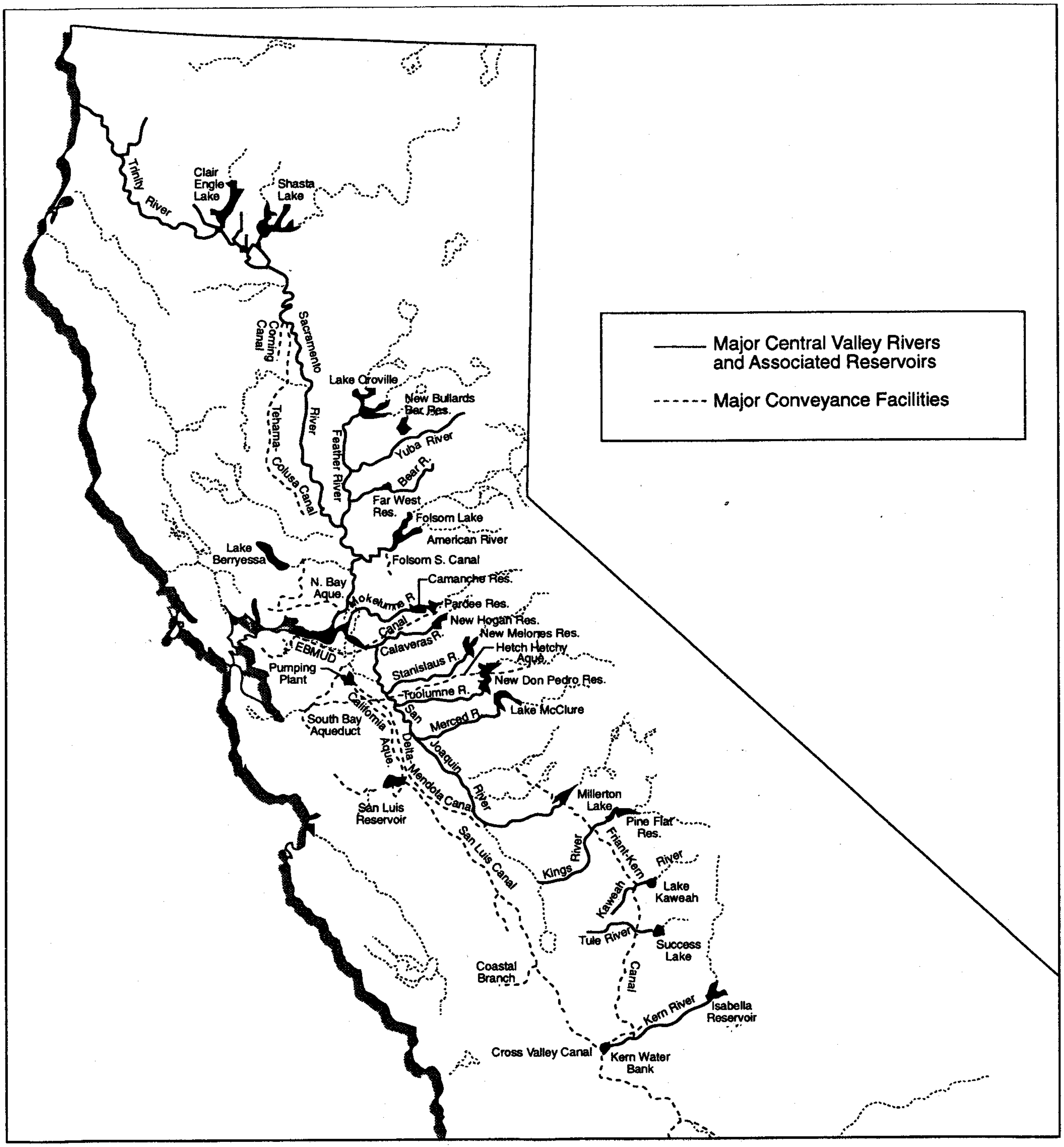


Figure I-1
California Surface Water Features

"California Water 2020: A Sustainable Vision," this balance would require implementation of increased urban conservation, modified cropping patterns, and additional water reclamation activities. Under drought conditions, however, water supply shortages could still occur.

A key factor in addressing California's future water needs is successful resolution of water reliability and environmental concerns in the Sacramento-San Joaquin River Delta. The on-going CAL-FED activities are addressing these issues.

Both the PEIS and the Yield Increase Plan were to be submitted to Congress in October 1995; preparation of the PEIS is currently ongoing.

The Yield Increase Plan presents findings, not recommendations. Its implementation by the federal

Glossary of Key Terms and Abbreviations

General Terms Used in This Report

- **Acre-foot of water:** A quantity or volume of water covering 1 acre to a depth of 1 foot; equal to 43,560 cubic feet or about 326,000 gallons.
- **Cost:** Total capital cost amortized over the anticipated life of the option (assumes 8 percent interest rate) plus annual expenses divided by the estimated yield.
- **CVP service area:** Areas of California's Central Valley, San Francisco Bay Area, and Central Coast Area where water service has been expressly authorized pursuant to the various feasibility studies and consequent congressional authorizations for the CVP.
- **Dedicated water:** CVP yield that has been allocated for fish and wildlife purposes as stated under the CVPIA.
- **Demand reduction:** Activity that increases CVP yield through actions such as conservation and land fallowing among users of non-CVP contracted water. Water saved through these actions would be transferred to CVP use. Additional demand reduction may be available from within the CVP. Demand reduction would serve to narrow the gap between statewide future water demand and future water needs.
- **Supplemental water:** Water needed to supplement the amount dedicated from CVP yield to meet fish and wildlife restoration goals in selected streams, refuges, and habitat areas.
- **Supply increase:** Activity that increases CVP yield through actions such as conjunctive use, modified facility operations, or new or modified surface storage and conveyance facilities.
- **Yield:** The amount of water made available annually during drought conditions.
- **Yield increase:** Yield made available through demand reduction or supply increase measures that may be authorized by Congress to minimize impacts to CVP water contractors attributable to the dedication of CVP yield for fish and wildlife purposes and to assist the State of California in meeting its future water needs.
- **Yield increase option:** A water supply and/or demand reduction activity with the potential to meet a yield increase need.

Abbreviations Used in This Report

- **af:** acre-foot (feet) of water
- **ARP:** Acreage Production Percent
- **BMP:** Best Management Practice
- **CEQA:** California Environmental Quality Act
- **COA:** Coordinated Operations Agreement
- **CVP:** Central Valley Project
- **CVPIA:** Central Valley Project Improvement Act of 1992
- **CVPM:** Central Valley Production Model
- **DWR:** Department of Water Resources
- **EIR:** Environmental Impact Report
- **EIS:** Environmental Impact Statement
- **ft:** foot (feet)
- **NEPA:** National Environmental Policy Act
- **PEIS:** Programmatic EIS
- **SNA:** Significant Natural Area
- **SWP:** The California State Water Project
- **USDA:** United States Department of Agriculture

government would require authorization of and appropriations for subsequent analysis and feasibility studies, environmental documentation, permitting, design, and construction. Options in the Yield Increase Plan are implementable by October 2007, as required in the CVPIA.
The options included in the Yield Increase Plan are potentially available as of the date of this report. However, as time passes they may be lost to other regional water managers and developers or otherwise become unavailable.

As a result, the specific components of the Yield Increase Plan likely will change over time and depend on the timing of any decision by Congress to replace the dedicated water, and the amount of yield Congress determines should be replaced, if any. Costs for implementing the Yield Increase Plan will also increase as competition for water supply in the California water market increases.

Other initiatives to increase water supplies in the Central Valley are being sponsored by the State of California, water districts, municipalities, private water developers, and through federal government programs. Activities authorized as part of the CVPIA to acquire water for fish and wildlife to supplement the amount dedicated are also underway. Partnerships with these activities could result in reduced implementation cost and could provide increased environmental and social benefits.

This Yield Increase Plan and the investigations and supporting documentation that led to its development were prepared as part of the Department of the Interior's program to implement CVPIA.

Section II
Development of the Least-Cost CVP Yield Increase Plan

In This Section:

- CVPIA overview
- Interpretation of Section 3408(j)
- Plan development process

CVPIA Overview

The CVPIA represents the first major legislation affecting the CVP since the Reclamation Reform Act of 1982. It makes significant changes to the management of the CVP, and it creates a complex set of new programs and requirements.

Section 3402 of the CVPIA identifies six purposes of the act: 1) to protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California; 2) to address impacts of the CVP on fish, wildlife, and associated habitats; 3) to improve the operational flexibility of the CVP; 4) to increase water-related benefits provided by the CVP to the State of California through expanded use of voluntary water transfers and improved water conservation; 5) to contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; and 6) to achieve a reasonable balance among competing demands for use of CVP water, including the requirements of fish and wildlife, agricultural, municipal, and industrial and power contractors.

Key provisions of the CVPIA related to achieving these purposes include:

- Development and implementation of a program to double anadromous fish populations in Central Valley rivers and streams by the year 2002, on a sustainable basis, from their 1967-1991 levels [Section 3406 (b)(1)]
- Dedication and management of 800,000 af of CVP water annually (600,000 af in dry years) for fish, wildlife, and habitat restoration [Sections 3406 (b)(2) and 3406 (d)(2)]
- Development and implementation of a program to acquire a water supply to supplement the quantity of water dedicated to fish and wildlife purposes [Section 3406 (b)(3)]
- Preparation of a PEIS analyzing the direct and indirect impacts and benefits of implementing the act [Section 3409]
- Development of a least-cost plan for increasing the yield of the CVP by the amount dedicated to fish and wildlife purposes to minimize adverse impacts, if any, upon existing CVP contractors and to assist the State of California in meeting its future water needs [Section 3408(j)]

Section 3408 (j) of the Central Valley Project Improvement Act (Title 34—PL 102-575)

Language of Section 3408 (j)

In order to minimize adverse effects, if any, upon existing Central Valley Project water contractors resulting from the dedication of water to fish and wildlife under this title, and to assist the State of California in meeting its future water needs, the Secretary shall, not later than 3 years after the date of enactment of this title, develop and submit to the Congress, a least-cost plan to increase, within 15 years after the date of enactment of this title, the yield of the Central Valley Project by the amount dedicated to fish and wildlife purposes under this title. The plan authorized by this subsection shall include, but shall not be limited to a description of how the Secretary intends to use the following options:

1. Improvements in, modifications of, or additions to the facilities and operations of the project
2. Conservation
3. Transfers
4. Conjunctive use
5. Purchase of water
6. Purchase and idling of agricultural land
7. Direct purchase of water rights

Such plan shall include recommendations on appropriate cost-sharing arrangements and shall be developed in a manner consistent with all applicable state and federal law.

Interpretation of the Language

- **...minimize adverse effects, if any, upon existing Central Valley Project water contractors:** The nature and the magnitude of adverse effects is being determined as part of the PEIS. Implementation of the Yield Increase Plan could serve to minimize any adverse effects.
- **... assist the State of California in meeting its future water needs:** Implementation of the Yield Increase Plan would also assist the state by narrowing the gap between future water needs and future water supplies.
- **Least-cost plan**: The least-cost set of yield increase options (supply increase and/or demand reduction) based on yield, costs, and environmental, social, institutional, and timing considerations, and how they may be used to meet potential yield increase needs.
- **...not later than 3 years after the date of the enactment of this title:** Yield Increase Plan submitted to Congress by October 1995.
- **Within 15 years after the date of enactment of this title:** Operational by October 2007.
- **Increase...the yield of the Central Valley Project:** Increase the existing supply of CVP water under drought conditions. In this Yield Increase Plan (reflecting the options specified in the law) demand reduction activities involving non-CVP water supplies were also considered for increasing CVP yield. Additional demand reduction may be available from within the CVP.
- **The amount [of yield] dedicated to fish and wildlife purposes under this title:** The 800,000 af dedicated in the act for fish and wildlife purposes, and a portion of the refuge water supply needs specified in the act.
- **Improvements in, modifications of, or additions to the facilities and operations of the project:** New or enlarged surface storage and conveyance facilities as well as modification to the operations of both CVP and non-CVP controlled streams through mechanisms such as spill management as well as changes in operational rules and conditions.
- **Conservation:** For agricultural water use, conservation is the reduction in the amount water that is lost to degraded bodies of water (degraded aquifers, saline sinks) or flows at quality levels that degrade bodies of water (such as occur on the west side of San Joaquin Valley and parts of the Tulare Basin). For urban use, conservation is the reduction in discretionary uses of water such as flushing toilets after every use and irrigating turf to maintain green landscape.
- **Transfers**: Voluntary water transactions.
- **Conjunctive use**: The storage of surface water in groundwater basins and the subsequent use of this stored water in place of or to supplement surface flows.
- **Purchase of water**: A subset of water transfers that involve buying water from a willing seller by means of an annual, multi-year, or permanent arrangement.
- **Purchase and idling of agricultural land**: Defined as land fallowing. Agricultural land could be temporarily or permanently removed from production, making the water otherwise used for crops available for other purposes.
- **Direct purchase of water rights**: A subset of water purchases that changes the holder of a water right. Results in permanent water transfer.
- **Cost-sharing arrangements:** Possible arrangements among the federal government, state government, local agencies (including federal and state water contractors), and private interests for sharing the cost of providing increased yield.

This report specifically addresses Section 3408(j). A least-cost plan is broadly defined as a plan in which all reasonable options, including supply increase and demand reduction, are assessed against an array of cost and social and environmental impact considerations. Key differences between this method of least-cost planning and earlier supply-focused methods of water resource planning are that demand-side management is given equal weight to the generation of new supplies and social and environmental impacts are given full consideration. In addition, the perspectives and viewpoints of various individuals and agencies affected by CVPIA are incorporated into the planning process. The language of the CVPIA makes clear that Congress intended this integration to be included in development of the *Least-Cost CVP Yield Increase Plan.*

Plan Development Process

The process followed in development of the Yield Increase Plan is shown in **Figure II-1**.

Preparation of the Yield Increase Plan was designed and conducted with broad public involvement and has included a series of public meetings, presentations, newsletters, and other announcements, as well as public participation in the review and refinement of information in this report.

The plan was prepared using five steps. They are:

- Identifying all water supply increase and demand reduction options potentially capable of increasing CVP yield
- Screening options to identify those to carry forward
- Developing detailed characterization of potential yield increase options
- Final screening of options to identify those to include in the Yield Increase Plan
- Presenting the *Least-Cost CVP Yield Increase Plan*

A least-cost plan is broadly defined as a plan in which all reasonable options, including supply increase and demand reduction, are assessed against an array of cost and impact considerations

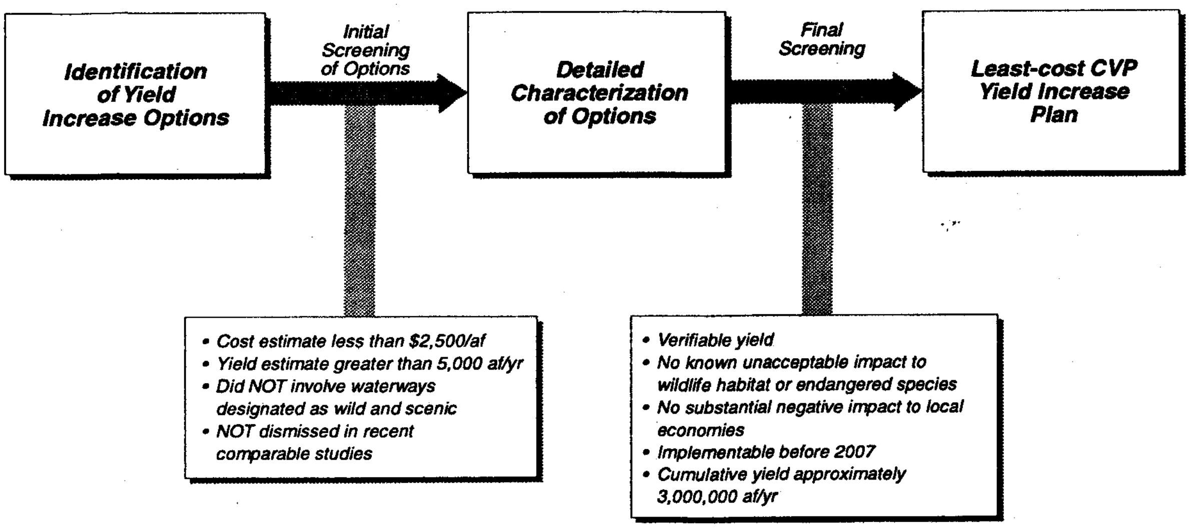


Figure II-1
Development of Least-Cost CVP Yield Increase Plan

Separate technical appendices have been written to provide a more detailed description of the methods than were used to estimate costs, yields, and impacts of the options that were considered for inclusion in the Yield Increase Plan. The technical appendices are:

- Economic Models
- Modified Operations
- Demand Management
- Conjunctive Use
- Urban Wastewater Reuse
- Surface Storage and Conveyance
- Weather Modification, Snowpack Management, Desalination and Water Importation
- Basin Models for Yield Increase Analysis
- Environmental Effects of Yield Increase Options
- Socioeconomic Effects

Identification of Yield Increase Options

Potential yield increase options were identified by reviewing available published reports; surveying water resource agencies; soliciting input from water districts, private developers, and the public; and conducting technical evaluation and limited field surveys. Initial estimates of yield, cost, and environmental impacts were made based on this available information.

The costs shown in this report represent the current annual cost for increasing CVP yield regardless of whether the federal government implements the physical option itself or purchases the water or water right from another entity

Screening of Options

Options were screened to identify those to carry forward for detailed characterization based on whether they meet the following criteria:

- Their yield was greater than 5,000 af/yr. Options that produce a smaller yield were considered impractical for inclusion in the Yield Increase Plan.
- Their annual cost was less than $2,500/af. A large number of options could be implemented for less than $2,500/af. It was not necessary to pursue more expensive options that would have a low probability of being implemented.
- They did not involve waterways designated as wild and scenic. Existing law prohibits development of these waterways.
- They had not been dismissed from further study in other recent and comparable studies. Options dismissed in other studies would have environmental, economic, or technical problems that make them impractical or infeasible.

Detailed Characterization of Options

The remaining options then were grouped into one of eight categories:

- Land fallowing
- Conservation
- Modifications of CVP/SWP operations
- Supplies from local water projects
- Conjunctive use

- Water reuse
- Surface storage and conveyance
- Other supply options

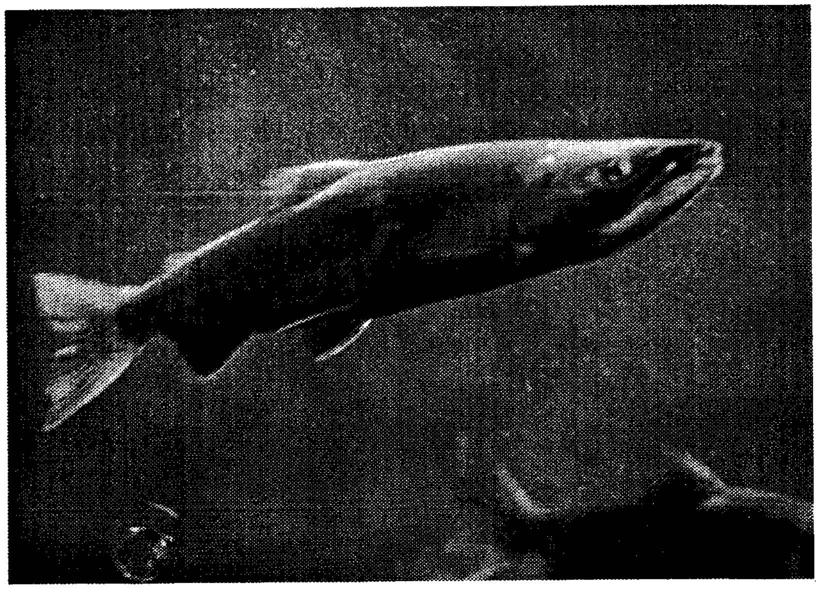
Transfers, purchase of water, and direct purchase of water rights are not considered yield increase options, but rather methods that can be used to convert an option that is implemented by others to increase CVP yield. For example, a water rights holder could fallow land and make the water that would have been used for irrigation available for transfer. This water could be purchased to increase the yield of the CVP. As another example, a private entrepreneur or agency could develop a new storage or conjunctive use facility and sell water for CVP yield increase.

The costs shown in this report represent the current annual cost for increasing CVP yield regardless of whether the federal government implements the physical option itself or purchases the water or water right from another entity.

The options were also located based on the agricultural region or hydrologic basin of their source. Yield increase options are not the same from region to region and basin to basin; an option that might be promising in one region/basin might not be technically feasible in another based on site-specific considerations such as geography, watershed characteristics, and soil conditions.

Attributes assessed as part of this detailed characterization included the following:

- **Cost:** Total capital cost amortized over the anticipated life of the project (assumed 8 percent interest rate) plus annual expenses, divided by the estimated yield.



- **Yield:** The amount of water made available annually during drought conditions.
- **Environmental Considerations:** The adverse or beneficial impact on the natural environment.
- **Social Considerations:** The adverse or beneficial impact on the local and regional economy.
- **Timing:** Time required for implementation of an option.
- **Institutional Issues:** Potential issues that could delay or prohibit implementation of an option.

The detailed characterization of these options is presented in Section III.

Final Screening

An appraisal-level final screening was applied to the options using the results of the detailed characterization. Options that pass this final screening will also be subject to additional screening in subsequent analyses and feasibility studies. Options were included in the Yield Increase Plan based on the following criteria:

- **Verifiable yield:** They provided a *verifiable* supply of water. Options that have speculative or unquantifiable yields and that include unproven technologies were not included.
- **Environmental Considerations:** They did not cause unacceptable adverse impacts on critical habitat or endangered species, or impacts are uncertain and require further study. Unacceptable adverse impacts are those considered unmitigable and contrary to the purposes of the CVPIA.
- **Social Considerations:** They did not produce substantial negative impacts on local or regional economies.
- **Timing:** They could be implemented before October 2007. This is a stipulation of the CVPIA.
- **Cumulative Yield:** They have a cumulative yield of approximately 3 million af. This cumulative yield is necessary to account for the possible effects of competition for water supply.

