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Supplemental Information to the Draft Environmental Impact Statement for the Central Valley Project, West San Joaquin Division, San Luis Unit Long-Term Water Service Contract Renewal

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region

February 2006

DRAFT SUPPLEMENTAL INFORMATION
TO THE DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
CENTRAL VALLEY PROJECT, WEST SAN JOAQUIN DIVISION,
SAN LUIS UNIT LONG-TERM WATER SERVICE CONTRACT RENEWAL

Lead Agency:	U.S. Bureau of Reclamation
Title of Proposed Action:	Renewal of Long-Term Water Service Contracts for the San Luis Unit of the West San Joaquin Division of the Central Valley Project
Affected Jurisdictions:	Fresno, Kings, and Merced Counties, California Cities of Avenal, Coalinga, and Huron, California
Designation:	Draft Supplemental Information to the Draft Environmental Impact Statement (DEIS) Central Valley Project, San Luis Unit Long-Term Contract Renewal

Reclamation initially released a draft Environmental Impact Statement (DEIS) for long-term contract renewal for San Luis Unit water service contractors of the Central Valley Project (CVP) in November 2004. The comment period on the original DEIS closed in January 2005. Upon review of the comments received, Reclamation decided to prepare a new DEIS. Comments on the first DEIS were not responded to in detail but were utilized in the preparation of the new DEIS.

A new DEIS was prepared and released for a 45 day public review and comment period that began on October 7, 2005. Prior to closure of the review period in late November 2005, Reclamation received requests for extension of the comment period. As a result of these requests and ongoing discussions with the Environmental Protection Agency, the comment period was extended to January 17, 2006. During the extended comment period, Reclamation decided to prepare supplemental information (supplement) to the DEIS.

Reclamation has concluded that the information and topics discussed/identified in this supplement represent additional information that does not bear on the effects of the proposed action, nor does it bear on differing environmental consequences between the alternatives. Rather, the information is beyond the scope of the proposed action. The additional information responds to questions raised to Reclamation during the comment period.

The topics discussed in the supplement include the following: Contract Reduction Alternative, Environmental Effects if Federal Drainage is not Provided, Potential Effects on Contractual Amounts with Land Retirement, Effects of Increases in Contract Deliveries, Drainage Management related to the Drainage Feature Reevaluation Study, and Contracts in the Context of the Central Valley Project Improvement Act.

The public comment period for this Supplemental Information extends until April 10, 2006. In addition the public comment period on the related DEIS will be extended until April 10, 2006. Written comments should be addressed to:

Mr. Shane Hunt, U.S. Bureau of Reclamation
South Central California Area Office
1243 N Street
Fresno, CA 93721-1813

TABLE OF CONTENTS

I. Background

Reclamation initially released a draft Environmental Impact Statement (DEIS) for long-term contract renewal for San Luis Unit water service contractors of the Central Valley Project (CVP) in November 2004. The comment period on the original DEIS closed in January 2005. Upon review of the comments received, Reclamation decided to prepare a new DEIS. Comments on the first DEIS were not responded to in detail but were utilized in the preparation of the new DEIS.

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During the extended comment period, Reclamation decided to prepare supplemental information (supplement) to the DEIS. Following the decision to prepare a supplement, Reclamation extended the comment period for the DEIS through the end of the comment period for the supplement. Comments on the DEIS and the supplement may be submitted together and are now due by close of business on April 10, 2006.

II. Purpose of the Supplement

The DEIS addresses the environmental effects of renewal of water service contracts as compared to a no action scenario of essentially continuing the status quo. Thus, the effects of the action analyzed in the DEIS resulted from changes in contract provisions and not from any significant changes in ongoing operations. This complies with the Council for Environmental Quality's (CEQ) guidance provided in their document entitled "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations". Question 3 of the guidance pertains to what must be included in a "no action alternative". The answer indicates that in cases where ongoing programs initiated under existing legislation and regulations will continue, "no action" is "no change" from current management or direction.

Notwithstanding CEQ's guidance, questions have been raised relative to the no action conditions and the effects of alternatives considered but eliminated from analysis. Responses to the questions that have been raised are not necessary to achieve NEPA compliance for the proposed action. However due to the high level of interest in the proposed action and in an effort to respond to requests for additional information on various scenarios (even though not resulting from the proposed action), Reclamation has decided to prepare this supplement to the DEIS to provide information responding to the questions raised.

Reclamation has concluded that the information and topics discussed/identified in this supplement represent additional information that does not bear on the effects of the proposed action, nor does it bear on differing environmental consequences between the alternatives. Rather, the information is beyond the scope of the proposed action.

III. Topics addressed

A number of topics were identified for clarification or additional information. These topics are identified in the following section with the additional information or further clarification following each topic. Since some of the topics are closely related to others information presented may overlap, while others are more accurately characterized as "stand-alone" topics. The topics and additional information or clarification provided are as follows:

III. A. Contract Reduction Alternative
Reclamation was requested to consider an alternative of reducing contractual amounts, either as a conservation alternative or as mitigation for ongoing effects of contract deliveries.

Consistent with 40 CFR 1502 the alternative of reducing contract quantities was considered but eliminated from analysis. The reasons for this were discussed on page 2-34 of the DEIS, and are stated as follows:

- Water needs assessments were completed that demonstrated that the entire contract amount could be put to beneficial use, and in all cases demand exceeds the total contract quantities.

- Contracts contain shortage provisions that allow for contract quantities to be reduced when hydrology, environmental requirements, or fish and wildlife provisions of the CVPIA reduce amounts available to water service contractors.

- Reductions in contract amounts would reduce the ability/opportunity to make investments for good water management, such as banking and storage facilities that would balance out supplies in wet and dry cycles.

- An alternative of reducing contract amounts would not fulfill the purpose and need statement which calls for contract renewal consistent with Reclamation authority and applicable federal laws, including the CVPIA.

Specific to the right to renew and contract quantity issues, the DEIS summarizes federal Reclamation Law supporting renewal of the contracts at pages 1-2 through 1-4. It notes that CVPIA Section 3404(c) provides that the Secretary "shall, upon request, renew any existing long-term repayment or water service contract for the delivery of water from the Central Valley Project for a period of 25 years each. . . (after) appropriate environmental review, including preparation of the environmental impact statement required in section 3409 (i.e., the Programmatic Environmental Impact Statement). . ."

The Programmatic Environmental Impact Statement (PEIS) itself considered renewal of existing contracts for the existing contract quantities in the context of implementing the full range of actions or programs to meet the objectives of CVPIA, as summarized at DEIS pages 1-4 through 1-6. The Record of Decision (ROD) based on the PEIS represents the agency decision on achieving the greatest level of a reasonable balance among competing demands. Thus, an alternative to reduce the contractual water quantity is inconsistent with the framework of the ROD for implementing the provisions of the CVPIA. In addition, a reduction in contract quantity is unnecessary to accomplish CVPIA goals because of the flexibility in adjusting contract allocation incorporated into the contract shortage provisions, the contract provisions to insure water conservation objectives, and the contract obligation to comply with environmental laws.

In terms of Reclamation's obligation to the contractors, the contractors requested renewal for the existing contract quantities, and the evidence developed as part of the renewal process demonstrates that each contractor has sufficient demand to put the full contract quantities to beneficial use. Additional support for renewing the contracts for the full contract quantities specified in the existing contracts can be found in Section 8 of the 1902 Federal Reclamation Act (43 U.S.C. 372), the 1956 Project Act (43 USC 485h1-4), State law, and various judicial opinions.

Under all of these authorities and circumstances, Reclamation implements its obligations to the contractors and to the environment by selecting contract renewal alternatives that provide the existing contract quantity, so it did consider, but eliminated from further consideration, the reduced quantity alternative.

<u>III. B. Environmental Effects if Federal Drainage is Not Provided</u>
Questions have been raised as to the environmental effects related to drainage if Federal drainage service is not provided following contract renewal.

The matter and future of drainage service is a separate action from renewal of water service contracts, and this is not the subject of the DEIS. Drainage is being addressed in a separate study and NEPA document, the San Luis Drainage Feature Re-evaluation Study (DFRES). Thus the potential impacts of not providing drainage service are described in the DFRES EIS. As stated above, the contract renewal DEIS focuses its analysis on the differences between the no action scenario and the implementation of new contract terms, which are primarily administrative and financial in nature. As also noted above, the law mandates contract renewal. The contractual action contains no provisions for and involves no discretionary action related to drainage. Because drainage service is mandated by law, it would not be appropriate to assume in the DEIS that the mandate would be ignored.