Least-Cost CVP Yield Increase Plan

Following this screening process the remaining options were arrayed on the basis of their cost and cumulative yield. The Yield Increase Plan is the lowest cost (including transportation cost) set of options that meets the yield increase needs and is available at the time of implementation. Other considerations addressed include physical means of conveyance that link options with potential need locations, issues related to water transfers, integration with CVP operations, and possible cost-sharing arrangements. The *Least-Cost CVP Yield Increase Plan* is presented in Section IV.

Section III
Detailed Characterization of Yield Increase Options

Following the initial screening, over one hundred options remained that are available to increase CVP yield. These options were grouped into eight categories for analysis and presentation. Where appropriate, the categories were further divided into subcategories.

- Land fallowing
- Conservation
  - Agricultural conservation
  - Urban conservation
- Modifications to CVP/SWP operations
- Supplies from local water projects
- Conjunctive use
  - Active recharge
  - Developable perennial yield
- Water reuse
  - Agricultural drainage reclamation
  - Urban wastewater reuse
- Surface storage and conveyance
  - Enlargement of existing storage
  - New onstream or offstream surface storage
  - New or extended conveyance
- Other supply options
  - Weather modification
  - Snowpack management
  - Desalination
  - Water importation

In This Section:

- Detailed discussion of eight potential yield-increase categories addressing:
  - Cost
  - Yield
  - Environmental considerations
  - Economic considerations
  - Timing
  - Institutional issues

The options are located geographically, based on either an agricultural region or a hydrologic basin. Agricultural regions are based upon groupings of the State Department of Water Resources' (DWR) Detailed Analysis Units. **Figure III-1** is a map showing these agricultural regions and hydrologic basins.

Information presented within this section includes cost, yield, socioeconomic, environmental, institutional, and timing considerations. Technical appendices have been prepared that include these analyses. The costs shown are capital costs, amortized over the life of the option assuming an 8 percent interest rate plus annual expenses, divided by the estimated yield. To the extent that potential environmental impacts could be identified, costs for mitigation were included in the cost estimate. Other factors affecting cost, such as mitigation for changes in power generation, will most likely have relatively small effects. These costs will be determined through subsequent analysis and feasibility studies. For those options that involve purchase of water, the cost information reflects current water

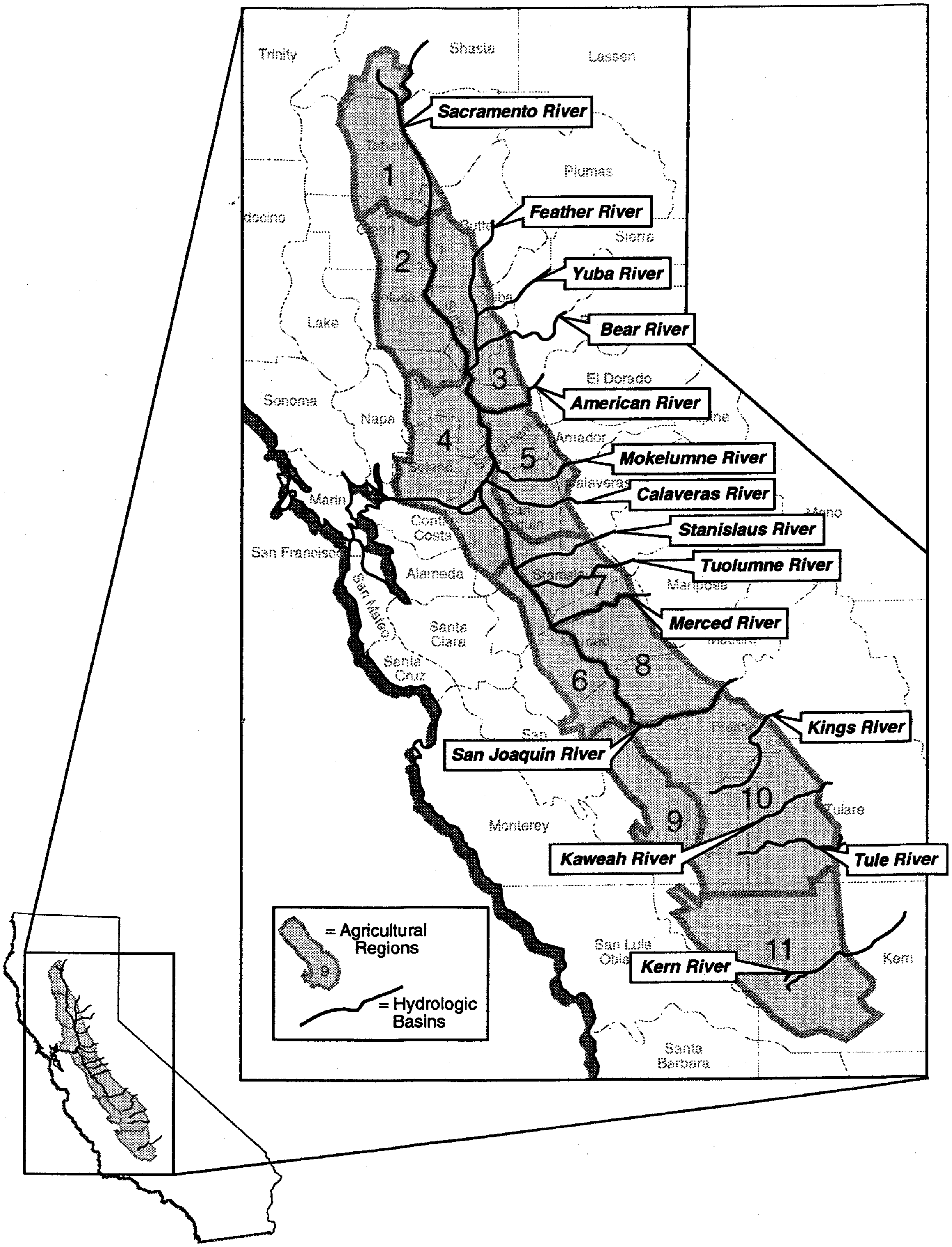


Figure III-1
Central Valley Agricultural Regions and Hydrologic Basins Used in the Development of the Least-Cost CVP Yield Increase Plan

supply and demand conditions and may be affected if higher levels of competition develop in the future. In addition, yield-increase options involving purchase of water activities assume willingness to sell under present market conditions at the costs indicated. Effects of competition on costs of water are discussed in Section IV.

Water banking concepts and the possible relationships between the categories presented and effects upon each other have not been analyzed. Such concepts and effects depend on site-specific characteristics that would be determined during further, more detailed investigations if Congress decides to authorize implementation of the Yield Increase Plan.

Analytical Tools Used in Developing the Yield Increase Plan

CVPM (Central Valley Production Model)

CVPM is a regional agricultural production and economic model that was originally developed by DWR. It simulates the decisions that Central Valley farmers make to maximize profit subject to resource, technical, and market constraints. CVPM has been updated and improved by Reclamation to include consideration of water transfers allowed by CVPIA. CVPM was used in this report to estimate the marginal value of water used in agricultural crop production and hence, the minimum price that agriculture would accept to sell different amounts of water that would be available from land fallowing.

LPTM (Linear Programming Transportation Model)

LPTM was developed for this report to determine optimum (least cost) scenarios for linking yield increase options with different locations and amounts of augmentation need. It includes transaction and transportation costs associated with moving water from one place to another.

IMPLAN (Impact Analysis Planning)

IMPLAN is a widely applied and accepted input-output model that estimates third-party economic impacts resulting from implementation of projects or actions. It was developed by the U.S. Forest Service. IMPLAN was used in this report to predict reduction in personal income and loss of jobs resulting from land fallowing.

TRIBSIM (Tributary Simulation Models)

TRIBSIM is a set of basin spreadsheet models developed for this report. It simulates operation of facilities on tributaries to the Sacramento and San Joaquin Rivers. TRIBSIM was used to estimate yields of new or enlarged surface storage facilities, local project reoperation, and conjunctive use sites.

PROSIM (Projects Simulation Model)

PROSIM was developed by Reclamation to simulate operation of the CVP and the SWP (in lesser detail). It was used in this report to estimate the potential yield of modified CVP/SWP operations and to provide water supply input data for CVPM. Input data files from PROSIM were used to provide basin hydrology for TRIBSIM.

SANJASM (San Joaquin Area Simulation Model)

SANJASM was developed by Reclamation to simulate the operation of facilities on the San Joaquin River. Input data files from SANJASM were used in this report to provide basin hydrology for TRIBSIM.

CVGSM (Central Valley Groundwater and Surface Water Model).

CVGSM was developed by Reclamation to evaluate groundwater conditions and groundwater/surface water interactions within the Central Valley. Input data files from CVGSM were used to identify location and hydraulic properties of potential conjunctive use sites.

Land Fallowing

Land fallowing is the complete or partial reduction in irrigation of cropland that would make consumptively used portions of applied water available for CVP yield-increase purposes. At present, approximately 20 million af of water is available for crop production in the Central Valley. Sources of this water include both groundwater and surface water supplied from the CVP, other federal facilities, the SWP, local water agencies, and private developments. Surface water supplies account for approximately 12 million af of the total available. The remainder is pumped from groundwater sources. Only the consumptively used portion of non-CVP contracted surface water supplies is considered potentially available for CVP yield-increase purposes. This amount is approximately 6 million af under drought conditions.

The federal government would implement the land fallowing option by contracting with growers or water purveyors to purchase a quantity of water currently used for irrigation

Fallowing options implemented on lands not irrigated with CVP-contracted water (lands supplied by local or SWP water) and subsequent transfer of the water to the CVP would not increase overall water supply in the state, but would decrease overall demand. Fallowing in this manner would increase yield of the CVP.

Also, under drought conditions there is approximately 1.5 million af of consumptively used CVP contracted surface water supply. Demand reduction could include fallowing of land irrigated with this water supply. While this does not increase CVP water supply, it would reduce CVP demand. CVP water contractors believe that this demand reduction from within the CVP is an inappropriate way to minimize adverse effects of dedicating water under the CVPIA. They perceive the impacts associated with fallowing land from within the CVP would be cumulative to those adverse impacts currently resulting from dedication of CVP yield to other purposes. At some future date, however, an individual CVP farm operator may choose to fallow land and sell water. This water may be available for purchase along with the non-CVP supplies.

The federal government would implement the land fallowing option by contracting with growers or water purveyors to purchase a quantity of water currently used for irrigation. In exchange the seller would agree to reduce crop consumptive use by an equal amount.

There are several important factors that should be considered.

- ❖ How frequently the water is needed
- ❖ Environmental considerations
- ❖ Social considerations
- ❖ Institutional issues

The implementation of fallowing options would depend on the frequency of need. Needs may occur under specific circumstances, such as a drought, or they may be constant from year-to-year. Therefore, to satisfy potential varying needs,

Consumptive Use of Applied Water and Associated Losses

Water resource planning and management makes an important distinction between consumptive use of applied water and losses incurred during the routing, delivery, and application of water intended for consumptive use. The report has defined the terms associated with the use of water in the following manner:

Consumptive use of applied water is water that is consumed during agricultural, municipal, and industrial production (i.e., consumption by crops and landscaping).

Conveyance loss is water that is lost during storage and delivery by natural processes such as reservoir and conveyance evaporation and stream/canal riparian vegetation consumption. Seepage associated with the conveyance has been excluded from this term and is instead included as part of the losses described below.

Associated loss is water that is lost as the result of inefficiencies in delivery and application that is not part of the aforementioned "conveyance loss" (i.e., deep percolation and surface runoff of applied water, conveyance system seepage, canal spillage, and gate leakage). There are two subsets of these associated losses:

- **Recoverable loss** is water that returns to the hydrologic system in a usable form. This water may return to supply sources by percolating deep into the soil to recharge groundwater basins or by running off into rivers and streams, or it may be used after its initial application by an immediate downstream user or to sustain a downstream habitat.
- **Irretrievable loss** is water that becomes unusable. Examples include percolation or surface runoff to poor-quality perched groundwater, salt sinks, or water that is high in undesirable constituents. It is currently infeasible or too costly to recover this water for use.

For purposes of this report, **consumptive use of applied water** may be sold, and the potential for yield increase from this source is assessed as part of the Land Fallowing discussion in Section III.

Losses associated with conveyance loss and irretrievable loss may be reduced and the net savings may be sold. The potential for yield increase in this regard is assessed as part of the Conservation discussion in Section III of this report.

In general, water associated with **recoverable losses** is not considered a potential yield increase option in this report because its conservation does not expand the total water supply. Conserving recoverable losses may provide other energy- or water quality-related benefits, however, because water associated with these losses may be degraded (by picking up leached salts, nutrients, or other chemicals) or may lose potential energy (by flowing downward to the water table).

fallowing could either be temporary or permanent. Temporary fallowing would idle land only when needed and would most likely use short-term lease or dry-year options contracts.

Permanent land fallowing would be necessary to provide a more consistent supply of water regardless of the water year type.

Either way, the seller could generate that water through increased rotational fallowing, long-term fallowing of certain parcels, or changing the mix of crops grown.

Rotational land fallowing spreads the occurrence of fallowing around a landowner's property or around an entire district or region. For example, a landowner may choose to increase fallowed acreage slightly above the level fallowed under current operations (acreage set-aside programs, crop rotations, or land/soil management). Annual or biennial rotation of fallowed acreage throughout a particular set of fields allows a landowner's entire operation to remain in production but at slightly decreased rates. A further expansion of this example would be the rotation of fallowed lands among several landowners within a given area, not allowing the same landowners to participate every year (such an activity may need to be administered by a water district or other local agency). Rotational fallowing tends to maintain the current number of producing landowners within a particular area, while slightly reducing production.

Willing sellers can also choose to fallow certain parcels on a long-term basis. Long-term fallowing does not necessarily prohibit dry land farming or the establishment of permanent wildlife habitat. Rather, irrigation water is withheld from these lands. Long-term fallowing may result in an actual reduction in the number of actively producing landowners, as well as a reduction in levels of regional agricultural activity.

Modified cropping is a third way of generating water to sell under the land fallowing option. A crop with high consumptive use (such as irrigated pasture) is replaced with a crop using less water (such as grain or safflower). The reduced consumptive use is available for sale to the CVP. Modified cropping is limited by agronomic and market conditions.

Modified cropping is a third way of generating water to sell under the land fallowing option

Table III-1 lists the cost and yield estimates associated with land fallowing of irrigated agriculture in the Central Valley. As indicated in the table, four levels of land fallowing were analyzed. Each level represents an increment of 5 percent of a region's non-CVP surface water supply (non-CVP includes water associated with SWP, local, and CVP settlement/exchange supplies) used in crop production. The incremental values shown reflect only the consumptive use portion of these available surface supplies.

Level 4 land fallowing was used as a maximum for purposes of analysis, and is consistent with the general guidelines set by Congress in Section 3405(e) of the CVPIA, yet it still allows for substantial water purchases. Values shown represent yield and cost estimates at the location of the fallowing (source). Conveyance losses and various costs of transporting water are not shown in these values but are included in the overall comparison of options. Transport costs are discussed in Section IV. Quantities of water that would be available through fallowing were estimated incrementally in four levels. Use of the four increments shows how the value of the water remaining in a region increases as available supplies diminish. The increments are treated as individual options and compared with other yield-increase options in the development of the Yield Increase Plan. Actual fallowing could occur in various quantities and not necessarily in these increments.

Costs shown in the table are estimates of the value of water where land fallowing would occur and reflect anticipated, near-term market conditions. The estimates consider commodity demands, irrigation

Table III-1
Land Fallowing
Yield Increase Options

Activity	Annual[a] Yield (1,000 af)	Cost[b] at Source ($/af)	Activity	Annual[a] Yield (1,000 af)	Cost[b] at Source ($/af)
Region 1			**Region 2**		
Level 1[c]	10	55-80	Level 1	33	60-90
Level 2	10	60-90	Level 2	33	75-110
Level 3	10	65-95	Level 3	33	85-130
Level 4	10	65-100	Level 4	33	100-145
Region 3			**Region 4**		
Level 1	47	55-85	Level 1	47	60-95
Level 2	47	65-95	Level 2	47	80-120
Level 3	47	75-110	Level 3	47	95-145
Level 4	47	85-125	Level 4	47	110-165
Region 5			**Region 6**		
Level 1	15	65-95	Level 1	23	55-80
Level 2	15	70-110	Level 2	23	60-95
Level 3	15	80-120	Level 3	23	75-110
Level 4	15	85-130	Level 4	23	85-130
Region 7			**Region 8**		
Level 1	45	55-80	Level 1	23	60-85
Level 2	45	70-105	Level 2	23	65-100
Level 3	45	85-130	Level 3	23	75-110
Level 4	45	100-150	Level 4	23	85-125
Region 9			**Region 10**		
			Level 1	39	70-105
none identified			Level 2	39	75-110
			Level 3	39	80-120
			Level 4	39	85-130
Region 11					
Level 1	27	135-205			
Level 2	27	145-215			
Level 3	27	155-235			
Level 4	27	170-255			

a) Annual yield increases represent the consumptive use portion of estimated non-CVP surface water supply after potential Bay/Delta and dedicated water needs are met. An additional 300,000 af of demand reduction through land fallowing may be available from within the CVP.

b) The range of costs shown reflect: 1) the variation in the value of water used for irrigation on different crops, and in different areas; 2) difference among potential sellers in their willingness to sell water; and 3) variations in the transferable fraction of water purchased. Individual situations may fall outside the ranges of costs shown.

c) Each level represents a 5 percent increment of consumptively used non-CVP surface water supply.

improvements, and constraints involving land and water availability, crop rotations, and other legal, physical, and economic limitations.

The range of values reflects the variation in the value of irrigation water to different crops in different areas, as well as the difference in sellers' willingness to sell. Individual situations may fall outside the range of costs shown. In addition, future levels of competition for water may further affect cost. Effects of competition are discussed in Section IV.

Values were developed using the Central Valley Production Model (CVPM), which estimates the marginal value of water used in agricultural crop production. The costs depict the annual value of water associated with agricultural production and are not specific to how land fallowing is implemented (rotational, long-term, or crop changes). Actual prices would be negotiated on an individual basis and might vary from those shown due to variations in willingness to sell water and in specific terms of fallowing contracts.

As a test of whether CVPM estimates are reasonably consistent with recent water market experience, the state's 1991 drought water bank was simulated with the model. At the state's offer price of $125 per af, the model estimated that land fallowing would generate about 320,000 af in sales to the Bank. Actual sales from land fallowing were about 420,000 af. Under these simulated conditions CVPM appears to give a consistent and somewhat conservative estimate of water sales at a given price.

The cost of water increases as surface water supplies decrease within a region—a higher value reflecting diminished availability

As **Table III-1** shows, annual yield estimates associated with land fallowing depend on the location within the Central Valley and the non-CVP surface water supplies available to that region. In addition, the cost of water increases as surface water supplies decrease within a region—a higher value reflecting diminished availability and the fact that remaining surface water is used for the remaining higher value crops and purposes. No values are shown for Region 9 because its surface water supply is entirely CVP.

Results of the CVPM indicate the lowest cost water was from land growing lower-value crops. Lower-value crops, however, are essential in the management practices of many agricultural producers and should not be the entire focus of land fallowing. For example, lower-value crops tend to be used as rotational crops to help revitalize soils or are planted as part of minimum production requirements specified under commodity contracts. In addition, some crops with low revenue per acre are also low-water-use crops, and a relative increase in these crops may occur as surface water supplies decline in a region. Value refers to the value per unit of water and not necessarily per unit of land.

In some instances, there may be additional reasons for fallowing particular lands, as is the case of lands affected by drainage problems. Drainage-affected land is characterized by shallow groundwater (less than 10 feet below surface), poor vertical movement of water through the soil, and salt accumulation in the soil. In many instances, poor-quality drainage water contributes to the water quality problems of existing sloughs and surface discharge areas (evaporation ponds) and is the focus of other agency programs. For example, the federal government currently has a program in place and funded under the CVPIA to assess the purchase and retirement of drainage-affected lands within the CVP service area for water conservation and water quality purposes (Section 3408(h)). Land fallowing for yield-increase purposes could focus on similar lands outside the CVP service area.

Environmental Considerations

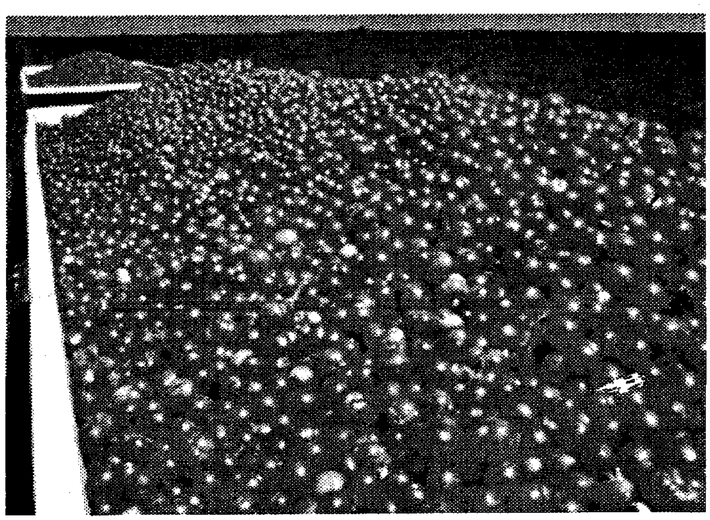
Both negative and positive environmental impacts could result from land fallowing activities.

Potential positive impacts resulting from land fallowing could include increased wildlife habitat, if permanently fallowed lands were appropriately restored or managed as habitat (this may also require small amounts of water allocation), and increased instream flows favorable to fish habitat. The latter may occur as the result of upstream diverters allowing their water to remain in streams and rivers for downstream diversion. Long-term management of fallowed lands may require additional federal action and funding.

Other potential positive impacts include water quality improvements, establishment of wildlife corridors connecting disjointed existing habitat areas, establishment of rare or declining types of habitat on fallowed lands, and the ability to establish setback levees to allow meanders on rivers for enhanced riparian and riverine habitat. A key item to note is that, under current Endangered Species Act interpretation, land that is fallowed (no crops are grown, including dry land crops) for a period longer than 3 years may be considered as habitat. Permitting may be required to return such land to production.

Potential positive impacts resulting from land fallowing could include increased wildlife habitat

Potential negative impacts resulting from land fallowing could include the loss of valuable habitat associated with irrigated agriculture. For example, in the Sacramento Valley, conveyance facilities used to deliver water to rice fields and associated wetlands provide habitat to several special-status species. In addition, during fall and winter months, rice fields are often managed to provide habitat for migratory and resident waterfowl, shorebirds, and other wildlife. Management of fallowed lands, especially when fallowing is temporary, may include leaving soils relatively barren or only with the residue from the last crop. Such management methods may have a less positive impact on habitat than would permanently fallowed lands.



If vegetative cover is not adequately maintained soil erosion and potential overpopulation by undesirable plant species such as non-native plant species or species that host insects and/or disease or that may invade neighboring fields can occur. In addition, concern has been expressed that fallowed land could be sold for urban development or for industrial purposes, further reducing local wildlife habitat.

Environmental effects relating to retirement of drainage-affected lands may include the reduction in the quantity of drain water produced, thereby reducing contaminant loading to receiving waters. However, contaminants could migrate upward, affecting the quality of the soil and limiting its use as habitat, or concentrations of contaminants may increase in remaining drain water because of lesser amounts of water available to dilute the loading. As with other potential impacts, determination would need to be on a site-specific basis.

The potential social impacts of land fallowing exceed those of any other option because of the possibility of negative effects on local economies. Many businesses and governments in rural areas depend on the expenditures of local growers and farm-related businesses

Social Considerations

The potential social impacts of land fallowing exceed those of any other option because of the possibility of negative effects on local economies. Many businesses and governments in rural areas depend on the expenditures of local growers and farm-related businesses. Land fallowing eliminates this local expenditure. On the other hand, part of the revenue from the sale of water may be re-spent in the local community. This spending reduces the overall negative impact of fallowing land but does not necessarily result in the same distribution of regional income.

Agricultural labor losses are not recovered if the grower spends the receipts from water sales out of the local region or on non-farm related purchases. This potential pattern of spending has resulted in conflicts among local interest as reported by RAND's study of California's 1991 drought water bank. This study found no economic impact in counties selling water, but concluded that water sales caused "divisiveness in the local community."

Economic impacts of land fallowing have been estimated using IMPLAN, a regional economic impact model. These impacts are summarized on **Table III-2**. The net local impact (income lost at the source location due to land fallowing offset by income gained from the sale of water at the source location) resulting from the Level 2 transfer of non-CVP surface water supply is estimated to cause a statewide total loss of $57 million in personal income and 2,664 jobs at locations from which the water is being transferred. Level 2 non-CVP surface water supply in the Central Valley under drought conditions would be associated with fallowing of approximately 195,000 acres, with a reduction of $57 million in personal income.

Level 4 transfer of non-CVP surface water supply will fallow approximately 395,000 acres and cause a $93 million reduction in personal income and a loss of 3,445 jobs. The job loss estimate includes a 24,682 loss because of reduced agricultural production and a 21,237

Table III-2 Summary of Land Fallowing and Its Impacts				
	Land Fallowed (acres)	Water Purchased (af)	Local Personal Income Lost	Local Number of Jobs Lost
Level 2	195,000	600,000	$57 million	2,664
Level 4	395,000	1,200,000	$93 million	3,445

gain from the portion of water revenue spent within the region.

These impacts could be mitigated by emphasizing diffuse versus concentrated fallowing, by targeting farmland that has minimal impact on small communities, and by targeting crops that are not labor intensive. It should be noted that these are estimates of changes in economic activity caused by the sale of the water only. The economic activity resulting from use of the purchased water (i.e., in areas that lose water to dedication) has not been estimated.

Social Impact Perspective

To put these figures in perspective, three comparisons are presented.

- Calculations of the total personal income reduction (estimated from IMPLAN) as a percentage of the total personal income in Central Valley counties.
- Comparison to results of a similar analysis of land fallowing in the state's 1991 drought water bank.
- Comparison to the amount of fallowing, associated with Level 4 reduction in non-CVP surface water supply to the fallowing that has occurred recently due to acreage reduction provisions of commodity programs.

Comparison with Total Personal Income

A common method for judging the possible significance of a change in economic performance is to measure the change as a percent of the total. The net change in farm revenue was used in IMPLAN to estimate total (direct plus secondary) changes in personal income caused by land fallowing. The analysis (summarized above) estimated a net loss of $93 million in annual personal income valley-wide from Level 4 fallowing.

The 1991 personal income of the 18 most important counties in the Central Valley (predominantly foothill and mountain counties such as Placer and Amador were excluded) was $81.85 billion . Therefore, a $93 million loss in personal income represents a change of about 0.11 percent. Even excluding largely urban Sacramento County from the total, the change amounts to less than 0.2 percent.

Assessing impacts to individual regions is more difficult. The Central Valley is a regional economy with economic linkages extending far beyond individual regions or counties. Also, the agricultural regions used for analysis correspond to groupings of DWR's hydrologic analysis units (which do not follow county lines), whereas personal income data are available at the county level. Nevertheless, a rough approximation can be made by comparing the personal income loss in agricultural regions 6, 7, and 8 (see **Figure III-1**) with data for Madera, Merced, and Stanislaus counties. Personal income for these counties in 1991 totaled about $9.64 billion. Net loss in personal income from Level 4 fallowing is estimated from IMPLAN to be $18 million ($83 million loss offset by a $65 million gain), or 0.2 percent.

The apparently minor net impact obscures a substantial redistribution of spending and income among sectors. Localized impacts on certain communities dependent upon agricultural production and processing could potentially be significant. A more site-specific analysis would be appropriate to assess extremely localized impacts.

Localized impacts on certain communities dependent upon agricultural production and processing could potentially be significant

Comparison with 1991 Drought Water Bank

In 1991, the state's drought water bank fallowed land to obtain about 420,000 af of transferable water. Howitt, Moore and Smith in "A Retrospective in California's Emergency Drought Water Bank" estimated personal income losses by county. For five counties (Sacramento, San Joaquin, Shasta, Solano and Stanislaus) which used only or practically only land fallow to transfer water, average reported personal income loss ranged from $77 to $388 and averaged $301 per acre. Our estimated loss per acre is $292 and $235 at Level 2 and Level 4 fallowing, respectively. This study indicates that even though impacts measured by personal income changes were modest, transfers nevertheless created divisiveness in local communities.

Comparison with Commodity Programs

Farm programs have also required large amounts of fallowing in the past. Participation in United States Department of Agriculture (USDA) farm commodity programs requires that a farmer comply with acreage reduction provisions. In return for receiving deficiency payments and other subsidies, farmers must also hold a percent of their participating acreage fallow. This percent, called the Acreage Reduction Percent (ARP) (also known as "set-aside") is set annually by USDA for each of the program commodities. Over the last 10 years it has ranged from 35 percent for rice acreage in 1987 to 0 percent for many commodities more recently. Major California crops subject to the ARPs are rice, cotton, corn, wheat, sorghum and barley.

Based on estimates of eligible acreage, participation rates, and ARPs provided by the Agricultural Stabilization and Conservation Service, land fallowed in the Central Valley due to ARPs averaged about 550,000 acres per year from 1985-1989. Changes in the 1990 Farm Bill and recent market conditions have reduced the need for such large ARPs in recent years. Land set aside in the Central Valley due to ARPs averaged only around 120,000 acres per year from 1991 to 1993. Therefore, the 395,000 acres idled under Level 4 fallowing is within the variation caused by ARP provisions of the farm programs. Again, fallowing in particular counties may exceed amounts that have been observed historically. Note also that fallowing for CVP yield increase would be in addition to the normal reduction in acreage due to drought and farm programs.

Social Impact Summary

In summary, implementing land fallowing in the range of Level 2 to Level 4 would cause a relatively small percentage reduction in local personal income, and is within the range of fallowing that results from the USDA Farm Commodity Program. Potential impacts can be mitigated through temporary, rotational, and diffuse land fallowing or by implementing only Levels 1 and 2. Because of the concern over potential social and economic impacts and local community divisiveness, however, land fallowing should only be implemented with full local partnerships.

Institutional Issues

Land fallowing represents a near-term CVP yield-increase option because it does not involve the construction of major facilities. Land fallowing, however, may encounter institutional difficulties.

Potentially significant issues could develop with state and local governments and water agencies regarding coordination of facility operations and water release schedules. Some local governments are also attempting to place restrictions and taxes on water transferred. For example, Yolo County is attempting to pass ordinances restricting the sale of any surface water outside of county boundaries.

Another institutional issue related to land fallowing is the potential for groundwater substitution. CVPIA and Reclamation Water Transfer Guidelines specify that, in the context of land fallowing, only water associated with consumptive use may be made available for transfer (water associated with other irretrievable losses is covered under *Conservation*). The long-term substitution of groundwater to replace surface water may not be allowed because of potential adverse impacts to the groundwater basin and associated water balance conditions with local rivers and streams.

Because of the concern over potential social and economic impacts and local community divisiveness, however, land fallowing should only be implemented with full local partnerships

Butte, Sutter, Tehama, and possibly other counties have passed ordinances requiring county approval of transfers of groundwater. San Joaquin County is considering such an ordinance. The California Water Code (Section 1220) similarly limits transfers of groundwater and may apply to surface water transfers when the transferred water is replaced with groundwater. Section 1011.5 of the Water Code places additional limits on these groundwater/surface water exchanges.

If, however, a demonstration of no significant impacts to the underlying groundwater basin is made, then groundwater substitution could be allowed. Substitution of groundwater from an overdrafted groundwater basin would be prohibited unless, perhaps, the water was previously recharged as part of an active groundwater recharge program (see *Conjunctive Use*).

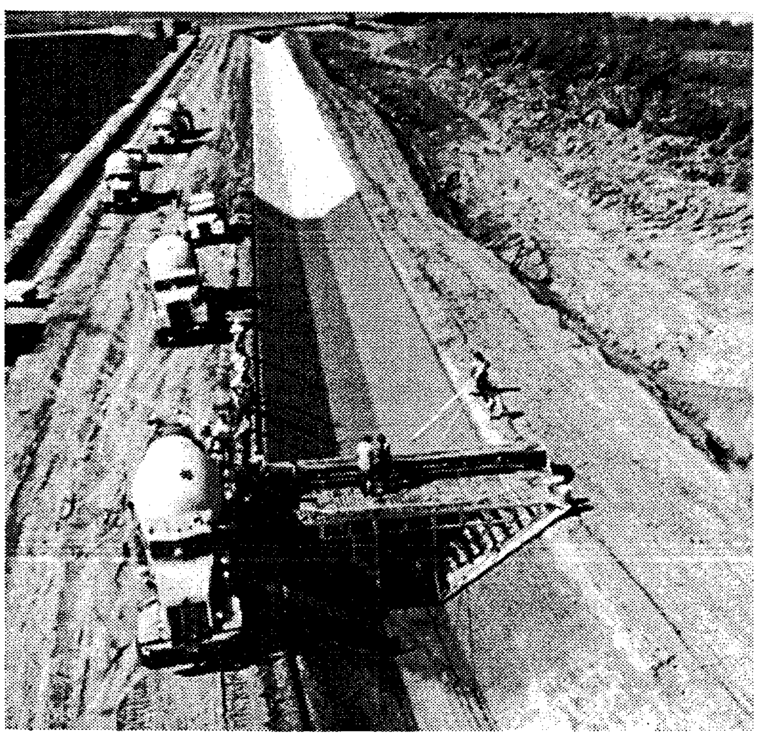
It is anticipated that purchase of water from land fallowing will require additional feasibility investigations, environmental documentation, permitting, and funding authorization. Total time required for implementation is estimated to be 6 years.

Conservation

Yield-increase potential may be realized through implementation of conservation activities. Two categories are presented here:

- Agricultural conservation
- Urban conservation

Estimates of yield-increase potential for these categories are based on extrapolations of data used in the development of the California Water Plan Update. Estimates for agricultural conservation are based on projected savings in conveyance loss (water lost in delivery by natural processes) and irretrievable losses (water that flows to degraded bodies of water). Estimates of urban conservation potential are based on projected decreases in the discretionary uses of water such as irrigation of turf to maintain green landscapes.



The implementation of conservation activities within CVP contractor lands was only allowed where non-CVP contracted water supplies are also used. Conservation of these supplies would be used to increase CVP yield. In addition, as with other yield-increase options, willing participants would be paid to implement certain activities.

Agricultural Conservation

Agricultural conservation focuses on improving the delivery and application of water in agricultural uses. Activities include:

- Agricultural water management
- Canal lining

Table III-2a lists costs and yield increase estimates associated with these activities.

Agricultural Water Management. Water management practices focus on reducing losses of irrigation water by improving the uniformity of its application and efficiency of its use and/or the timing and method of its delivery. Practices include improvements in:

- Irrigation management (improved irrigation scheduling, improved system maintenance, and education of irrigators)
- Irrigation system selection (switching to more efficient methods or better-performing hardware for water application)
- On-farm ditch lining and piping to minimize seepage and evaporation losses on the field

Table III-2a
Conservation
Yield Increase Options
Agricultural Conservation

Activity	Annual Yield (1,000 af)	Cost at Source ($/af)
Region 1		
none identified		
Region 2		
none identified		
Region 3		
none identified		
Region 4		
none identified		
Region 5		
none identified		
Region 6		
Group (2)	5	200
Group (3)	45	500
Canal Lining	15	160
Region 7		
Group (3)	15	500
Region 8		
Group (3)	20	500
Region 9		
none included		
Region 10		
Group (2)	5	200
Group (3)	95	500
Canal Lining	20	160
Region 11		
Group (2)	25	200
Group (3)	55	500
Canal Lining	5	160

- Irrigation delivery (increased flexibility in the frequency, rate, and duration of water delivery by the district to allow improved management and methods by growers)
- Farm delivery measurement and reporting systems to provide better management information to growers to help them evaluate their irrigation practices and facilitate scheduling

Many of these practices are interdependent. For example, irrigation scheduling cannot be used effectively with an inflexible delivery system. Moreover, some practices can be implemented at both the on-farm and district levels. On-farm improvements involve changes in the way water is applied on the field; district level improvements principally involve changes in the way water is delivered to the field.

As shown in **Table III-2a,** agricultural water management encompasses ways in which current practices can be improved and is divided into three groups:

❖ Group 1 improvements are those that can be accomplished for approximately $100 per af annually. Examples include simple changes in on-farm water management techniques, such as more closely monitoring applications, replacing worn sprinkler nozzles, and installing tailwater recycling systems, and district-level education programs and incentives.

Obtaining the yields indicated will require efficiency improvements throughout each region

❖ Group 2 improvements are those that can be accomplished for approximately $200 per af annually. Examples include on-farm hardware improvements in irrigation systems and more intense application and recovery/recycling activities achieved, for example, through computerization and the hiring of full-time irrigation managers and district level irrigation experts.

❖ Group 3 improvements are those that can be accomplished for approximately $500+ per af annually. This group also assumes 90 percent efficiency throughout an entire region with high uniformity of application. Examples include major improvements in district delivery systems such as the installation of automated canals that can rapidly respond to changes in irrigation demand (interceptor canals, regulating reservoirs, and automated control gates).

Costs shown include construction and operation and maintenance estimates as well as potential mitigation measures.

The possibility of yield increases resulting from agricultural conservation is not shown to exist in Regions 1, 2, 3, 4, and 5. Water lost in these regions is considered recoverable and typically goes back into groundwater or streams for subsequent potential use by others, and does not result in yield increase. Conserving recoverable losses may provide other energy or water quality-related benefits, but is not considered for CVP yield-increase purposes.

Annual yield estimates listed in the table were inferred from on-farm water loss relationships developed for the west side of the San Joaquin Valley. Obtaining those yields will require efficiency improvements throughout each region (that is, all irrigation systems must have high levels of uniformity and efficiency); however, in some regions all improvements may not be feasible. As a consequence, quantities shown represent a theoretical upper limit that may not be fully achievable.

As the table reflects, the potential for yield increases attributable to improvements in agricultural water management practices increases with dollar outlay, with the greatest potential at the Group 3 level and the least potential at the Group 1 level. This is attributable in large part to the fact that the more feasible, less expensive improvements have, for the most part, already been implemented by the grower or district. Yield estimates for each group are independent and additive.

Environmental impacts associated with agricultural water management likely would be minimal, and felt principally as a result of reductions in surface runoffs and percolation to groundwater. The significance of any impact would vary from site to site and would need to be evaluated for each individual case. For example, reduced runoff may reduce groundwater recharge and wetland and riparian areas created by, or dependent on, runoff. This in turn would reduce emergent vegetation and aquatic and wetland habitat, and vegetation in drainage ditches. In addition, reduced percolation could add to groundwater overdraft in some areas.

Impacts could be mitigated by restoring area wetlands and managing them for wildlife.

Social benefits could result from the purchase of the new supplies and equipment required to improve system efficiency and with the attendant increase in jobs for construction and implementation of these improvements. In addition, improvements in water conservation and management in the agricultural sector would benefit relationships with other water users such as environmental and urban interests.

Some options, such as farm delivery measurement and hiring of district level irrigation experts, could be implemented quickly. However, it is anticipated that implementation of agricultural water management options will require additional feasibility investigation, environmental documentation and permitting, funding authorizations, and advanced planning, design, and construction (when applicable). The total time required for implementation is estimated to be 10 years.

Canal Lining. This activity would line presently unlined earthen canals and regulating reservoirs with concrete or another impermeable material, or replace earthen canal facilities with pipes, to limit or eliminate water seepage to unusable groundwater sources during delivery.

Less expensive improvements have, for the most part, already been implemented by the grower or district

Costs are low relative to other options, but the yield potential is small, reflecting the fact that in many cases steps have already been taken to minimize seepage loss where this is cost-effective. Additionally, many regions currently use unlined canals to recharge groundwater basins. This is especially prevalent on the east side of the San Joaquin River and in the Tulare Basin.

Annual yield estimates reflect recovery of water associated with irretrievable losses only. As a result, no yield is available from Regions 1, 2, 3, 4, 5, 7, and 8 (primarily in the Sacramento Valley and areas along the eastern side of the San Joaquin Valley where seepage was assumed to add to groundwater recharge). It was assumed that a maximum of 90 percent of the estimated seepage was available for recovery. This estimate recognizes that, even with lining, some fraction of the water will seep.

The assumption also was made that lining could be preferred over piping because lining is less expensive. However, piping is economical in some smaller applications. Piping also would eliminate loss to evaporation, but this is a smaller component than seepage and does not, in itself, represent large, cost-effective savings.

The primary environmental impact of canal lining could be permanent loss of in-channel and bank vegetation. This loss would remove habitat for dependent wildlife, increase water temperature and rates of evaporation, increase mortality (drowning occurrences) of wildlife by creating an unnatural surface that inhibits escape from canals, inhibit wildlife migration, and reduce seepage that recharges adjacent wetlands. In addition, during construction activities, native vegetation might be removed, possibly allowing non-native plant species to dominate the reestablished community. However, the potential exists for reestablishing this habitat using less water (by directly irrigating) than occurred through seepage.

The residential sector offers the greatest potential for long-term urban water conservation

Social benefits would include the creation of new jobs for construction and implementation of these improvements.

It is anticipated that implementation of canal lining options will require a similar amount of time as shown with agriculture water management.

Urban Conservation

Urban conservation focuses on reducing short- and long-term per capita urban water demand. Because a large percentage of total urban demand is considered a "recoverable loss," meaning it returns to the hydrologic system after treatment, conservation of urban demand may not always result in actual yield increases.

Conservation estimates were developed for the 11 agricultural regions used in this study as well as for the North and South Bay Aqueducts, Contra Costa Water District, and San Felipe Division. These latter areas were included because, although they currently receive a portion of their water from CVP contracts, they receive water from other sources as well. Conservation of these other sources would be used to increase CVP yield. Principal urban locations within the Central Valley include Redding, Sacramento, Stockton, Modesto, Fresno, and Bakersfield.

Table III-2b lists costs and yield increase estimates associated with urban conservation.

Because the residential sector offers the greatest potential for long-term urban water conservation, estimates for this sector only are shown. In 1990, residential water demand averaged 58 percent of total urban use statewide. Residential water demand averaged about 134 gallons per capita day in California with indoor uses (showers, toilets, cleaning, etc.) accounting for 80 gallons per capita day. Outdoor demands (landscaping and washing cars) vary significantly depending on climate and population density and can account for up to 60 percent of total residential water demand.

Table III-2b
Conservation
Yield Increase Options
Urban Conservation

Activity	Annual Yield (1,000 af)	Cost at Source ($/af)	Activity	Annual Yield (1,000 af)	Cost at Source ($/af)
Region 1			**Region 2**		
Residential (in/outdoor)	15	315-390	Residential (in/outdoor)	15	315-390
Region 3			**Region 4**		
Residential (in/outdoor)	50	315-390	Residential (in/outdoor)	20	315-390
Region 5			**Region 6**		
Residential (in/outdoor)	30	315-390	Residential (in/outdoor)	5	315-390
Region 7			**Region 8**		
Residential (in/outdoor)	25	315-390	Residential (in/outdoor)	25	315-390
Region 9			**Region 10**		
Residential (in/outdoor)	none identified		Residential (in/outdoor)	55	315-390
Region 11			**North Bay Aqueduct**		
Residential (in/outdoor)	30	315-390	Residential (in/outdoor)	10	315-390
Contra Costa W.D.			**South Bay Aqueduct**		
Residential (in/outdoor)	10	315-390	Residential (in/outdoor)	10	315-390
San Felipe Division					
Residential (in/outdoor)	10	315-390			

Cost estimates in this table were developed assuming adoption of strict landscape management practices such as xeriscaping and installation of ultra-low flush toilets, as well as other Best Management Practices (BMPs) considered implementable on a long-term basis by the State of California.

Short-term drought management relies more extensively on temporary habit changes and discretionary uses of water. Theoretically, if extensive long-term conservation is implemented, the potential for short-term drought management is reduced because some of the waste or "slack" has been eliminated.

Urban conservation options are often seen as potential ways of increasing or stretching water supplies within the area or region in which they are identified. However, because most urban areas have an increasing demand and water is more valuable to them than the income it might bring on the market if sold, they are generally reluctant to implement conservation measures solely for the purpose of making water available for sale outside their area. In other words, the financial gain from the sale of water may not offset the loss of that source of water to their communities.

Environmental benefits of urban conservation include reduced pumping of source water and possibly reduced amounts of wastewater outflow (this can affect reuse opportunities), and generally can be expected to outweigh any adverse effects on urban wildlife. However, reductions in green landscape may have adverse effects on urban wildlife.