The no action alternative in the DFRES was developed for a specific purpose, to describe the worst case scenario if no drainage plan were implemented. This description is hereby incorporated by reference and Appendix A of this supplement provides a summary of that description. In contrast, the contract renewal DEIS included both more current information and describes the scenario that a federal plan would be implemented or in the alternative, local interests would take action on their own to address drainage problems as that would be in their best interest.

Thus effects described in the DFRES DEIS under the no action alternative cannot appropriately be ascribed to the contract renewal DEIS no action alternative. It is also notable that both under the DFRES DEIS and the contract renewal DEIS, compliance with applicable water quality standards and legal requirements will still have to be achieved. Most fundamentally, however, regardless of how the no action condition relative to drainage is described, the contract renewal action will make no decision relative to drainage.

III. C. Potential Effects on Contractual Amounts with Land Retirement

Concerns have been raised relative to the effect of potential future land retirement on water demand/use within the San Luis Unit.

Retirement of lands from irrigated agriculture would preclude the use of water on the retired land, but that may not affect the quantity of CVP water that could be put to beneficial use within the contracting district. As contracts are renewed, the contractual amount is based on an established procedure wherein a Water Needs Analysis (WNA) is completed documenting the need for the contractual amount. In agricultural districts, this is largely based on irrigable acres multiplied by the water needed per crop acre.

The concern raised for Westlands Water District (WWD) is that, if its long-term contract is renewed based on the WNA in the DEIS and lands are retired from irrigation, then it may have a contractual right to an amount of water exceeding its demand (need). In WWD, the demand for water significantly exceeds the contract supplies available, particularly in years in which less than the full contract quantity is delivered. A provision has been added to the water service contract for WWD to address this area of concern. The language of the contract provision is provided below. The contract, including the new provision, will undergo a 60-day public review period (expected to begin by the end of February). The finalized language of the provision will be included in the Final EIS after the contract public review period has ended. Negotiations and technical meetings have been held to develop this language. The provision recognizes that, if a substantial area of lands is retired, water needs may be affected and then a procedure will be implemented wherein a new WNA will be completed and the contractual amount would, if needed, be limited to reflect the new WNA.

There are no environmental effects associated with this contractual language that can be analyzed as part of this supplement. This is because the language simply calls for a process to be engaged if a particular set of circumstances occurs in the future. In fact, it is speculative if this process will ever be implemented, and furthermore, even if this process is implemented the outcome of the process is highly speculative. If such changes require federal action, before the changes are made, they would be subject to appropriate environmental compliance.

Draft Language of Provision to be added to WWD Contract

3. (a.1) Notwithstanding any other provisions of this Contract, in the event the Secretary implements a program to retire land from irrigated agricultural production within the Contractor's Service Area as a means of addressing drainage in the San Luis Unit, the Contracting Officer shall conduct a water needs assessment to determine whether the Contract Total will be reduced. An initial water needs assessment shall be conducted upon the retirement of 25% of the land projected to be retired under such land retirement program. Subsequent assessments shall be conducted upon the retirement of 50% and 75% of the land projected to be retired and a final assessment will be conducted at the conclusion of the land retirement program. Any water needs assessment performed pursuant to this paragraph (1) shall update the water needs assessment used to compute the quantity of Project Water to be made available under this Contract, which was submitted to the Contractor on November 2, 2000, and shall be conducted pursuant to the methodology attached to this Contract as Exhibit "C". The Contractor may request the Contracting Officer update the methodology employed based upon Contractor specific information made available to the Contracting Officer by the Contractor. Upon completion of any water needs assessment performed pursuant to this paragraph, the Contracting Officer may make a determination to reduce the quantity of water to be made available under this Contract, and the Contract Total shall be reduced according to that determination; Provided, so long as the then-existing Contract Total can be put to reasonable and beneficial use as determined by the water needs assessment on Eligible Lands within the Contractor's Service Area that are not retired, the retirement of land shall not affect the quantity of Project Water to be made available pursuant to this Contract.

III. D. Effects of Increases in Contract Deliveries

Concerns have been raised that potential increases in water deliveries may have effects not analyzed.

The proposed contract terms provide for the delivery of the same total maximum contract amount as the existing contracts, subject to shortages imposed for hydrologic conditions and regulatory constraints. The best available information (2004 CALSIM II modeling) indicates that future agricultural deliveries over the life of the contract to the San Luis Unit will average about 60% of the total maximum contract quantity. The range includes deliveries from as low as about 8,000 acre-feet (AF)/year to as high as about 1.3 million AF/year (See Table 1). The CALFED Record of Decision from 2000 indicated an expectation that south of Delta deliveries in average years may increase to 65 to 70% but recognizes this will not occur in all average years, and that increase is dependent on other water management actions (many of which require separate environmental compliance).