Reduced green landscape areas may be considered an aesthetic impact, at least until people accept the visual changes. An additional consideration is that conservation may limit an area's ability to stretch limited supply in drought years because of reduced "slack" in the system, thereby increasing the frequency of mandatory conservation measures during severe drought periods.

The financial gain from the sale of water may not offset the loss of that source of water to a community

Social benefits would include creation of new jobs for construction and implementation of conservation measures.

Laws and agreements exist to facilitate implementation of urban conservation. For example, cities in California are required to institute BMPs to achieve greater water use efficiency and decrease per capita consumption. By 1994 more than 180 water agencies and other groups had signed a Memorandum of Understanding Regarding Urban Water Conservation in California committing them to implement these practices by 2001. The extent to which implementation of these practices will reduce the yield-increase potential of this option is unknown.

It is anticipated that implementation of urban conservation options will require additional feasibility investigation, environmental documentation and permitting, funding authorizations, and advanced planning, design, and construction (when applicable). The total time required for implementation is estimated to be 10 years.

Modifications to CVP/SWP Operations

Modifications in water management operations of CVP and SWP facilities can increase CVP yield without structural modifications or construction of new facilities. Modified operations, for the purpose of yield increase, involve changes in operating criteria that allow greater amounts of water to be delivered to water users while at the same time protecting other CVP objectives such as fish and wildlife enhancement and flood control.

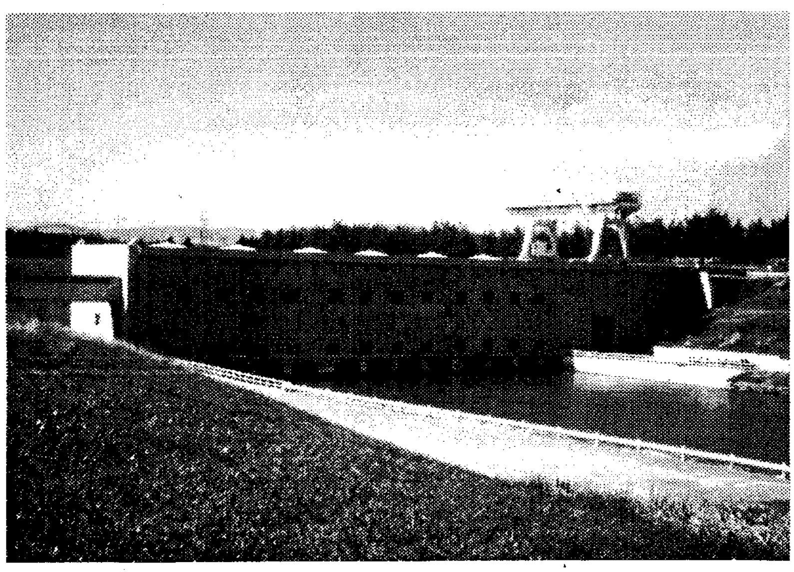
The activities presented in this category are all part of ongoing efforts of Reclamation and the state, as well as other organizations, to continually increase the efficiency of the CVP. Undoubtedly, these activities, to the extent feasible under ever-changing operating criteria, would be implemented regardless of this Yield Increase Plan.

Modifications to CVP and SWP water management operations involve changes in policies and agreements that regulate water deliveries from Shasta and Folsom lakes on the Sacramento and American rivers (CVP facilities), and Oroville Lake on the Feather River (a SWP facility), to control Delta water quality and maintain minimum water storage levels in reservoirs. Operational modifications involving CVP/SWP facilities do not always create additional water that can be carried over from year to year; rather most yield is made available during the year that the option is implemented.

Yield increases using modification of CVP/SWP operations could be accomplished through a number of activities:

- Modifying the Coordinated Operations Agreement (COA) sharing formulae between the CVP and SWP. These formulae specify the proportion of water that can be pumped from the Delta or retained in upstream reservoirs by the CVP and SWP when the Delta has "surplus" flows (flows beyond those required to maintain water quality). At present, the SWP has greater latitude than the CVP in retaining and/or pumping this surplus water. The formulae currently in use establish sharing percentages that are based on studies performed in the early 1980s. If the concept of a "first in time" approach is revisited and applied to current levels of demand, sharing percentages could shift in favor of Reclamation. A shift could increase CVP yield by reducing the SWP's flexibility in meeting requirements. Such actions,

The activities presented in this category are all part of ongoing efforts to continually increase the efficiency of the CVP



although increasing CVP yield, would have an adverse effect on SWP yields.

- Adjusting Delta "carriage water" requirements. Carriage water is water released from reservoirs to repel salinity intrusions when water is pumped out of the Delta. According to the state, present carriage water requirements under balanced conditions (that is, when water releases must be made from reservoirs to maintain Delta water quality) represent approximately 35 percent of additional water flow. Studies are currently underway (by others) to revisit this percentage with the possibility of its restructuring. If restructuring results in reducing this proportion, an increased supply potential for both the CVP and the SWP would exist. Such increases would result only when relatively large flows occur. During summer months of dry and critically dry years, there is a potential for total exports to be limited by a percentage of total Delta inflow. Such limitations might negate the potential yield increase associated with carriage water reductions.

  CVP and SWP operators believe, however, that additional yield created from any reduction is available only "on paper." They reason that current facilities are operated to meet Delta outflow requirements, not fixed percentages, so any change in carriage water percentages would only better reflect current operations.

- Reducing reservoir minimum storage levels (minimum pool). Minimum storage levels, otherwise known as minimum pools, are mandated for most reservoirs. These levels are usually determined by the need to preserve fishery habitat in the reservoir and/or the minimum operating head needed for effective power generation.

Table III-3 lists yield increase estimates associated with these activities. As can be seen, the largest potential yield might exist with modifications to the COA Sharing Formulae. Costs are not included in the table for modifications of COA or carriage water requirements because there would be no cost in addition to those incurred with ongoing activities. These activities will continue with or without implementation of this Plan. Costs for reduction in minimum pool reflect losses associated with power generation. Yield increases potentially achievable with reductions in minimum pool levels reflect data for Shasta Lake only. Reducing minimum pools at Folsom was not considered possible because of physical constraints. Reducing minimum pools at Oroville was not considered because of head requirements for power generation.

Reducing minimum pool levels would raise a number of environmental issues. Examples include the negative impacts on fish-spawning habitat and production within reservoirs and on habitat and organisms existing on and in bottom sediment. Potential changes in water temperature within and downstream of reservoirs also could affect species and habitat. Preliminary analysis indicates that existing minimum pool levels at Shasta already are

Table III-3
Modification of CVP/SWP Operations
Yield Increase Options

Activity	Annual Yield (1,000 af)	Activity	Annual Yield (1,000 af)
Sacramento River (Shasta)		**American River (Folsom)**	
Modify COA Sharing Formulae	160	Modify COA Sharing Formulae	40
Adjust Carriage Water Required	80	Adjust Carriage Water Required	20
Reduce Minimum Pool [a]	80		
Feather River (Oroville)			
Adjust Carriage Water Required	50		

a) Option may have impact on temperature control without a temperature curtain.

constrained by the necessity to maintain downstream temperature, thus potentially making further reduction infeasible.

If implemented properly, modifications to COA and carriage water requirements might have minimal effects on environmental habitat within the Delta. Timing of releases along with "real-time" monitoring of hydrologic conditions in the Delta would aid in the implementation of these activities while maintaining necessary environmental safeguards.

Social considerations include the potential for increases or reductions in recreation and power generation attributable to modified reservoir levels. For example, further reductions in Lake Shasta water levels would have a negative impact on recreation in the lake and associated local economies. Modifying the COA would gain water for the CVP but could have negative impacts on those dependent on SWP water supplies.

All activities would involve a variety of government agencies and resulting institutional issues, some of which could delay or prevent implementation. For example, water quality control plans for the Delta may force increased—not decreased—outflow requirements as compared to those required to meet current Delta outflow criteria. The state may also be unwilling to negotiate changes in the COA.

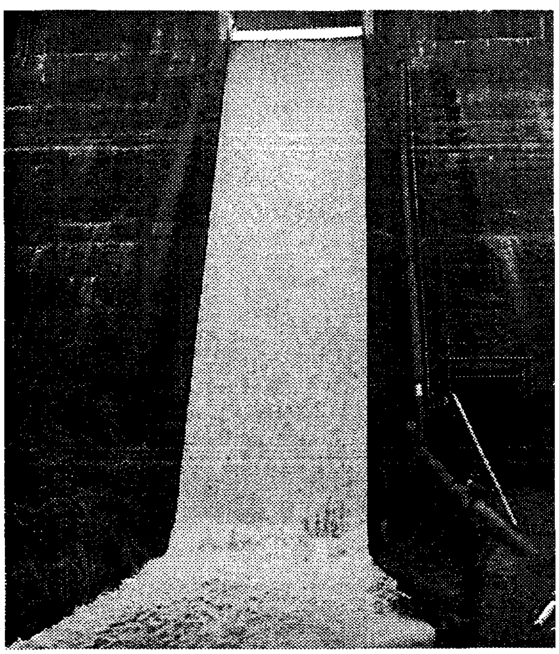
Social considerations include the potential for increases or reductions in recreation and power generation attributable to modified reservoir levels

Supplies from Local Water Projects

Many local projects have the flexibility to operate their facilities to store and release water in a way that not only meets their own purposes, but could also make water available for CVP yield increase. For the most part, these local purposes include water supply and power generation. Changes in the operation and management of some local water supply projects could make water available for CVP yield-increase purposes. However, such changes might have impacts on the projects' primary purposes. Water supplies from local water projects that would be used for CVP yield increase would be purchased from willing sellers.

The following two types of management activities demonstrate the yield increase potential associated with local project supplies:

- Wet weather spill management
- Operational spill management



Wet Weather Spill Management

Wet weather spill management involves changing the timing of releases from reservoirs as they relate to flood control criteria (typically December through May) such that water released is timed to meet downstream demands and/or facilitate downstream storage in offstream or conjunctive use sites. This option is available only on a year-to-year basis, and only during years in which it is anticipated that the reservoir will accumulate adequate additional inflow to fill and meet annual yield and carryover requirements. A few local agencies may be able to carry over otherwise spilled water in their facilities for use in the following year.

To achieve the maximum yield increase benefit from this option would probably require storage of this released water in a downstream surface or subsurface reservoir, preferably south of the Delta (San Luis Reservoir, for example). In some months, agricultural demand might allow for direct delivery of this water. If storage does not exist or direct delivery cannot occur, the potential of this option for yield increase will be reduced.

Operational Spill Management

Changes in operational spill management would be designed to reallocate end-of-season releases from reservoirs on schedules that provide maximum benefit to downstream water users. End-of-season releases are typically made to provide flood control capacity for the ensuing winter months. Many reservoirs in California currently do not lower storage levels until the late summer/ early fall in order to facilitate recreation and power generation. This option calls for the release of this water earlier in the summer for direct delivery to meet CVP demands.

Costs and yield increase estimates associated with these options are shown in **Table III-4**. These estimates were developed and evaluated using operation models, and in some cases

Table III-4
Supplies from Local Water Projects
Yield Increase Options

Activity	Annual Yield (1,000 af)	Cost at Source ($/af)	Activity	Annual Yield (1,000 af)	Cost at Source ($/af)
Yuba (New Bullards Bar)			**Bear (Camp Far West)**		
Wet Weather Spill Management	120	30-70	Wet Weather Spill Management	5	30-70
Operational Spill Management	5	30-70	Operational Spill Management	none identified	
Mokelumne (Pardee/Camanche)			**Calaveras (New Hogan)**		
Wet Weather Spill Management	30	30-70	Wet Weather Spill Management	none identified	
Operational Spill Management	none identified		Operational Spill Management	none identified	
Stanislaus (New Melones)			**Tuolumne (Don Pedro)**		
Wet Weather Spill Management	none identified		Wet Weather Spill Management	5	30-70
Operational Spill Management	40 [a]	30-70	Operational Spill Management	none identified	
Merced (McClure)			**San Joaquin (Millerton)**		
Wet Weather Spill Management	5	30-70	Wet Weather Spill Management	none identified	
Operational Spill Management	10	30-70	Operational Spill Management	none identified	
Kings/Kaweah/Tule (Pine Flt,Kaw.,Succ.)			**Kern (Isabella)**		
Wet Weather Spill Management	none identified		Wet Weather Spill Management	none identified	
Operational Spill Management	none identified		Operational Spill Management	none identified	

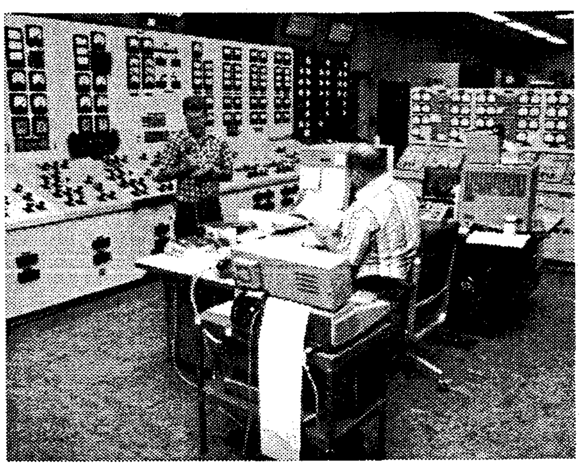
a) Value reflects potential yield increase available from non-federal water rights holders on Stanislaus River with no impact to current levels of delivery.

include projections based on historic spillage records. Costs reflect the price of water as purchased by the state 1991 drought water bank and by other public and private agencies. The cost of these options will be affected by future levels of competition for water supply. Effects of competition are discussed in Section IV. No estimates are shown for some basins because of low inflows in comparison to storage capacity (during periods of drought these reservoirs may never reach full capacity and thus never spill). Yield estimates are shown for drought conditions.

For most local agencies, only a minimal potential exists for yield increase from operational spill management

As can be seen in the table, wet weather spill management has greater yield increase potential than operational spill management. Many reservoirs have little or no wet weather spill potential, however. The water supply indicated for the Yuba River is large because of the presence of New Bullards Bar Reservoir, a fairly large facility on a watershed with high runoff in relation to relatively small demand (effects of near-term demand increases are reflected in yield estimate).

For most local agencies, only a minimal potential exists for yield increase from operational spill management because these agencies already operate their systems efficiently and regularly space their outflows through the year. The biggest opportunity is on the Stanislaus River.



The potential environmental impacts of these options may include effects associated with changes in river stage (either higher or lower water levels depending on the time of year). Streambed, riparian, or terraced wetland habitat could be affected. Wet weather spills likely could have the added benefit of being used to increase instream flows during winter and spring months above current levels in addition to being diverted downstream for use as a yield increase option.

Wet weather spill management could increase the risk of reduced water deliveries in dry years if spring runoff were insufficient to refill the reservoir to normal levels. The cost associated with increasing the risk to the local users would play a role in the determination of the value of the water and the price at which it might become available for yield increase. However, the option does offer the potential for greater power generation attributable to controlled water releases through the turbines versus over the spillway.

Operational spill management could affect recreation on reservoirs if levels were lowered earlier than usual.

It is anticipated that purchase of water supplies from local water projects will require environmental documentation, permitting, and funding. Total time required for implementation is estimated to be 4 years.

Conjunctive Use

Conjunctive use means storing surplus surface water in groundwater basins for future use during periods when surface supplies are inadequate. Coordinated use of surface and groundwater resources increases both the yield and reliability of long-term water supplies when compared to the separate operation of either.

Conjunctive use operation can be accomplished by recharge programs that can be characterized as either:

- ❖ Active recharge
- ❖ Developable perennial yield

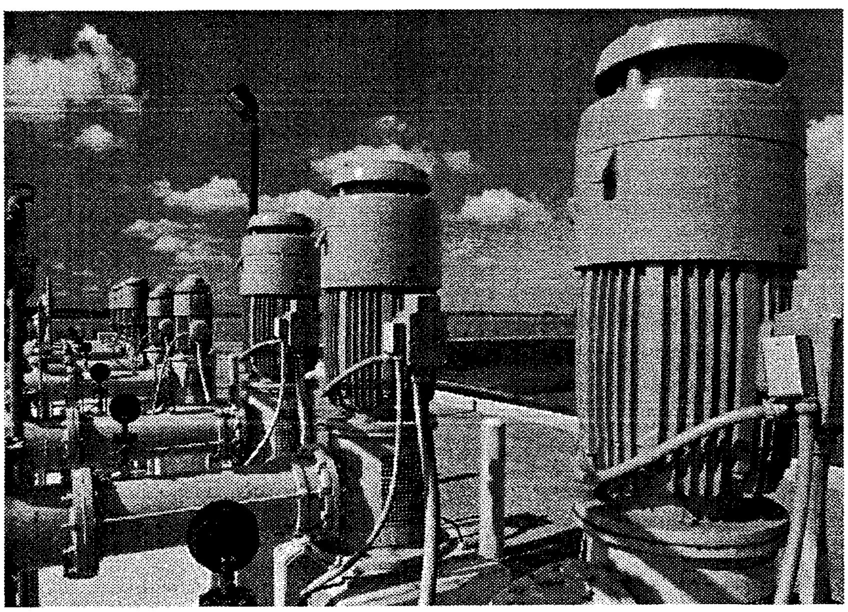
Under an active recharge program, surface water is diverted for storage during wet or above normal years, when streams typically carry higher flows than may otherwise be beneficially used. Diverted water is recharged into groundwater basins that have available storage "space" and that meet hydrologic criteria for economic water storage and withdrawal. Stored water is then withdrawn during drier years when surface water supplies are not sufficient to meet demands.

A slightly different type of active recharge program would include direct use of surface water instead of groundwater in wet years (in-lieu); leaving the otherwise pumped groundwater in storage for use when surface supplies are not available. However, this practice requires a storage facility to allow winter and spring stormflows to be held and reregulated through the remainder of the year. This type of conjunctive used is currently practiced in several areas of the Central Valley.

Supplies for storage could be obtained by diverting portions of storm flows on local rivers, importing water from out-of-basin sources (from north of the Delta to the San Joaquin Valley), or by using reclaimed or desalinated water. Supplies are placed in groundwater storage by percolation or direct recharge through basins or injection wells.

Potential active recharge sites need to meet a certain set of hydrologic criteria (for example, soil type and aquifer characteristics). Based on these criteria, a number of potential sites for active recharge storage have been identified throughout the Central Valley.

Developable perennial yield, as the name implies, does not involve diversion or importation of water, nor does it require construction of recharge facilities. This use of



groundwater depends on nature's ability to recharge more water into underlying aquifers when streamflows and rainfall are higher than normal. During these wet years, the aquifer receives more net inflow than the "perennial yield." Perennial yield refers to the long-term average annual groundwater pumping that will not result in any net change in aquifer storage (that is, the quantity that can be pumped each year without causing overdraft conditions). In groundwater basins where existing groundwater use is less than the perennial yield, there is potential for further groundwater development. In such cases, a developable yield program would use the unused portion of the perennial yield. However, the existence of under-utilized groundwater basins is not widespread because most groundwater basins in the Central Valley are either in hydraulic balance with local rivers and streams or in overdraft conditions.

In essence, this coordinated operation is a mechanism to allow dry period beneficial use of surplus surface water available during wet periods

During dry years, a conjunctive use program uses surface water that has been stored in the aquifer during wet years. In these dry years, groundwater pumping is in excess of normal pumping, but only to the extent that stored water is available. Pumped water can then either be transported to areas of need inside or outside of the basin or exchanged within the basin for use of surface water rights and contracts (in-lieu). In essence, this coordinated operation is a mechanism to allow dry period beneficial use of surplus surface water available during wet periods.

A regional groundwater model characterizing the Central Valley (CVGSM), together with an accompanying database and other information regarding soil and aquifer characteristics, was used to identify potential sites for use in active recharge programs. The sites examined are considered "elements" that average about 14 square miles in size. Elements that might be feasible conjunctive use sites were identified. The regional model was then used to determine the available conjunctive use storage capacity for the model elements. Storage was determined under pre-established operational guidelines that considered recharge effects on basins and in recharge and extraction cycles.

The conjunctive use capacity of the sites (or elements) is defined in this study as the amount of water that can be recharged and extracted over the site without causing a water level fluctuation of more than 30 feet compared to historic water levels. The depth to groundwater from the surface was also considered during these evaluations.

It should be noted that the model is a large-scale regional model with an average element size of 14 square miles, far bigger than the practical size of an active recharge basin. As a result, the evaluated capacities shown in **Table III-5** provide a general idea about the conjunctive use potential of an area and are not exact values.

Also, the results serve as a guide for relative effectiveness of conjunctive use potential of one region over another.

Table III-5
Conjunctive Use
Yield Increase Options

Activity	Evaluated Capacity [a] (1,000 af)	Annual Yield (1,000 af)	Cost at Source ($/af)	General Site [b] Location(s)	Potential Source(s) of Water
Region 1					
Active Recharge	60	15	95	E. of Anderson	Upper Sacramento River
Region 2					
Active Recharge	360	90	95	SW and W of Orland, Tehema-Colusa canal in vicinity	Upper Sacramento River
Developable Yield		55	60	Within Glenn County	Groundwater
Region 3					
Active Recharge	280	85	95	S of Chico, near Wheatland, E. Sutter Bypass, and NE of Rio Linda	Feather and Bear rivers and Dry Creek (north of Sacramento)
Developable Yield		25	60	Within Yuba County	Groundwater
Region 4					
Active Recharge	120	30	90	NW of Woodland and SW of Davis (near Dixon), Yolo Bypass nearby	Cache Creek, Sacramento River
Region 5					
Active Recharge	400	185	90	NE of Galt, SE of Elk Grove, SE of Lodi, and S of Manteca	American (using Folsom S canal), Consumnes, Mokelumne, Calaveras, and Stanislaus rivers
Region 6					
Active Recharge	275	200	95	NW of Volta and at Oro Loma	Delta Mendota Canal, California Aqueduct
Region 7					
Active Recharge	100	20	90	N of Modesto	Stanislaus or Tuolumne rivers
Region 8					
Active Recharge	350	140	90	E of Atwater, NE of Merced, W of La Vina, and NE of Red Top	Merced, Chowchilla, Fresno and San Joaquin rivers
Region 9					
Active Recharge				none identified	
Region 10					
Active Recharge	unknown	125	120	N. of Raisin City, S of Kingsburg, S of Hanford, W of Visalia, and SW of Tipton	Kings, Kaweah, and Tule rivers
Region 11					
Active Recharge	500	50	120	W of McFarland, and SW of Bakersfield	Kern River, California Aqueduct

a) Capacity is taken to be the amount of water that can be recharged and extracted over any area without causing a water level fluctuation of more than 30 feet compared to historic water levels and has been estimated using a large-scale regional model. Values are not maximums and are used for comparison purposes.
b) Location(s) descriptions are reflective of general areas where active recharge programs were estimated to be feasible. Each reference to a city or town represents a single site (NW of Woodland and SW of Davis refers to two potential site areas). Many regions have multiple sites where active recharge is possible.