Notwithstanding, questions have arisen as to the environmental effects if the long-term average for deliveries made under the contract were to increase. As a preliminary matter, any such increase would not be an effect of the renewal of the contract, because the no action alternative assumes continuing deliveries subject to the constraints mentioned above, and contracts have no provisions specifying delivery amounts (other then recognizing the aforementioned constraints).

Table 1. Modeled deliveries to the San Luis Unit based on the 1922 to 1994 hydrologic record that would occur under current and foreseeable circumstances.

Year	Total Delivery (af)	Year	Total Delivery (af)
1922	1,179,001	1959	960,896
1923	836,569	1960	296,312
1924	8,236	1961	763,558
1925	541,042	1962	840,168
1926	53,894	1963	1,066,325
1927	1,102,392	1964	595,661
1928	806,005	1965	1,091,555
1929	40,206	1966	975,842
1930	409,375	1967	1,277,362
1931	96,299	1968	986,753
1932	170,422	1969	1,277,759
1933	8,236	1970	915,420
1934	138,085	1971	1,024,104
1935	390,277	1972	928,177
1936	614,682	1973	1,096,364
1937	447,990	1974	1,116,593
1938	1,277,659	1975	1,014,323
1939	701,097	1976	218,398
1940	791,280	1977	56,479
1941	1,191,617	1978	1,266,104
1942	1,208,421	1979	895,904
1943	1,176,139	1980	1,263,719
1944	501,162	1981	873,153
1945	943,167	1982	1,272,112
1946	918,108	1983	1,277,758
1947	520,720	1984	1,093,632
1948	765,780	1985	800,607
1949	854,008	1986	841,486
1950	403,921	1987	427,891
1951	1,005,686	1988	27,503
1952	1,277,160	1989	555,688
1953	1,036,989	1990	8,236
1954	1,064,399	1991	174,662
1955	521,369	1992	335,644
1956	1,058,531	1993	1,064,327
1957	1,065,215	1994	871,721
1958	1,252,341		

Additionally, total water use is determined by the total demand, which is quite stable. The irrigable lands within the San Luis Unit are fully developed, so additional water is not applied to new land. Except for annual fluctuations in fallowed ground, either for crop rotation purposes, because of constrained supplies, or otherwise, the total farmed acreage remains constant. Water users within the San Luis Unit service area meet the demand by utilizing a variety of sources, such as contract deliveries, ground water use, and contractor or farmer generated transfers. In years of increased contract deliveries, it is likely that as the use of contract water would meet an increasing portion of the demand, uses of other supplies would diminish. As an example, water use in WWD shows about 1.2 million acre-feet of water used on an average annual basis (see Figure 1). Table 2 provides information on the levels of the various supplies WWD utilizes to meet demand. Based on Table 2 the total (of all sources) average supply is about 1,169,000 MAF over 18 years with relatively minor deviation. While the average level of use remains relatively constant, the contribution of sources vary considerably. Thus, even with higher contract deliveries, overall water use within WWD would be expected to remain fairly constant. Higher deliveries of contract water would result in less use of ground water and transfer water.