Site-specific studies would be required to determine the operational capacity of a particular conjunctive use program.

Table III-5 lists costs and yield increase estimates associated with conjunctive use. Yield estimates for active recharge programs are based on the availability of a portion of storm flows on adjacent rivers. As can be seen, the greatest conjunctive use potential exists in Regions 5, 6, 8, and 10. Potential in Region 11 could be greater if importation of water was included (via the California Aqueduct of Friant-Kern Canal). It should be noted that the local water supply availability almost always limits the potential of a particular site. As a consequence, importation of water from out of basin sources may be required to maximize the local potential.

Beneficial impacts include the ability to develop recharge basins and percolation ponds into wetland habitat that can also provide aesthetic value

Costs are higher for an active recharge program because of the need to construct recharge basins, diversion facilities, and extraction wells as well as monitoring. Costs for a developable yield program include extraction wells and groundwater monitoring only.

Developable perennial yields were estimated using data from the state, and by comparing estimates of the perennial yield of the subbasins within the Central Valley with recent estimates of groundwater production. Extensive use of groundwater and the declining groundwater levels throughout most of the Central Valley limit the potential of this resource. Only Regions 2 and 3 were found to have developable perennial yields, and there, only in relatively small quantities.

A number of potential environmental effects have been identified regarding active recharge operations. Beneficial impacts include the ability to develop recharge basins and percolation ponds into wetland habitat that can also provide aesthetic value.

However, diversion of portions of high storm flows into active recharge basins could have adverse effects on downstream habitat or on instream water quality that depends on periodic high flows. Other potential impacts include permanent or temporary loss of habitat due to the construction of extraction facilities, new canals and pipelines to transport diverted water to recharge basins or to in-lieu users, and maintenance corridors.

Depending on location, it is possible for some agricultural chemicals present in basin soils to percolate and contaminate groundwater or have adverse effects on wildlife using the basin. Further investigation of feasible conjunctive use sites would need to be evaluated with specific reference to localized soil and water quality conditions.

Potential environmental impacts attributable to developable yield are uncertain at this time. However, areas where this has been identified as an option are part of the larger hydrologic system, and their use may reduce water in adjacent streams or wetlands or may create overdraft conditions in a particular area.

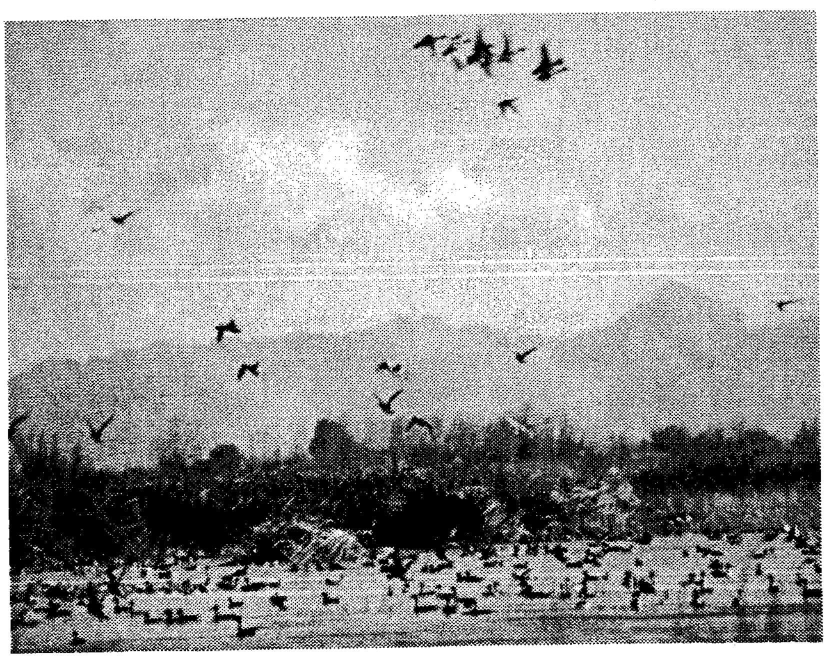
Implementation of active recharge programs could help stabilize groundwater depths and minimize overdraft potentials, thereby benefiting local communities with declining groundwater levels. Additional social benefits could be realized if a wetland habitat were established in conjunction with the program and the public were given access into these areas for wildlife viewing.

Institutional issues are expected with both conjunctive use programs. Prior to implementation of a conjunctive use program, a Groundwater Management Plan addressing interaction of surface water and groundwater, and water rights issues would also need to be in place. Without such a plan, the federal government will not participate in the development of, or purchase from, a conjunctive use site.

In addition, permits may be required for both active and natural recharge programs that would depend on site-specific conditions and planned operations. Examples of permits include a Department of the Army permit under Section 404 of the Clean Water Act and a Regional Water Quality Control Board permit under Section 402 of the Clean Water Act, as well as water rights and well construction permits. Permits could require creation or maintenance of wetlands habitat prior to operation of a site.

Concerns with a conjunctive use operation using perennial yield include assurance that water withdrawals will not exceed long-term net inflows or upset hydrologic balances. Such assurance would require close monitoring of extraction facilities as well as that of local groundwater users. Conjunctive use operations using active recharge could raise water rights issues associated with water that "leaks" into surrounding aquifers.

It is anticipated that implementation of conjunctive use options will require additional feasibility investigations, environmental documentation and permitting, funding authorization, and advanced planning, design, and construction . The total time required for implementation is estimated to be 10 years.



Water Reuse

Yield-increase potential may be realized through implementation of water reuse activities. Two such activities are presented here:

- Agricultural drainage reclamation
- Urban wastewater reuse

Estimates of yield-increase potential for these subcategories are based on extrapolations of data used in the development of the California Department of Water Resources Draft California Water Plan (Bulletin 160-93), together with other available statewide data. Estimates for agricultural drainage reclamation are based on capturing irrecoverable losses (that is, water that flows to degraded bodies of water) and treating them to sufficient levels—reclaiming—to allow for reuse. Estimates of urban wastewater reuse potential are based on projected changes in the current destinations of wastewater streams so that the water typically discharged is used for yield-increase purposes. Additional treatment may be required to make use of urban sources.

Even in areas with existing agricultural drainage systems, pumping and treatment costs are high, making agricultural drainage reclamation very expensive compared to other yield increase options

Agricultural Drainage Reclamation

Agricultural drainage reclamation involves the collection of water associated with irretrievable losses and treatment of this water to levels sufficient for subsequent agricultural use, refuge purposes, or as a raw water source for urban users. Substantial treatment levels could potentially be required if the water were sold as a raw water source for urban use.

Table III-6a lists costs and yield-increase estimates associated with this activity. Estimates are not shown for Regions 1, 2, 3, 4, or 5 because water lost in these areas goes back into groundwater or streams for subsequent use by others (this water is associated with recoverable losses).

As can be seen, yield is obtainable primarily on the west side of the San Joaquin Valley and the Tulare Lake basin area in Regions 6, 7, 8, 9, 10, and 11. Some lands within these regions traditionally have had drainage problems attributable to high water tables, confining layers of soil, and their location downslope from other irrigated agricultural areas. As a result, drains are frequently in place

Table III-6a
Water Reuse
Yield Increase Options
Agricultural Drainage Reclamation

Activity	Annual Yield (1,000 af)	Cost at Source ($/af)	Activity	Annual Yield (1,000 af)	Cost at Source ($/af)
Region 1			**Region 2**		
	none identified			none identified	
Region 3			**Region 4**		
	none identified			none identified	
Region 5			**Region 6**		
	none identified		Agricultural Drainage Reclamation	115	2,250
Region 7			**Region 8**		
Agricultural Drainage Reclamation	5	2,250	Agricultural Drainage Reclamation	15	2,250
Region 9			**Region 10**		
	none included		Agricultural Drainage Reclamation	130	2,250
Region 11					
Agricultural Drainage Reclamation	160	2,250			

in these locations to convey water to sumps, where it can be pumped out and disposed of.

Even in areas with existing agricultural drainage systems, pumping and treatment costs are high, making drainage reclamation very expensive compared to other yield increase options.

Potential environmental impacts include the loss of habitat due to construction of conveyance and storage facilities, and the concentration of pesticides, herbicides, and other constituents (such as selenium) in storage facilities that could attract and adversely affect wildlife populations. However, under most circumstances, these impacts are mitigable and do not preclude this option. In some cases, the related yield increase may be used for environmental benefits.

From a social perspective, reclamation would allow for continued agricultural activity on drainage-affected land. Landowners in some of these areas currently pump drainage water away, but more stringent water-quality requirements might be adopted in the future, thus limiting this potential. Drainage reclamation also would create new jobs related to construction and operation of collection systems and treatment plants, and the treated water might produce byproducts (salts and other minerals) that could be marketed.

Legal questions likely would arise relating to the responsibility of upslope water users potentially contributing to drainage problems for costs incurred in installing these downslope facilities.

It is anticipated that implementation of agricultural reclamation options will require additional feasibility investigation, environmental documentation and permitting, funding authorizations, and advanced planning, design, and construction. The total time required for implementation is estimated to be 10 years.

Urban Wastewater Reuse

Urban wastewater reuse represents a potential source of raw water for agricultural and urban uses as well as for environmental purposes. A large and growing portion of urban wastewater is currently being treated and reused, especially in water-short areas such as Southern California. However, a significant portion is still being released to surface outfalls (rivers and streams) or to recharge ponds and saline sinks (evaporation ponds, oceans, bays, coastal lagoons).

In many cases, wastewater currently discharged to surface outfalls is included as part of the baseline downstream flow of the receiving body of water, and its reuse might require diversion and exchange of compensatory water to account for that loss. As a result, reclaiming this water might not create new water supplies but rather provide delivery scheduling benefits. However, increased quantities of urban wastewater generated in the future might provide yield-increase potential. Current California water law is vague as to how to account for the actual effect on receiving waters and the level of responsibility for any compensatory releases. A number of large urban centers in the northern Central Valley currently discharge their wastewater in this manner (for example, Sacramento and Stockton).

Wastewater discharged to ponds percolates into the ground usually at a rate greater than the aquifer can convey it away from the ponds. This sometimes results in temporary "mounding" of the water. However, mounding does not always translate into true water availability. In some areas, groundwater is pumped to water users in exchange for use of their surface rights. In others, extraction wells and pumping facilities would need to be built. Fresno and Bakersfield are two large municipalities currently discharging into ponds.

Most wastewater discharged to saline sinks goes to bays and the ocean. As a result, its recapture and reuse would represent a wholly new resource. Large municipalities on the coast typically discharge into the ocean or to a river or stream that quickly discharges into the ocean, so there is less opportunity for recapture/reuse of that water. San Francisco and Los Angeles currently follow this practice.

Table III-6b lists costs and yield increase estimates associated with urban wastewater reuse. As the table shows, substantial quantities exist but

Table III-6b
Water Reuse
Yield Increase Options
Urban Wastewater Reuse

Activity	Annual Yield (1,000 af)	Cost[a] at Source ($/af)	Activity	Annual Yield (1,000 af)	Cost at Source ($/af)
Region 1			**Region 2**		
Discharge to Rivers/Streams	10	285	Discharge to Rivers/Streams	none identified	
Discharge to Pond/Saline Sink	none identified		Discharge to Pond/Saline Sink	none identified	
Region 3			**Region 4**		
Discharge to Rivers/Streams	10	285	Discharge to Rivers/Streams	25	285
Discharge to Pond/Saline Sink	5	285	Discharge to Pond/Saline Sink	none identified	
Region 5			**Region 6**		
Discharge to Rivers/Streams	90	285	Discharge to Rivers/Streams	none identified	
Discharge to Pond/Saline Sink	5	285	Discharge to Pond/Saline Sink	5	285
Region 7			**Region 8**		
Discharge to Rivers/Streams	20	285	Discharge to Rivers/Streams	10	285
Discharge to Pond/Saline Sink	20	285	Discharge to Pond/Saline Sink	10	285
Region 9			**Region 10**		
Discharge to Rivers/Streams	none included		Discharge to Rivers/Streams	none identified	
Discharge to Pond/Saline Sink	none included		Discharge to Pond/Saline Sink	100	285
Region 11			**Bay Area Dischargers**		
Discharge to Rivers/Streams	none identified		Discharge to Rivers/Streams	none identified	
Discharge to Pond/Saline Sink	55	285	Discharge to Pond/Saline Sink	450	1,200[b]
San Felipe Division					
Discharge to Rivers/Streams	none identified				
Discharge to Pond/Saline Sink	55	330			

a) Conveyance costs were added to the cost at source for the Bay Area Dischargers and San Felipe Division. For Central Valley regions, conveyance is assumed to be available in existing systems on natural drainages.
b) Values are from the Central California Regional Water Recycling Program Draft Report (July 1995) and includes added cost of collection and conveyance.

at a comparatively high cost attributable mainly to increased treatment requirements and their associated cost. Yield estimates for the 11 Central Valley regions shown in the table represent the cumulative potential for the urban areas present within each particular region. In addition, estimates were developed for the Bay Area Dischargers and the Central Coast component of the San Felipe Division of the CVP. These latter areas were included because they receive a portion of their water from streams within the Central

Valley. Southern California was not included because of perceived desire to retain reuse water to meet its own expanding needs.

Costs represent an average for improvements in treatment for use by urban, environmental, and agricultural users, and can be expected to vary depending on the constituents in the waste stream and the specific intended use of the water. This cost is the cost at the treatment plant and does not include additional conveyance facilities that would be required by some users (in effect, a "dual system"). The dual system is required to separate the potable water from the reclaimed and would significantly add to the cost of reused water. Variations from conventional treatment processes, such as aquatic bioenhancement, could produce lower prices if such new technologies prove effective and acceptable.

The largest yield increase potential is associated with discharges to saline sinks, especially from the Bay Area Dischargers

The largest yield increase potential is associated with discharges to saline sinks, especially from the Bay Area Dischargers (an association of wastewater treatment agencies and municipalities in the San Francisco Bay Area). One concept currently being studied is to bring treated wastewater from these sources into the Delta for transportation to agricultural users on the west side of the San Joaquin Valley. Estimated costs for this project are very high compared with other reuse options, however. This is mainly the result of added cost of collection and conveyance to make the water available for CVP yield increases.

The potential for recovering wastewater currently going into rivers and streams is especially large in Region 5, associated with discharges from the Sacramento Regional Wastewater Treatment Plant; the potential for recovery of wastewater currently going into percolation ponds is largest in Region 10, associated with discharges from the City of Fresno.

Environmental considerations related to wastewater reuse center on the need to ensure that reclaimed water meets water quality requirements imposed mainly by federal EPA and by the state Department of Health Services. For example, some sources of treated water may be good enough for agricultural or environmental purposes, but others may contain high salt contents and other constituents that were not removed or were entrained during the treatment process. These constituents might adversely affect the usefulness of the water source for yield-increase purposes.

Undesirable plant growth may also occur as a result of the nutrient content of the treated water. Such plant growth where the water is reused could affect the ability of native vegetation to survive or cause increased weed cultivation in agricultural fields.

From a social perspective, recycling wastewater might require construction of additional treatment processes at existing treatment plants and people to staff them. This would be a function of the end-use of the treated water. In some instances buildings have been plumbed to permit use of both potable water for drinking, cooking, etc., and wastewater for toilets. This practice is being adopted in parts of Southern California with an attendant beneficial impact on the job market and local economy.

Reuse of wastewater raises institutional issues, including the need to meet provisions of the Clean Water Act, Safe Drinking Water Act (if treated water uses the same conveyance facilities as raw sources of drinking water), and state health standards.

It is anticipated that implementation of urban wastewater reuse options will require additional feasibility investigation, environmental documentation and permitting, funding authorizations, and advanced planning, design, and construction. The total time required for implementation is estimated to be 10 years.

Surface Storage and Conveyance

Enlargement of existing Central Valley reservoirs and large interregional man-made canals, or construction of new facilities of this type, would substantially increase CVP yield and facilitate water management activities in the valley.

Only those projects and facilities identified in current or past studies of interest were considered. These cover all basins flowing into the Delta and include:

- **Enlargement of existing storage.** Options include onstream storage at Shasta, Folsom, Pardee, and Friant reservoirs, and offstream storage at Farmington Reservoir and Berryessa Reservoir.
- **New onstream surface storage.** Options include storage at Cottonwood, Marysville, Garden Bar, and Auburn.
- **New offstream surface storage.** Options include storage at Clay Station, Deer Creek, Duck Creek, South Gulch, Montgomery, Delta Wetlands reservoir, and Los Banos Grandes.

- **New or extended conveyance.** Options include the extension of the Folsom South Canal, a Delta Isolated Facility, and the Mid-Valley Canal. With the exception of the Delta isolated facility, these options do not necessarily result in increased annual yield, but rather extend conveyance to potential need locations.

  As it currently exists, the Folsom South Canal could be used to reach most potential conjunctive use sites identified in the Cosumnes River area; expansion would extend this capability farther down the east side of the valley to the Mokelumne, Calaveras, and Stanislaus river areas.

  The Delta isolated facility would divert water from the Sacramento River near the town of Hood down to Clifton Court Forebay, and would include facilities designed to protect water quality and fish and wild-life habitat in the Delta that could be negatively impacted by this diversion.

  The Mid-Valley Canal is a new facility that delivers water exported south out of the Delta farther into the San Joaquin Valley. Its purpose is to offset groundwater overdrafts and potentially facilitate conjunctive use projects.

Figure III-2 is a map highlighting the approximate location of the surface storage facilities discussed.

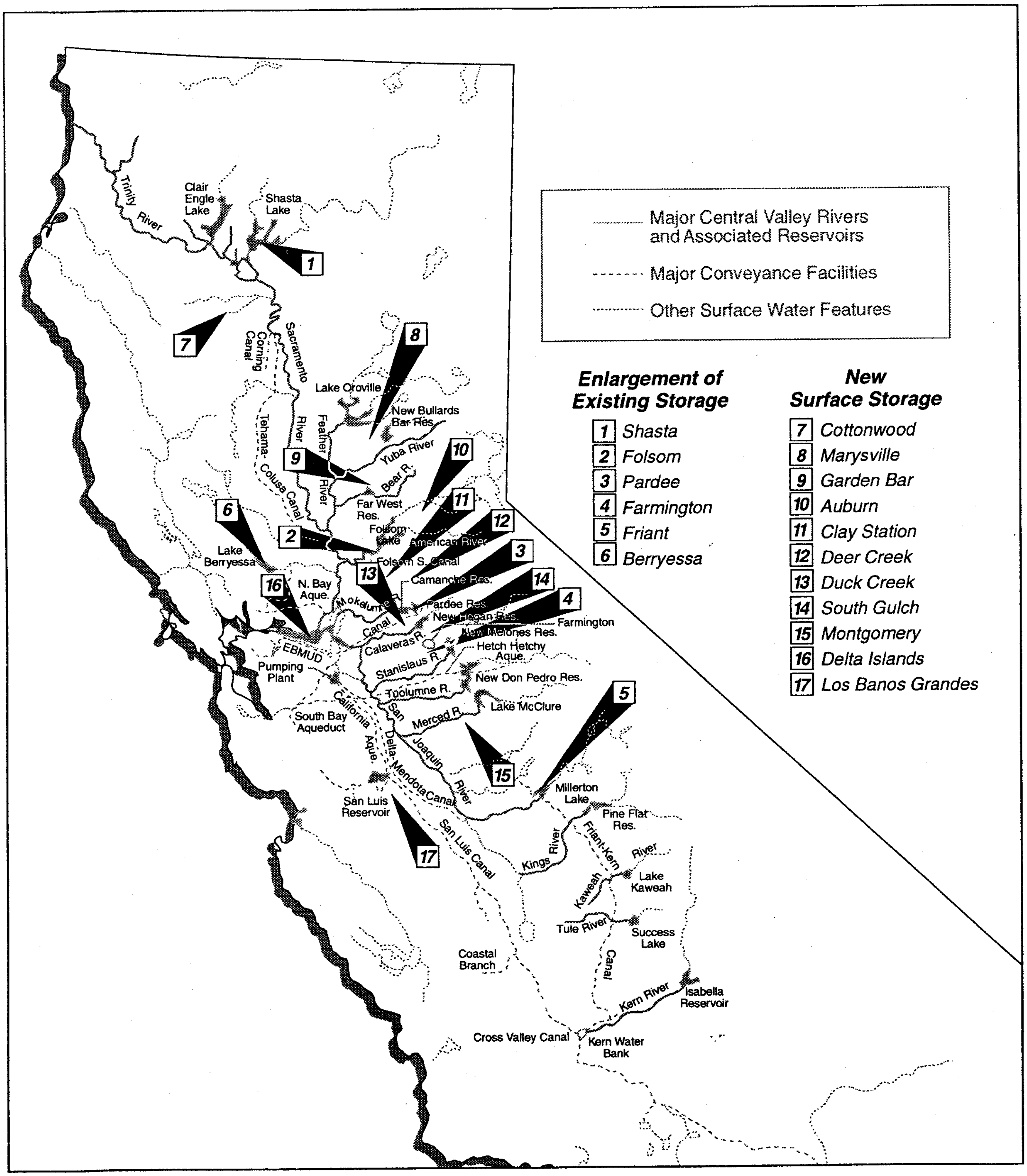


Figure III-2
Approximate Locations of New or Enlarged Surface Storage Facilities

Figure III-3 is a map highlighting the location of proposed conveyance facilities in the Central Valley.

Cost and yield estimates are derived from numerous available reports and studies. The information used in these studies may not fully reflect effects of current or anticipated instream flow requirements or full mitigation requirements on yield potential.

Table III-7a lists costs and yield increase estimates associated with enlargement of existing storage; **Table III-7b** lists cost and yield estimates for new onstream and offstream surface storage; and

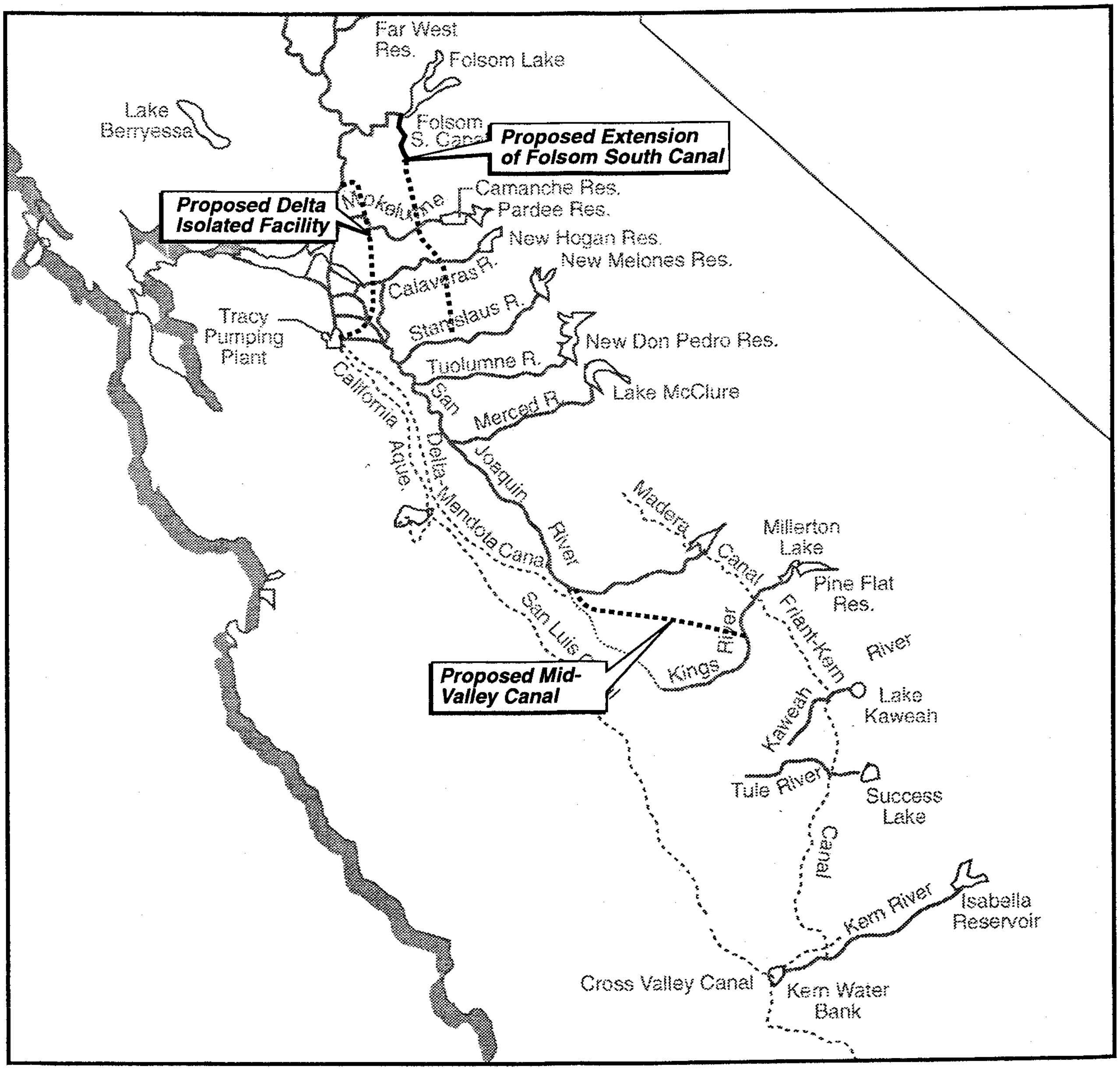


Figure III-3
Approximate Locations of New or Extended Conveyance Facilities

Table III-7a
Surface Storage and Conveyance
Yield Increase Options
Enlargement of Existing Storage

Activity	Total [a] Storage (1,000 af)	Annual Yield (1,000 af)	Cost [b] at Source ($/af)	Activity	Total [a] Storage (1,000 af)	Annual Yield (1,000 af)	Cost [b] at Source ($/af)
Upper Sacramento Basin				**Feather River Basin**			
Shasta	14,300	1,250	430			none identified	
Yuba River Basin				**Bear River Basin**			
		none identified				none identified	
American River Basin				**Mokelumne River Basin**			
Folsom	1,340	70	1,080	Pardee	360	20	1,640
Calaveras River Basin				**Stanislaus River Basin**			
		none identified		Farmington [c]	160	30	300
Tuolumne River Basin				**Merced River Basin**			
		none identified				none identified	
San Joaquin River Basin				**Delta Area**			
Friant	1,400	45	2,920	Berryessa	13,000	1,000	610
Delta Export Region							
		none identified					

a) Total storage values include existing reservoir storage capacity.
b) Cost are based on indexing of cost estimates in other studies and are only for enlarged portion and related supply.
c) Existing facility is a flood control dam only. Potential problems exists with facility "leakage."

Table III-7c lists cost and yield estimates for new or extended conveyance.

Annual yield increase estimates are based on estimates in other studies, modeling of historic flow data, or preliminary yield calculations. Data for capacity enlargements include existing reservoir storage; yield and cost estimates are for the enlarged portion and its added annual yield.

Quantities are assumed to be available when construction is completed as a result of reservoir filling during the last years of construction. Additional time would be required to achieve the estimates shown if construction were to take place during a drought period.

Yield and cost estimates shown for an enlarged Farmington and for South Gulch assume operation in conjunction with groundwater sources. Yield estimates assume that surface water supplies from local streams are stored in the reservoir. The potential for minor diversions

Table III-7b
Surface Storage and Conveyance
Yield Increase Resources
New On/Offstream Surface Storage

Activity		Total[a] Storage (1,000 af)	Annual[n] Yield (1,000 af)	Cost[b] at Source ($/af)
Upper Sacramento Basin				
Onstream	Cottonwood[c]	1,600	215	480
Offstream			none identified	
Yuba River Basin				
Onstream	Marysville[d]	1,050	160	1,240
Offstream			none identified	
American River Basin				
Onstream	Auburn[f]	2,300	260	420
Offstream	Clay Station[g]	170	30	1,230
	Deer Creek[h]	600	110	1,220
Calaveras River Basin				
Onstream			none identified	
Offstream	Duck Creek[i]	100	15	2,760
	South Gulch[j]	180	40	430
Tuolumne River Basin				
Onstream			none identified	
Offstream			none identified	
San Joaquin River Basin				
Onstream			none identified	
Offstream			none identified	
Delta Export Region				
Offstream	Los Banos[m] Grandes	1,730	260	660
Feather River Basin				
Onstream			none identified	
Offstream			none identified	
Bear River Basin				
Onstream	Garden Bar[e]	245	25	1,060
Offstream			none identified	
Mokelumne River Basin				
Onstream			none identified	
Offstream			none identified	
Stanislaus River Basin				
Onstream			none identified	
Offstream			none identified	
Merced River Basin				
Onstream			none identified	
Offstream	Montgomery[k]	240	35	760
Delta Area				
Onstream			none identified	
Offstream	Delta Wetlands[l]	240	150	800

a) Total storage values include existing reservoir storage capacity.
b) Cost are based on indexing of cost estimates in other studies.
c) Two reservoirs are included: Dutch Gulch and Tehema. This facility acts as a represnetative of other potential facilities on the westside of the Sacramento Valley.
d) Actual location is the Narrows damsite alternative.
e) Estimates are based upon the South Sutter W.D. license application to FERC, Nov. 1985.
f) Estimates are based upon a multipurpose reservoir.
g) Cost includes new canal facility to divert water from Folsom South Canal to reservoir site. Project would use American River water.
h) Site is located west of Rancho Murieta at Kiefer Boulevard. Yield is based on diversion of American River water.
i) Reservoir would use surplus water from the Mokelumne River diverted at Pardee Reservoir.
j) Reservoir would use surplus water from both the Calaveras and Stanislaus Rivers.
k) Limited to 2,000 cfs gravity inflow and 1,000 cfs outflow. Cost does not include pumping power cost for outflow.
l) Based on HYA's Delta Wetlands project. Cost would be in $150 to $300/AF range based on average annual yield of 250 TAF. Project may be more cost effective in conjunction with other projects.
m) Based upon information from Department of Water Resources.
n) Yield is based on past studies except for Delta Wetlands values, which are based upon recent water quality agreements, and South Gulch, which requires in-lieu operation.

Table III-7c
Surface Storage and Conveyance
Yield Increase Options
New or Extended Conveyance

Activity	Capacity (cfs)	Annual Yield (1,000 af)	Cost [a] at Source ($/af)	Activity	Capacity (cfs)	Annual Yield (1,000 af)	Cost [a] at Source ($/af)
Upper Sacramento Basin				**Feather River Basin**			
		none identified				none identified	
Yuba River Basin				**Bear River Basin**			
		none identified				none identified	
American River Basin				**Mokelumne River Basin**			
Folsom South Canal	2,000 at start	Qty. will vary depending on intended use				none identified	
Calaveras River Basin				**Stanislaus River Basin**			
		none identified				none identified	
Tuolumne River Basin				**Merced River Basin**			
		none identified				none identified	
San Joaquin River Basin				**Delta Area**			
Mid Valley Canal [b]	2,150 at start	Qty. will vary depending on intended use				none identified	
Delta Export Region							
Delta Isolated Facility [c]	23,300 at start	400	410				

a) Values are based on indexing of cost estimates in other studies.
b) Project's main purpose is to reduce groundwater overdraft by importing surface water. May have added benefit of conveyance facility to allow in-lieu conjunctive use projects. Reclamation, June 1990 report included delivery to wetland habitat in the Sacramento and San Joaquin Valleys.
c) Based upon Reclamation's Peripheral Canal studies and California Water Plan Update. Supply quantity reflects savings due to reduction in carriage water releases.

from the Stanislaus River in wetter years to provide additional yield require further study due to existing demands on the river. Quantities will depend on the findings of Interior's New Melones Water Management Study, scheduled for completion in early 1996, which will address Stanislaus River yield allocation issues. Stored local inflow is reregulated throughout the remainder of the year to meet agricultural demands in the local area. In turn, local farmers will not pump groundwater as would otherwise be done. This will leave groundwater stored in the aquifer for use during years when surface water is not available. Curtailment of groundwater pumping over several wetter years would allow for large quantities of water to remain in local aquifers. Unique to this area's hydrologic conditions, the aquifer can easily store this water without significant loss to other areas.

Costs shown in the tables were taken from previous studies and indexed up to reflect current conditions. Annualized costs include construction, operation, and maintenance.

Most of these studies did not include mitigation costs and discussed levels of impacts only. Mitigation costs have been developed separately based solely on the discussion of impacts and added to the other costs. Preliminary analysis of mitigation for environmental effects, based on cost associated with habitat restoration and maintenance, indicates costs may be substantial for the estimated impacted acreage. For purposes of this analysis, mitigation costs are assumed to equal estimated annual construction and operation and maintenance costs and have been included in the cost estimate shown. Future site-specific analysis, if warranted, may result in the mitigation cost changing significantly.

Table III-7d lists the estimated year of completion for the surface storage and conveyance facilities considered in this study. The estimates assume implementation by the federal government. Preliminary steps already have been accomplished for some projects.

A number of environmental impacts could occur with new onstream or offstream surface storage and with enlargements

But for others, and especially larger projects (e.g., expansion of Shasta reservoir and construction of Auburn Dam and the Delta isolated facility), the remaining steps could take 10 to 20 years (if past efforts are any indication of the future). As a result, the projects most likely to be completed within the available time frame (by October 2007) would be those of smaller scale or where some of these steps/challenges already have been completed or resolved.

In some cases, implementation at the size shown of one project could compromise another. For example, enlargement of Shasta may preclude enlargement of Berryessa because both are envisioned to capture water from the Sacramento River (for Berryessa, available water would be pumped from the Sacramento River into the enlarged facility). Smaller sizes, however, might be feasible.

A number of environmental impacts could occur with new onstream or offstream surface storage and with enlargements. Impacts associated with these facilities include obstruction of fish migration (if no downstream obstruction currently exists), loss of terrestrial and stream habitat due to the establishment of facilities, fill excavation and removal from within and outside reservoir areas, and temporary reservoir drawdowns to facilitate expansions of existing facilities. Impacts to fisheries and Delta flows are expected with the Delta Wetlands Project. The cost shown for this project does not include mitigation cost for these possible impacts. Concern over Delta Wetlands has been expressed by wildlife agencies because of limited information on how this project will affect fisheries.

Impacts associated with inundation of any of the reservoir sites include loss of habitat, erosion and slumping of slopes, and effects resulting from changes in flood frequency and magnitude as a result of increased storage capacity. **Tables III-7e and III-7f** list habitat effects associated with the specific facilities.

Table III-7d
Surface Storage and Conveyance
Estimated Time of Completion

Project	Tasks [a] 1	2	3	4	5	6	7	8	Total Years	Calendar Year [b]
	Years to Complete									
Enlargement of Existing Storage										
Shasta	-	-	1	4	2	1	4	5	17	2013
Folsom	2	1	2	3	2	1	3	3	17	2013
Pardee									8 [c]	2004
Farmington	-	-	-	3	2	1	2	2	10	2006
Friant	2	1	2	3	2	1	3	4	18	2014
Berryessa	2	1	2	4	2	1	4	4	20	2016
New Surface Storage										
Cottonwood	-	-	1	4	2	1	2	5	15	2011
Marysville	2	1	2	4	2	1	3	9	24	2020
Garden Bar									8 [c]	2004
Auburn	-	-	-	-	2	2	4	6	14	2010
Clay Station	-	-	1	2	2	1	2	3	11	2007
Deer Creek	2	1	2	4	2	1	3	5	20	2016
Duck Creek	-- not estimated because of high cost --									
South Gulch	2	1	2	2	2	1	2	2	14	2010
Montgomery	-	-	1	2	2	1	3	5	14	2010
Delta Wetlands									1 [c]	1998
Los Banos Grandes									14 [c]	2010
New or Extended Conveyance										
Folsom South Canal	-	-	-	-	1	2	2	3	8	2004
Mid-Valley Canal	-	-	1	2	2	1	2	4	12	2008
Delta Isolated Facility	-	-	1	2	2	1	3	5	14	2010

a) The required tasks include: 1) obtain general investigation funds; 2) appraisal investigation; 3) obtain feasibility authorization and funds; 4) feasibility investigation and EIS; 5) obtain construction, authorization and advanced planning funds; 6) advanced planning; 7) design, supplemental EIS, and permits; 8) constuction. A "-" indicates that this portion of the potential project has already been accomplished.
b) Calendar year estimates are based on a start year of 1996.
c) The total years shown for these projects was based on values indicated by the agencies or companies involved with the concept.

Table III-7e Summaries of Estimated Environmental Effects due to Enlargement of Existing Facilities	
Potential Site	**Estimated Environmental Effects**
Shasta	Loss of 30,000 acres of upland and 72 miles of stream habitat; 162,000 acres required to mitigate; SNA[a] for bald eagle, and other special status wildlife species
Folsom	Loss of up to 1,952 acres of upland and 3.4 miles of stream habitat; 3,740 acres required to mitigate; two SNAs for several special status plant species
Pardee	Loss of wetland habitat and 4.8 miles of stream, including 3.5 miles of high quality perennial stream; 5 special status plant species possible; Ione Chaparral sensitive plant community. Potential presence of 2 federally endangered species, including bald eagle; loss of spawning habitat for rainbow trout and Kokanee salmon.
Farmington	Loss of scarce riparian corridor and swallow nesting habitat; SNA for special status tricolored blackbird nesting
Friant	Loss of scarce riparian habitats; SNA for vernal pool habitats and a special status plant species
Berryessa	Loss of scarce riparian habitats, oak woodland, chaparral, and grassland; water conveyance facility and impacts from diverting water from the Sacramento River are not yet identified and may be significant.
a) Significant Natural Area as defined by the California Department of Fish and Game: Habitat areas having high ecological diversity, of significance to one or more species of plant or animal, unique for its assemblage of species, rare as a natural commodity.	

Environmental impacts associated with new or expanded conveyance primarily include temporary and/or permanent removal of existing vegetation and its attendant habitat value during construction and maintenance. In addition, canals would contribute to increased mortality (drowning occurrence) of wildlife populations by creating an unnatural surface that prohibits escape (although, new canal designs try to minimize this potential) and inhibiting wildlife migration.

A Delta isolated facility may have the ability to benefit Delta habitat and ecosystem by potentially reducing fish mortality and salt intrusions, and improving water circulation. However, operation of the facility may have opposite effects also. Adverse impacts could include reversal of tide flows in the Delta portion of the Sacramento River. Altered flow directions may disorient fish during migration. Positive social impacts could be felt with recreational opportunities and aesthetic benefits associated with the creation of new lakes/reservoirs; however, these could have negative offsetting effects through the loss of similar benefits associated with compromised river areas.

Economically, each of these options would create construction, operation, and maintenance jobs. However, the construction of some facilities may also have large impacts on traffic flow (this is an issue with Auburn Dam site).

New conveyance facilities would help ensure supplies of water to agricultural, environmental, and urban users in Central California.

Table III-7f
Summaries of Estimated Environmental Effects due to Construction and Operation of New Surface Storage Facilities

Potential Site	Estimated Environmental Effects
Cottonwood Creek	Loss of 19,500 acres of habitat, much of it riparian, and 28 miles streams; blockage of anadromous fish; SNA[a] for bald eagle, special status bank swallow, and riparian forest
Marysville	Loss of several thousand acres of habitat, including 300 acres riparian and 18 miles of streams; substantial impacts to deer, turkey, and quail; SNA for western yellow-billed cuckoo
Garden Bar	Loss of 2,000 acres, including riparian and wetlands; impacts to anadromous fish and deer; conversions to agricultural land use; enlarged reservoir area of little value as fishery
Auburn Dam	Loss of 10,000 acres highly diverse upland habitat, and 50 miles of ecologically important stream and riparian corridor; a rare habitat configuration that is irreplaceable
Clay Station	Loss of 238 acres of wetlands, 63 miles of stream; SNA for vernal pools; Ione Chaparral sensitive plant community; four special status plant species
Deer Creek	Loss of 13,000 acres of habitat, including riparian and wetland; SNA for vernal pools, special status insects, birds, and plants; importation of water from source stream would compete with existing environmental needs of the water
Duck Creek	Loss of grassland and riparian habitat; importation of water from source stream would compete with existing environmental needs of the water
South Gulch	Loss of grassland and riparian habitat; importation of water from source stream would compete with existing environmental needs of the water
Montgomery	Loss of 8,000 acres, including riparian and seasonal wetlands important to waterfowl; vernal pools throughout grasslands
Delta Wetlands	Reduced water quality and reversed flows; fish migration impacts; increased predation, entrainment and water temperature; adverse affects to listed fish species; could substantially impact the environmental standards established in the December 15, 1994, Bay-Delta Accord and the May 1995 SWRCB Water Quality Control Plan
Los Banos Grandes	Loss of 14,000 acres of habitat, including extremely rare and ecologically important sycamore alluvial woodland, and 10 miles stream; special status birds, insects, and mammals, including kit fox
Fine Gold	Loss of riparian and wetland habitat; SNAs for plant species

a) Significant Natural Area as defined by the California Department of Fish and Game: Habitat areas having high ecological diversity, of significance to one or more species of plant or animal, unique for its assemblage of species, rare as a natural commodity.

Other Supply Options

A number of yield-increase options exist that do not readily fall into generic categories. Key among these are:

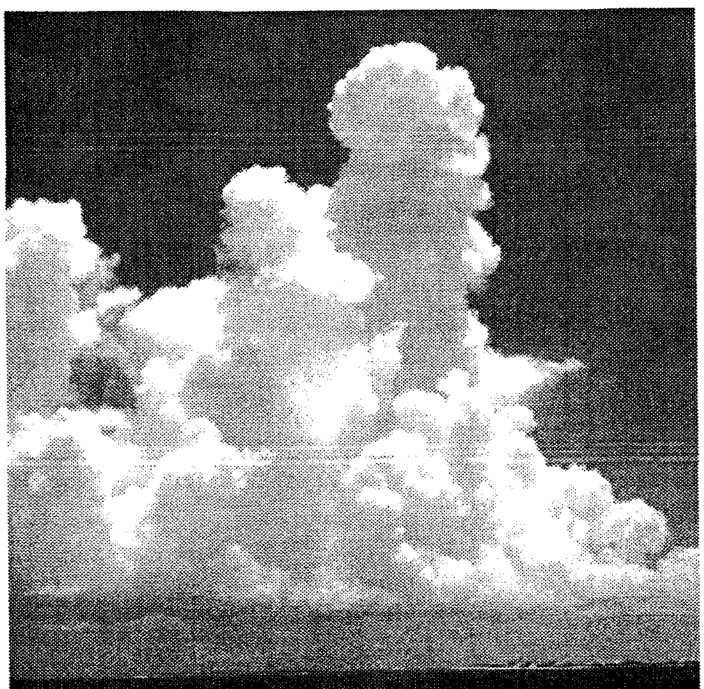
- Weather modification
- Snowpack management
- Desalination
- Water importation

Tables III-8a and III-8b list cost and yield increase estimates associated with these options.

Weather modification has a relatively large potential and small cost; however, yield assessment is difficult because there is no way to verify resulting water quantities

Weather Modification

Weather modification involves the seeding of storm clouds to induce rain or snow and thereby increase the quantity of subsequent precipitation. Seeding may be done from the ground, with the release of small amounts of propane, or from the air, with the release of propane or droplets of silver iodide.



Weather modification has a relatively large potential and small cost, and it has been widely practiced in California and a number of other locations. However, yield assessment is difficult. There is no way to verify resulting water quantities.

Yield estimates listed in **Table III-8a** for the upper Sacramento River basin are based on studies conducted in the Clair Engle Lake watershed over a 10-year period; estimates for other basins represent 5 percent of historical, unimpaired inflow (based on extrapolation of Clair Engle data). Estimates during drought conditions assume a 25 percent reduction in potential.

A number of environmental concerns have been expressed regarding weather modification. Primary attention has been given to the potential for lower soil temperatures and shortened growing seasons, greater levels of soil moisture, and erosion. Potential effects include delayed plant growth, changes in vegetation composition, delayed breeding activity by small mammals and other organisms, and effects on animal migration and winter range use.