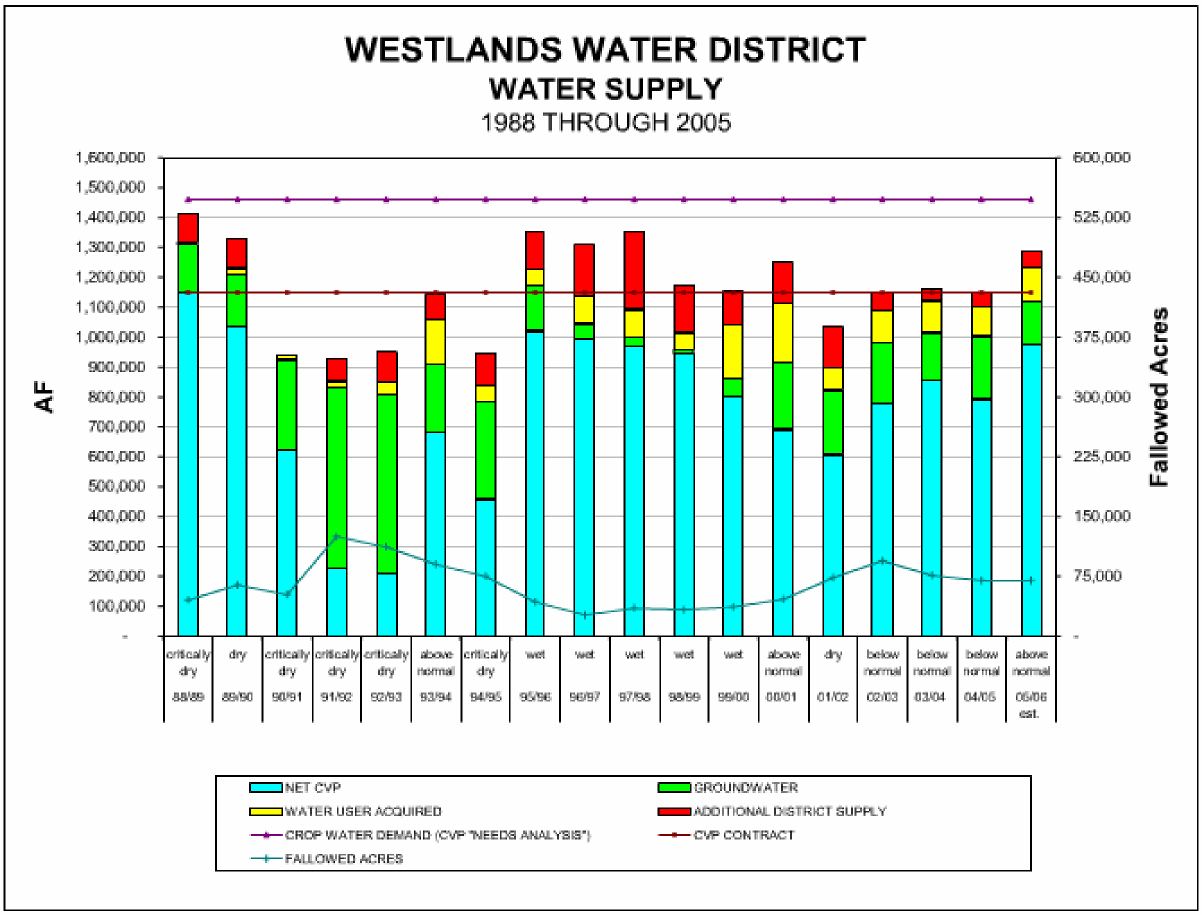


Figure 1. Westlands Water District water use by source each year from 1988 to 2006.

To address a hypothetical set of circumstances where full contract supplies are delivered throughout the contract term, Reclamation has prepared a qualitative analysis/discussion of the consequences of increasing contractual deliveries relative to potential effects on salt loading, ground water and drainage. This analysis is included as Appendix B.

A major caveat concerning the analysis contained in Appendix B is that most of the major constraints to meet deliveries to the San Luis Unit are regulatory requirements in the Sacramento/San Joaquin Delta that restrict exports and thus reduce projected future deliveries to a level of about 60% on average. Completing the analysis described above (which addresses effects of higher deliveries within the service areas) does not imply that Reclamation is intending, as part of the action of contract renewals, to implement any changes to the regulatory regime that govern the export levels. The analysis that is described above and found in Appendix B is a hypothetical exercise for informational purposes and is not intended to serve as analysis to support decisions on unrelated actions, which will require their own decision making processes and environmental compliance.

Table 2. Westlands Water District Water Supply 1988 to 2005 (1/).

District Water Supply							
Water Year	CVP Allocation %	Net CVP (AF)	Groundwater (AF)	Water User Acquired (AF)	Additional District Supply (AF)	Total Supply (AF)	Fallowed Acres
1988	100%	1,150,000	160,000	7,657	97,712	1,415,369	45,632
1989	100%	1,035,369	175,000	20,530	99,549	1,330,448	64,579
1990	50%	625,196	300,000	18,502	(2,223)	941,475	52,544
1991	27%	229,666	600,000	22,943	77,399	930,008	125,082
1992	27%	208,668	600,000	42,623	100,861	952,152	112,718
1993	54%	682,833	225,000	152,520	82,511	1,142,864	90,413
1994	43%	458,281	325,000	56,541	108,083	947,905	75,732
1995	100%	1,021,719	150,000	57,840	121,747	1,351,306	43,528
1996	95%	994,935	50,000	92,953	172,609	1,310,497	26,754
1997	90%	968,408	30,000	94,908	261,085	1,354,401	35,554
1998	100%	945,115	15,000	54,205	162,684	1,177,004	33,481
1999	70%	802,398	60,634	178,632	114,786	1,156,450	37,206
2000	65%	691,624	225,000	198,294	137,802	1,252,720	46,748
2001	49%	608,200	215,000	75,592	138,106	1,036,898	73,802
2002	70%	776,526	205,000	106,043	64,040	1,151,609	94,557
2003	75%	855,306	160,000	107,958	40,362	1,163,626	76,654
2004	70%	793,383	210,000	96,872	51,728	1,151,983	70,367
2005 est.	85%	977,479	140,000	115,000	57,000	1,289,479	70,367