Concern also has been expressed regarding the cumulative effects of cloud seeding, possible decreased air mass humidity contributing to decreased precipitation and/or

Table III-8a
Other
Yield Increase Options
Weather Modification and Snowpack Management

Activity	Annual Yield (1,000 af)	Cost [a] at Source ($/af)	Activity	Annual Yield (1,000 af)	Cost [a] at Source ($/af)
Upper Sacramento Basin			**Feather River Basin**		
Weather Modification	65 [b]	10	Weather Modification	160	10
Snowpack Management	25	200	Snowpack Management	65	200
Yuba River Basin			**Bear River Basin**		
Weather Modification	85	10	Weather Modification	10	10
Snowpack Management	35	200	Snowpack Management	5	200
American River Basin			**Mokelumne River Basin**		
Weather Modification	100	10	Weather Modification	25	10
Snowpack Management	40	200	Snowpack Management	10	200
Calaveras River Basin			**Stanislaus River Basin**		
Weather Modification	5	10	Weather Modification	40	10
Snowpack Management	0	200	Snowpack Management	15	200
Tuolumne River Basin			**Merced River Basin**		
Weather Modification	65	10	Weather Modification	35	10
Snowpack Management	25	200	Snowpack Management	15	200
San Joaquin River Basin			**Kings, Kaweah, Tule River Basins**		
Weather Modification	65	10	Weather Modification	85	10
Snowpack Management	25	200	Snowpack Management	35	200
Kern River Basin					
Weather Modification	30	10			
Snowpack Management	10	200			

a) Cost values for weather modification are based on studies conducted in the Clair Engle Reservoir watershed over a 10 year period (USBR Report No. R-93-19). Values for snowpack management are based on U.S. Forest Service studies but will vary greatly with implementation of specific sites.

b) Yield estimates are for the Trinity River watershed above Clair Engle Lake. The increased yield is assumed to be exported to the Sacramento River basin.

increased "downwind" evapotranspiration, and the potential need for increased downstream flood control because of sustained high flows.

From a social perspective, weather modification likely would increase skiing, river sport, and other winter recreational opportunities. At the same time, however, longer-lasting snowpacks could cut short other activities (such as camping) and also increase costs for highway snow removal.

From a legal perspective, it could be difficult to establish water rights to additional precipitation that might result, both in terms of amounts and location. For example, cloud seeding during a dry year might increase flows in a particular basin above what might otherwise have occurred. The question is whether the increased quantity should be available to riparian users and other diversions or only to the agency that performed the seeding.

It is anticipated that implementation of weather modification options will require additional appraisal-level investigations, feasibility investigation, environmental documentation and permitting, funding authorizations, and advanced planning, design, and construction. The total time required for implementation is estimated to be 12 years.

Snowpack Management

Snowpack management involves controlling vegetation so as to develop shadows over snowfields and subsequently delay snow melts and water runoff to streams. This would be accomplished by controlling timber harvests to maintain consistent tree heights at varying elevations of a mountain slope. Timber harvests would occur in stages that would maintain maximum shadows on snowfields. However, considering this activity relates to an increasingly regulated and declining timber industry, locations for implementation are probably limited. Yield estimates shown in **Table III-8a** were developed assuming 2 percent additional unimpaired runoff. Costs are relatively high reflecting the need for extensive forest management practices.

The yield increase potential with desalination is high, but it's also very expensive

Environmental considerations regarding snowpack management are comparable to those for weather modification (that is, the potential for lower soil temperatures and shortened growing seasons, greater levels of soil moisture, and erosion). In addition, concern has been expressed about artificially extending winter and delaying spring, in essence "changing the seasons."

Social, environmental, and timing considerations are comparable to those for weather modification, as well.

Desalination

Desalination involves the treatment of seawater or other brackish water to remove the salts and make the water usable for agricultural and urban purposes. There is extensive experience abroad with this technology, but application in the United states has been limited, short-term, and mainly to provide emergency water supplies (the City of Santa Barbara has a desalination plant online for use as an emergency supply). Desalination of brackish water (not as salty as ocean water) is, however, extensively practiced in Florida.

As indicated in **Table III-8b,** the yield-increase potential with desalination is large. However, this potential logically exists near oceans and bays and, therefore, water would have to be transported to inland users. To obtain these quantities for CVP yield would

Table III-8b
Other
Yield Increase Options
Desalination and Water Importation

Activity	Annual Yield (1,000 af)	Cost [a] at Source ($/af)	Activity	Annual Yield (1,000 af)	Cost [a] at Source ($/af)
Mokelumne River Basin			**Tuolumne River Basin**		
Desalination [b]	245	1,200	Desalination [b]	265	1,200
Water Importation			Water Importation		
Marine Transport [c]	200	700	Marine Transport [c]	200	700
Nylon Bags [d]	200	230	Nylon Bags [d]	200	230
Delta Export					
Desalination [c]	1225	1,200			
Water Importation					
Marine Transport [c]	200	700			
Nylon Bags [d]	200	230			

a) Values shown are based upon recent reports on desalination costs and, for importation, information from the State of Alaska and the Medusa Corporation.
b) Allowable desalination potenial exists when demand is adjacent to the ocean or a bay and demand area currently imports water from within the Central Valley. For purposes of this study, these areas include: San Francisco (through exchange of Tuolumne River water); East Bay Area (through exchange of Mokelumne River water); and Southern California (through exchange of Delta Export water). Yield values are based on average 1990 demands.
c) Importation of fresh water from sources in Washington or Alaska via single-hull tankers.
d) Importation of fresh water via nylon mesh bags specifically designed to transport water. Based on information from Medusa Corporation, Calgary, Alberta, Canada.

require coastal communities to sell their rights or contracts to allow water originating in the Central Valley to remain in the Central Valley. For this reason, estimates have been limited to the quantities exported from the Central Valley to these coastal communities. As indicated in the table, however, desalination is very expensive and the cost differential between desalinated water and inland water supplies undoubtedly would be substantial and negate potential exchanges.

Environmental considerations with desalination relate to the disposal of the concentrated waste products, impacts at the source of the water, and impacts attributable to construction and operation of conveyance, storage, and pumping facilities.

From a social perspective, establishment of desalination facilities would create construction, operation, and maintenance jobs. At the same time, however, construction would raise institutional issues comparable to those for surface storage and conveyance facilities.

It is anticipated that implementation of desalination will require additional appraisal-level investigations, feasibility investigation, environmental documentation and permitting, funding authorizations, and advanced planning, design, and construction. The total time required for implementation is estimated to be 17 years.

Water Importation

Importation of fresh water from Canada and Alaska via marine transport represents another potential water supply increase option.

Importation of fresh water from Canada and Alaska via marine transport represents another potential water supply increase option

Transportation was considered using single-hull tankers and nylon mesh bags towed by tug boats (so-called Medusa bags, specially constructed for water transport). Single-hull vessels are attractive because they are less expensive than other larger ships and a number currently exist in retired "moth-ball" fleets. Nylon mesh bags are attractive because they can carry more water than a typically sized, single-hulled ship and operational costs are less than with single-hull vessels because tug boats are used. However, their use is currently unproven for transport of large quantities of water on the open ocean, and more study and testing is required to determine their applicability and actual cost.

As indicated in **Table III-8b**, yield-increase potential with this option is sizable. However, costs are high, reflecting the need for docking facilities at the intake and discharge ends and transport facilities to inland sites. As with the desalination option, the potential exists that some coastal communities might be willing to sell their rights or contracts for water originating in the Central Valley to Central Valley users in exchange for imported water. However, this likelihood is small because imported water would be substantially more expensive. An alternative would be to bring the water into the Delta to a location such as the Port of Stockton and conceivably discharge it into an existing conveyance facility.

Potential environmental considerations with water importation include impacts at the source of the water; fisheries impacts; construction issues surrounding construction, maintenance, and operation of storage and conveyance facilities; and the potential that importation of non-native species in the water could cause an imbalance in the destination ecosystem.

The total time required for implementation of water importation options is estimated to be greater than 17 years.

Section IV
The Least-Cost CVP Yield Increase Plan

In This Section:

- Summary of characterized options
- Results of final screening
- Transport costs and constraints
- Least-cost CVP yield increase plan
- Implementation considerations
- Cost sharing

Summary of Characterized Options

The CVPIA required preparation of a *Least-Cost CVP Yield Increase Plan* with the purpose of increasing the yield of the CVP by the amount dedicated to fish and wildlife purposes. This plan serves to: 1) minimize adverse effects, if any, to existing CVP water contractors resulting from dedication of water to fish and wildlife, and 2) to assist the State of California in meeting its future water needs.

The PEIS is describing effects on CVP contractors of dedicating CVP yield for fish and wildlife purposes. The magnitude of this effect will be taken into account by Congress in determining whether to implement all or any of the Yield Increase Plan.

Implementation of the Yield Increase Plan would also serve to narrow the gap between statewide future water demands and future water supplies as projected by DWR.

Over one hundred yield increase options have been identified in Section III. **Figure IV-1** is a summary of all the options identified showing the range of yield potential and the range of costs, including transport costs. Options have been presented in two separate groups, demand reduction, and supply increase. As can be seen on the graph, the two groups combined could account for over 11 million af of potential yield. Effects of implementation of any upon the yield estimate of another are not taken into consideration. Rather, this graph represents the basic "order" of options.

The CVP Yield Increase Plan includes the lowest cost set of these options that pass the final screening criteria. As required by CVPIA, both supply increase and demand reduction options have been considered. Implementation of demand reduction options can increase the yield of the CVP because water supplies from those options would be acquired from outside existing CVP contracted water supply only.

Final Screening

An appraisal-level final screening was applied to the options using the results of the detailed characterization to determine which could be included in the *Least-Cost CVP Yield Increase Plan*. Options were screened based on verifiable yield, environmental considerations, social considerations, timing criteria, and cumulative yield. Options that pass this final screening will also be subject to additional screening in subsequent analyses and feasibility studies.

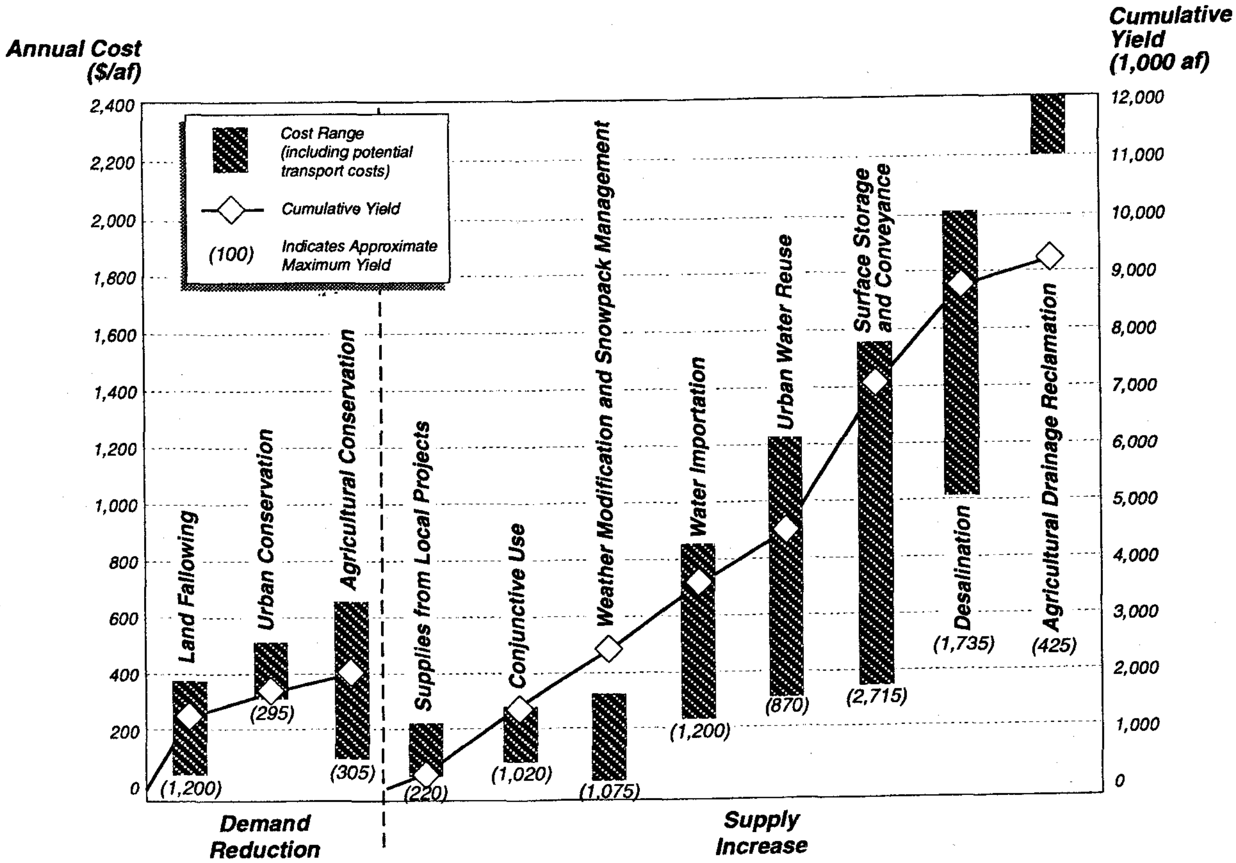


Figure IV-1
Summary of Demand Reduction and Supply Increase Options for CVP Yield Increase

What's Included in the Yield Increase Plan

Options that have been retained for consideration in the Yield Increase Plan fall within the following categories: *Land Fallowing, Conservation, Supplies from Local Projects, Conjunctive Use, Water Reuse, and Surface Storage and Conveyance.*

Table IV-1 shows total annual yield estimates of these options and their prominent characteristics. Yields shown in this table differ slightly from those shown in Section III because they take into account transport considerations.

A number of options with smaller yields rather than a single, large yield option are available for inclusion in the Yield Increase Plan. Together, they offer approximately 3 million af of yield. These options and yield are designed to give the Yield Increase Plan flexibility to adapt and remain viable over time and to account for increasing competition for water in California. Multiple options also offer the flexibility to tailor yield increase activities to best match specific needs. If Congress decides to authorize implementation of the Yield Increase Plan, it will be necessary at that time to determine which options may have been implemented for other purposes since this report was prepared, and thus which are still available.

The largest potential annual yield is associated with *Conjunctive Use* programs using active recharge. The combined valley-wide potential is over 800,000 af. The capability exists to expand this yield potential in the southern San Joaquin Valley, if water supplies are imported into groundwater basins that have ample "space" but limited local supplies. Importation, however, will raise the unit cost to account for additional conveyance. Furthermore, the ability to import water to conjunctive use sites south of the Delta is uncertain until a Bay/Delta management plan is developed. Implementation of conjunctive use programs will require that Groundwater Management Plans be in place.

Although when added together, *Land Fallowing* options have the potential for more yield than conjunctive use programs, they are presented as four levels of increasing water supply. Because of their wide range in cost, the probability of implementation of *all* land fallowing potential options is low.

Based on the analyses presented in Section III, it appears that it is possible to implement up to Level 4 land fallowing in some regions.

Impacts can be mitigated by requiring that land fallowing be temporary, part of normal agronomic rotation, and dispersed throughout the Central Valley. In addition, impacts can be minimized by limiting land fallowing to Levels 1 and 2. Regardless of the predicted impact, land fallowing has the potential to cause substantial concern and divisiveness within local communities. In order to respond to these concerns, land fallowing should only occur with complete local agency, government, organization, and public partnerships.

The DWR and other organizations believe the land fallowing should not be relied on too heavily for CVP yield increase. Although fallowing of land with non-CVP contracted water supply can increase CVP yield, it does not increase total water supplies in the state. However, it would serve to decrease future water demands.

Another category with a relatively large potential for yield increase is *Supplies from Local Water Projects*. Under this category are options to develop yield through wet weather or

Final Screening

Options were included in the *Least-Cost CVP Yield Increase Plan* based on the following screening criteria:

- **Verifiable Yield:** They provided a *verifiable* supply of water. Options that have speculative or unquantifiable yields and that include unproven technologies were not included.
- **Environmental Considerations:** They did not cause known unacceptable impacts on wildlife habitat or endangered species. Unacceptable adverse impacts are those considered unmitigable and contrary to the purposes of the CVPIA.
- **Social Considerations:** They did not produce substantial negative impacts on local or regional economies.
- **Timing:** They could be implemented before October 2007. This is a stipulation of the CVPIA.
- **Cumulative Yield:** They have a cumulative yield of approximately 3 million af/yr. This cumulative yield is necessary to account for the possible effects of competition for water supply.

Table IV-1
Categories of Options Included in the Least-Cost CVP Yield Increase Plan [a]

Yield Increase Options	Annual Yield [b] (1,000 af)	Range of [c] Cost at Source ($/af)	Characteristics
Land Fallowing			
Level 1	309	55-205	Potential social impacts can be mitigated through temporary, rotational, and dispersed fallowing; may cause divisiveness in local communities, especially at higher levels; would be implemented with local partnerships
Level 2	309	60-215	
Level 3	309	65-235	
Level 4	309	65-255	
Conservation			
Agricultural conservation	215	100-200	Supports the economic viablity of agriculture, environmental benefits with decrease in irretrievable losses
Urban conservation	230	315-390	More efficient use of water resources; environmental benefits with decreases in irretrievable losses
Supplies From Local Water Projects	180	30-70	Low cost; potential environmental benefits; timely potential implementation
Conjunctive Use			
Active recharge	840 [d]	90-120	Relatively large-yield, low-cost storage alternative; makes efficient use of limited resources; operational flexiblity; environmental effects of stream diversions require study
Developable perrenial yield	70	60	No construction required; low cost; operational flexiblity
Water Reuse			
Urban discharges to ponds/saline sinks	200	285-330	Potential for groundwater recharge; wholly new source of water; proximity to agricultural areas
Surface Storage & Conveyance			
Enlarged Farmington	30	300	The facility included is offstream and operated for temporary storage only
TOTAL ANNUAL YIELD	**3,001**		

a Section III presents a detailed characterization of these options.
b Includes multiple projects with differing levels of effectiveness.
c Costs for options involving purchase of water may increase as competition for water supplies increases.
d Yield adjusted for transport considerations.

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operational spill management. Almost 200,000 af is estimated to be available from these types of options. Obtaining yields associated with these options will require purchases of water from the local agencies that own the projects. Such purchases could be annual or multi-year but probably would not involve permanent transfer of associated water rights.

The cost for local project options was estimated using recent payments for similar purchases of water by federal, state, and local agencies. In addition, because these options can be implemented almost immediately, there is a high chance that their availability for CVP yield increase will significantly diminish in the next several years.

The inclusion of urban *Water Reuse* adds an estimated 200,000 af of yield increase potential. Options included are only those that currently discharge to ponds or saline sinks. Estimates are based on planned increases in wastewater outflow as population grows. The potential exists for municipal wastewater agencies to plan on these increases as part of their own water supplies, thus diminishing the potential for use as CVP yield. For treatment plants located within agricultural regions outside of the urban areas they serve, reused water would be transported directly to an area of need. However, many of the large treatment plants in the Central Valley that discharge to ponds are not located within CVP service area lands. Use of this potential would require exchanges of water supplies, which may further reduce the potential for implementation.

Conservation potential in both the agricultural and urban sectors adds over 200,000 af of yield increase potential. In addition, conservation would need to be implemented over a widespread area to obtain its full yield potential. For example, obtaining urban conservation savings would require implementation of BMPs throughout an urban area, not just in isolated neighborhoods. In the same manner, development of agricultural conservation potential would require all growers to make improvements to their water application systems and methods. Need for widespread adoption of BMPs can make achievement of full yield potential more difficult.

What's Not Included in the Yield Increase Plan

Some of the options that were eliminated as part of the final screening conceivably could have been eliminated in the initial phases of the study. However, they were carried forward through detailed characterization to obtain sufficient information to more fully and fairly assess them, and in response to requests from individuals and agencies that may be impacted under the CVPIA.

The largest category of options eliminated from inclusion in the Yield Increase Plan is *Surface Storage and Conveyance*, with the exception of an enlarged Farmington Dam.

These options were eliminated primarily because of timing considerations and because their cost does not place them within the first 3 million af of lowest-cost yield increase options. In addition, substantial concern regarding the environmental effects of these options exist. Environmental effects have been summarized in Tables III-7e and III-7f.

Options under the *Modifications to CVP/SWP Operations* category were eliminated because they are part of ongoing efforts of Reclamation and the State of California, as well as other organizations, to continually increase the efficiency of the projects. Implementation of some of the options listed under this category may occur regardless of this Plan. These options are not considered to be viable CVP yield increase options.

Urban Discharges to Rivers or Streams has been eliminated as a yield increase option. The potential lies only with the increase between current discharge levels and those that may occur in the future. Because these flows are not yet present, and because they may be considered part of required instream flows, their yields are not verifiable.

Agricultural Drainage Reclamation options were eliminated because they were not among the first 3 million af of lowest-cost options.

Other options eliminated include those under the *Other* category. Desalination and water importation projects are not cost-effective when compared to the other options. In addition, importation of water from sources to the north of California raises substantial environmental concerns. As for weather modification and snowpack management options, there simply is no method to verify yields produced. Although weather modification does appear to produce yield at very low cost, unquantifiable yields along with the potential adverse effects on the local and "downwind" environments make this subcategory infeasible for CVP yield increase.

Transport Costs and Constraints

Transport Costs

Development of a *Least-Cost Yield Increase Plan* from the options passing the final screening requires consideration of transport costs and potential physical transport constraints.

The additional cost resulting from transport and delivery of water to need locations is referred to as the transport cost. This cost includes the operational and maintenance costs incurred in conveying water to the destination and the cost associated with conveyance and carriage water losses. Carriage water requirements are assumed to be included as a 35 percent surcharge for all deliveries that require transportation through the Delta (outcome of the recent December 15, 1994, Bay/Delta agreement may change this requirement under certain hydrologic conditions).

Table IV-3 presents the added transport cost that is associated with delivering water from a particular option to a particular need location. The values shown have been calculated for an assumed annual cost of water of $100 per af. Costs less than or greater than this will affect the added transport cost accordingly.

Table IV-3
Annual Transport Cost ($/af)

From→ / To↘	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	Region 11
Region 1	0	34	32	15	30	-7	✘	✘	-7	-7	-7
Region 2	29	0	26	8	24	-10	✘	✘	-10	10	10
Region 3	21	20	0	-1	15	0	✘	✘	0	0	0
Region 4	37	36	34	0	31	8	8	8	8	8	8
Region 5	✘	✘	26	6	0	✘	-11	✘	✘	✘	✘
Region 6	110	109	104	92	99	0	35	34	34	34	34
Region 7	✘	✘	✘	✘	✘	✘	0	48	✘	✘	✘
Region 8	✘	✘	✘	✘	✘	✘	✘	0	✘	36	36
Region 9	120	119	113	101	109	43	40	39	0	39	39
Region 10	123	121	116	103	111	54	50	49	49	0	49
Region 11	126	125	119	106	114	76	72	70	70	70	0
M1	47	47	45	27	45	36	✘	✘	36	36	36
M2	172	170	165	154	161	123	123	123	123	123	123
M3	129	128	122	110	118	90	90	90	90	90	90
M4	232	230	225	211	220	223	223	223	223	223	223

Notes:
1) The transport cost includes cost for use of facilities, transaction cost, and conveyance loss. For purposes of display in this table, conveyance loss is valued at $100 per af.
2) Cells marked with an ✘ assume water transfers are not feasible.
3) M1 through M4 represent urban centers in the following areas: M1=North Bay areas/Sacramento Valley; M2=East and South Bay areas; M3= Central and South coast; M4= San Joaquin Valley

The federal government has not yet established written policies on the rates associated with transportation that would be applicable for implementation of yield increase options. The costs shown were developed pursuant to anticipated rules based on provisions of CVPIA along with existing transfer rates. In general, transport of water would incur an additional cost associated with operations and maintenance, but would not be subject to additional capital costs for CVP facilities. (The costs of these facilities are already being paid under allocations to existing project contractors.)

Negative values reflect implementation options. For example, south of the Delta, which eliminated a portion of the need to export water and thus reducing operational cost and conveyance losses through the Delta.

Potential Transport Constraints

The remaining consideration to allow "linking" options with potential yield increase need locations is the establishment of possible conveyance limitations for water to be transported through the Delta. Existing and pending requirements for Delta water quality and fish and wildlife habitat do limit the ability to transport water south of the Delta. However, given that this plan addresses replacing yield that had been delivered in the past, and capacity is already in place to convey CVP yield, the total quantity of CVP export will not exceed recent levels.

In addition, yields for options are based on estimates during periods of drought. Typically, shortages for both CVP and SWP contractors occur during drought periods because of reduced supplies. As a result, it is expected that capacity for transport of replacement supply across the Delta and subsequent exportation exists.

The flexibility designed into the Yield Increase Plan could accommodate Delta constraints greater than expected. Since the plan includes 3 million af of yield increase potential, many options for which occur south of the Delta, sufficient sources of supply would be available to meet the replacement needs without Delta transport.

The Least-Cost CVP Yield Increase Plan

The results of the screening process produced a number of options with more than 3 million af CVP yield increase potential. These options are located in various regions and hydrologic basins within the Central Valley.

Because of the existence of major conveyance facilities and established exchange potentials, most of the options can be used to meet yield increase needs anywhere in the Central Valley.

Figure IV-2 is a summary array of the options available for inclusion in the Yield Increase Plan. The array is shown by category with the ranges representing variations in cost (including transport) and potential yields achievable through implementation of the options. Categories are arrayed on the basis of their financial cost and cumulative water supply. Other attributes are less quantifiable and are not shown although they have been taken into account during the screening. As shown by **Figure IV-2** the differences in costs among the categories that make up the first 2 million af of cumulative yield (Categories 1 through 6) are not significant. Therefore, the order of implementation of options in these categories most likely will be driven by factors other than cost.

Costs in this figure differ from those in Section III and **Table IV-3** in that they include increases or savings attributable to the transport. This cost increment can influence decisions to implement one option versus another in a specific need location. For example, a seemingly more expensive option in Region 9 may actually be less expensive in meeting a local need than a seemingly lower cost option in another region when transportation costs are included (see earlier transport discussion).

Recent developments indicate increased future competition for water, both for currently developed supplies and for future supply increase options. Effects of competition can be demonstrated with the aide of **Figure IV-3.** This Figure shows the CVP Yield Increase curve that is the result of ordering individual options form the least costly to the most costly, rather than the ordering of yield increase categories that is shown in **Figure IV-2.**

Competition will affect the cost of CVP yield increase in two ways. First, other water users may develop some of the low-cost supply options before the federal government can. Referring to **Figure IV-3**, this may mean eliminating some options at the lower left section of the cost curve. Second, the price of water purchased through market mechanisms (e.g., from reoperation of local reservoirs, supplies from local projects, or from

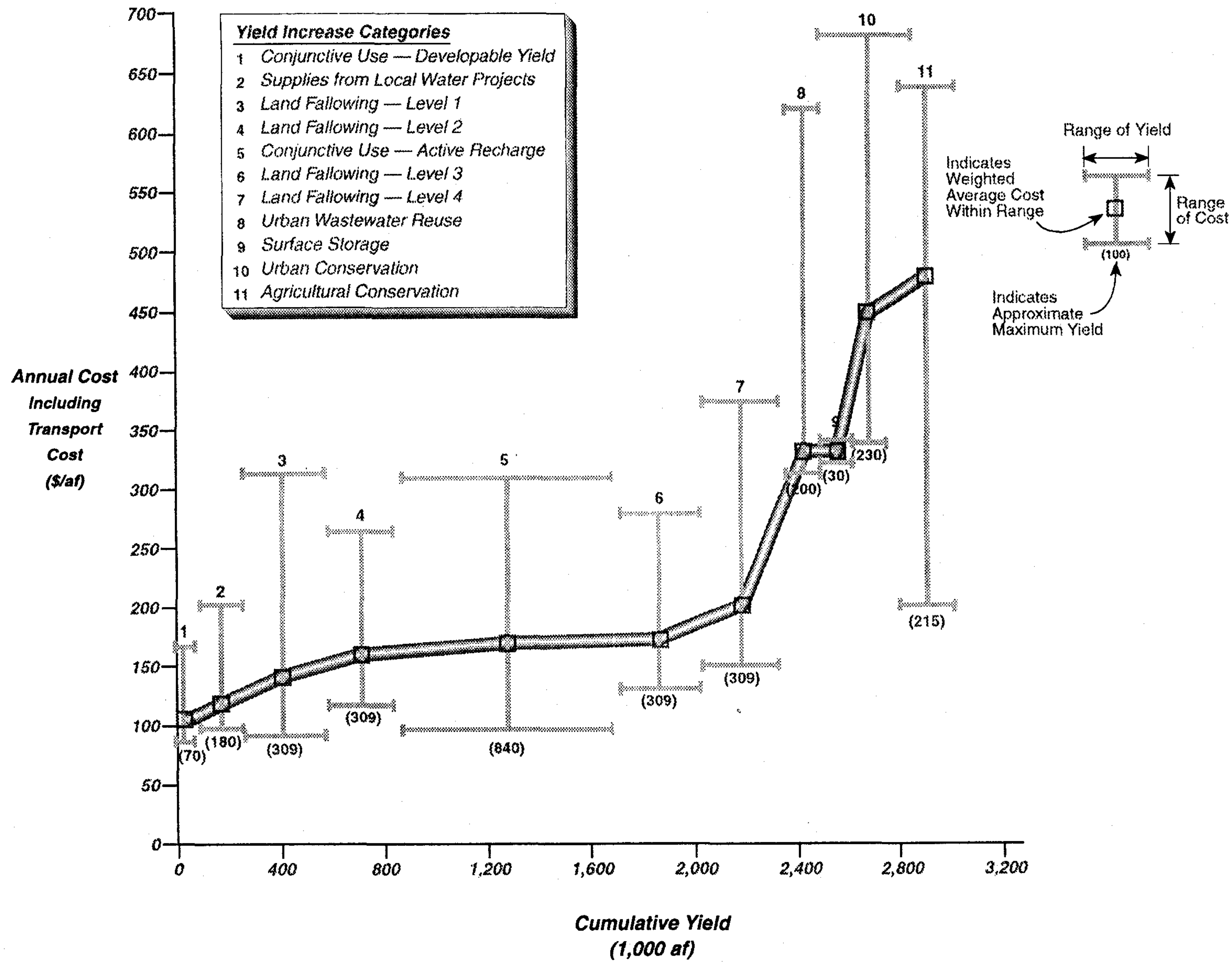


Figure IV-2
Summary Array of Options

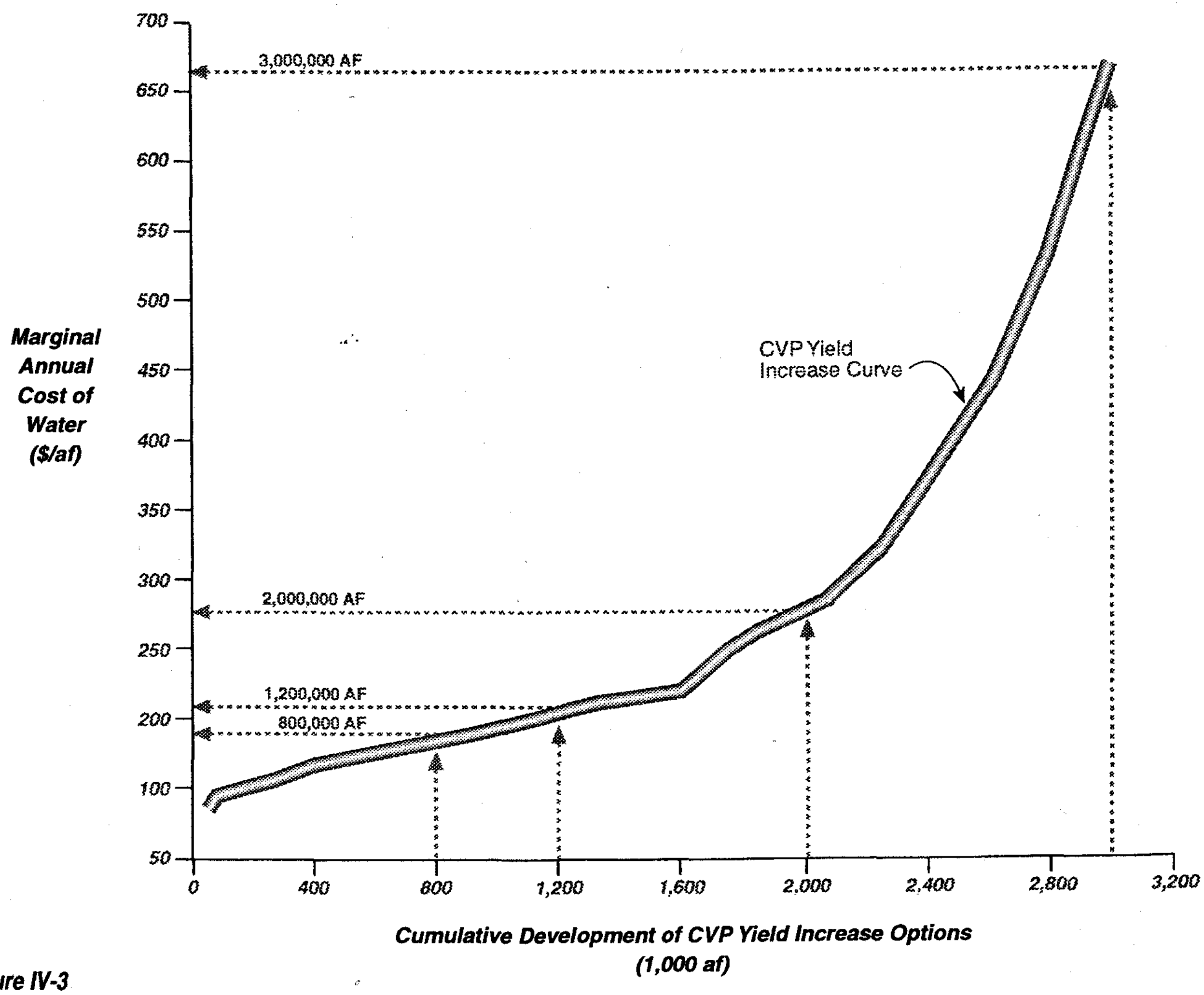


Figure IV-3
Effects of Competition on Cost

land fallowing) will be bid upward over time by other federal and non-federal demands, including increasing M&I demands and supplemental water for fish and wildlife restoration. In **Figure IV-3**, this means shifting upward any portion of the cost curve corresponding to market-based options. Potentially the shift could mean that some new supply options may have lower financial cost than some market-based options.

Competitors for water in the near term, in addition to the 800,000 af of yield increase that this plan addresses, may include over 1 million af of municipal needs, 550,000 af for CVPIA supplemental water (purchase of yield increase water and purchase of supplemental water would be coordinated), and 800,000 af for the state's 1991 drought water bank. A total of over 3 million af of competition could affect costs for purchasing yield increase water.

An important implication of a purely competitive market for water is that all water would be sold at or near a market-clearing price. This price is determined by the marginal cost of water, that is, the cost associated with the next increment of supply that would enter the market. Using

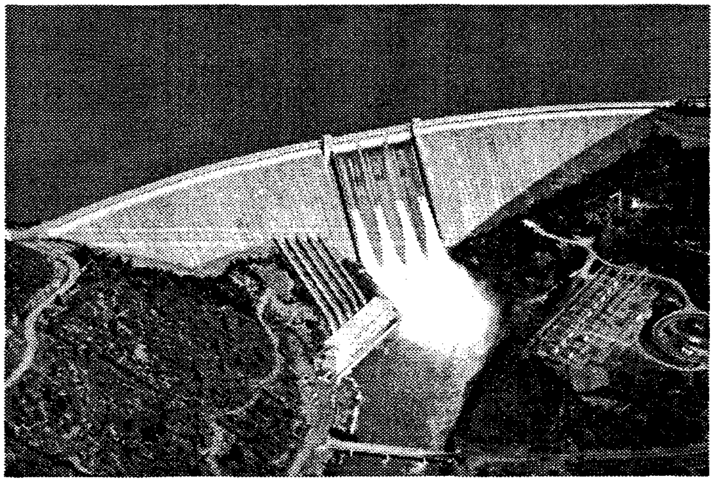
Figure IV-3 for illustration (and ignoring locational differences in price), if 800,000 af were being sold in a purely competitive market under present market conditions, the price for all water sold would be about $170 per af, even though the first increments of water may actually cost less than $100 per af to produce. If 3 million af were being sold in a purely competitive market, the marginal cost for implementing the Yield Increase Plan with options that involve purchase of water could be as high as $650 to $700 per af. The difference between price and cost for those increments is profit to the seller. In reality, the market for water will not be purely competitive with a single market price, but will produce a variety of selling prices. The variety will reflect differences in contract terms, location, bargaining power, and information. Nevertheless, the marginal cost of water will strongly influence all water sale agreements. As competition for water increases in the future, the marginal cost and market price will be driven upward. Also, as competition increases, options not requiring purchase of water, such as conjunctive use, become relatively more attractive.

At some future date, Congress may authorize implementation of the Yield Increase Plan. At that time, it will be necessary to determine the current condition of the California water market and its impact on costs for purchasing water. It will also be necessary to determine which options have been acquired or developed by other water suppliers since this report was prepared. A refined set of options that serve to mitigate any adverse impacts as identified in the PEIS, and are available at the time of authorization, would be determined.

This plan presents an appraisal level evaluation of options that will need to be refined as specific needs for yield increase become better known with the completion of the PEIS. The methodology that was used to optimally link options with areas of need can be applied to these specific need areas. In this way, the most cost-effective options can be determined. It is likely that no option category will dominate a refined set of options. The refined plan will contain a combination of option categories that would minimize reliance on a single yield increase type and would also minimize any particular kind of adverse impact.

Implementation Considerations

Many of the options identified as part of the Yield Increase Plan represent small increments of yield when compared to the large quantities of water managed by the CVP in meeting the geographically dispersed and diverse needs of its water contractors. In addition, many involve options that originate with or would be controlled by public agencies or private organizations other than the federal government.



Water Transfers

Water transfers may be required in order for the yield associated with an option discussed in the Yield Increase Plan to become available to increase the yield of the CVP.

Water transfers must be conducted under California law and be consistent with federal regulations.

Water associated with most types of water rights can be transferred. Most water rights themselves can also be transferred.

Water rights are either riparian or appropriative. Appropriative rights established after 1914 are acquired with a permit from the State Water Resources Control Board (SWRCB).

Riparian rights cannot be transferred, but riparian water can be made available, through contract or purchase, to a downstream diverter. This action does not require approval from the SWRCB.

Transfer of pre-1914 appropriative rights or associated water also does not require approval of the SWRCB as long as there is no adverse effect on another water user.

Transfer of post-1914 appropriative rights or associated water does require approval of the SWRCB if the transfer involves a change in the permitted purpose of use, point of diversion, or place of use.

Transfer of water purchased from outside the CVP to increase the yield of the CVP would require SWRCB approval.

There are several procedures for obtaining SWRCB approval.

If the transfer lasts 1 year or less, a "temporary change" is the most commonly used approach. CEQA is not required for this approach, but the SWRCB usually requires supporting information to be submitted to support a finding of no unreasonable social or environmental impact.

Long-term transfers (more than 1 year) require CEQA compliance.

The SWRCB is currently not allowing transfers that involve additional export from the Delta. For the purposes of the *Least-Cost CVP Yield Increase Plan*, it is assumed that water transfers across the Delta would be allowed because there would be no increase in export above that which occurred before the CVPIA.

As a result, implementation of these opportunities will add to the overall complexity of the CVP system, requiring application of new, more sophisticated management tools (e.g., real time monitoring, dynamic modeling) and closer cooperation with other water resource agencies and users.

Many of the options presented in the Yield Increase Plan have the potential of being implemented by local or private interests with the intention of making the associated yield available for purchase. In these cases, transfers of the water from the implementor to the federal government would be required. For example, in order for a farmer to fallow a portion of his land and sell the associated water to the federal government, he would be required to transfer the water to the federal government. In the same way, a local agency may develop an active recharge conjunctive use program and wish to sell some of the associated yield to the federal government. This would also require the water to be transferred to the federal government.

Implementation of water purchase options by the federal government should be coordinated with acquisition of CVPIA supplemental water and other federal programs that could result in the fallowing or retirement of farmland. Options that can be implemented with multiple purposes are more cost effective than those implemented for environmental or yield increase purposes alone. Coordination would assure that the federal government would enter the water market in a consistent and appropriate manner, that water acquisition would be conducted to provide the greatest benefit to both the environment and water contractors, and that local economic impacts and social concerns would be minimized.

Implementation of the Yield Increase Plan is not expected to be in conflict with or contrary to any other on-going federal activity. Flexibility was specifically designed into the development of the plan. Since additional analyses or feasibility studies would be required prior to implementation, the Yield Increase Plan easily can be updated or revised to reflect changes. These changes could include: delta transport constraints, water quality standards, endangered species, competition in the California water market, and permits and licenses.

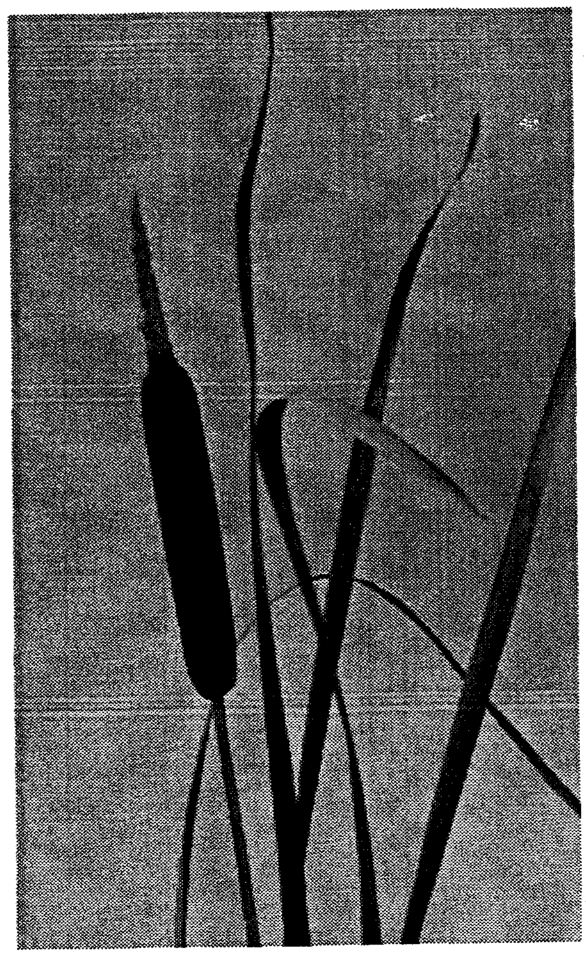
Congress may also choose to reduce the federal role to that of technical and administrative assistance. Assistance could include special studies, design, streamlining of rules and procedures, and innovative cost-sharing arrangements.

Cost-Sharing

Cost-sharing can include both the financing of the implementation of an option and annual costs. Cost-sharing formulae can range from only federal participation to no federal participation. Willing cost-sharing partners could include the State of California, and local agencies or other interest groups.

Some organizations believe that the cost should not be borne by the state or federal taxpayers, but by those entities who benefited from CVP water supplies prior to enactment of the CVPIA and who would receive water supplies resulting from implementation of the Yield Increase Plan. Others believe the federal government should bear the full cost in order to mitigate for adverse impacts associated with dedication of CVP yield. The PEIS is being prepared to analyze adverse effects, if any, of dedicating yield under the CVPIA. These results will serve as a guide in determining appropriate cost-sharing arrangements.

Cost-sharing with the state may be appropriate if options are implemented that provide yield to both the CVP and the SWP. Local agencies in areas impacted by the dedication of CVP yield may be capable of implementing options more efficiently than the federal



government. Therefore, cost-sharing could take the form of federal grants to local communities or agencies. Other groups may be interested in cost-sharing if implemented options provide some ancillary environmental or other benefit (such as recharge basins for conjunctive use managed as a wildlife habitat). In these instances cost-sharing could be in the form of federal grants or federal/non-federal partnerships. Cost-sharing could also be modeled after current CVP cost allocation and ratesetting policies.

Appropriate cost-sharing arrangements would be developed as part of subsequent analysis, feasibility studies, and environmental documentation that would be required before implementation of the Yield Increase Plan.