Definitions:
Water Year - March 1 to February 28
CVP Allocation - Final CVP water supply allocation for water year (100% = 1,150,000 AF)
Net CVP - CVP Allocation adjusted for carry over and rescheduled losses
Groundwater - Total groundwater pumped (see District's Deep Groundwater Report)
Water User Aquired - Private Landowner water transfers
Additional District Supply - Surplus water, supplemental supplies, and other adjustments.
Fallowed Acres - Agricultural land out of production

1/ The columns entitled CVP Allocation and Net CVP are representative of water supplies provided pursuant to the water service contract. The amounts in the columns entitled Water User Acquired and Additional District Supply include transfers of CVP water above contract supplies.

III. E. Drainage Management related to the Drainage Feature Reevaluation Study

Concerns were raised that implementing a drainage solution will have substantial impacts and that these impacts were not addressed in the contract renewal DEIS and were not included in the cumulative effects analysis. The DEIS does discuss drainage issues. Nevertheless, as stated previously, there is a separate effort proceeding, under court order, to develop and implement a drainage solution. The drainage solution is a distinct action from contract renewal with its own decision making process. Effects of implementing a drainage solution are beyond the scope of the contract renewal process. At this time, no decision has been made relative to implementing a drainage solution alternative. Thus, trying to project impacts of a drainage solution would be highly speculative since no solution has been identified from those alternatives being analyzed in the DFRES environmental/decision making process. It is not the purpose of, nor appropriate to include in the contract renewal DEIS a reiteration of the various alternatives (and related environmental consequences) being addressed in the DFRES. The contract being evaluated has neither provisions nor discretionary actions related to drainage that could affect a drainage solution and simply recognizes that the federal government has an obligation to provide drainage. For detailed information about the drainage alternatives and environmental effects see the DFRES which is available either on Reclamation's web site or upon request.

III. F. Contracts in the context of the Central Valley Project Improvement Act

In 1992 the 102nd Congress passed and the President signed the Central Valley Project Improvement Act (CVPIA). This landmark legislation mandated changes in the purposes and management of the CVP. A programmatic Environmental Impact Statement and Biological Opinion were completed and a ROD was signed in 2001 detailing the actions to be implemented. Included among the actions to be implemented was the decision to " Proceed with the process of long-term renewal of CVP water service contracts …". Also included were decisions on numerous other activities specifically addressing fish and wildlife as required by the CVPIA.

The criticism that the renewal contracts, in and of themselves, do not address fish and wildlife needs is without merit. The contracts must be viewed within the context of the CVPIA. This is addressed in part in section III A above. The CVPIA, in total, is the mechanism and means Congress utilized to address fish and wildlife by mandating numerous fish and wildlife programs, in addition to requiring the renewal of water service contracts. Interior has prepared various reports addressing the implementation of the CVPIA. Appendix C of this supplement provides the latest CVPIA 10 Year progress report. This report provides information on the purposes of the CVPIA and provides details on the implementation of the numerous fish and wildlife programs. Other information is available at Reclamation's Mid-Pacific web site at *www.usbr.gov/mp/cvpia*.

As stated above, consideration of the purposes and effects of the contract renewal process must be considered within the context of the CVPIA as a whole.

Appendix A – DFRES No Action Alternative Summary

San Luis Drainage Feature Reevaluation Draft EIS
No Action Alternative Summary

Introduction

The No Action Alternative defines conditions in the project area through the 50-year planning time frame if drainage service is not provided to the San Luis Unit and related areas. It represents existing conditions for drainage management in 2001 with individual farmers and districts making limited changes in management in the absence of Federal drainage service. These changes would be "the future without the project." No Action includes only regional treatment, conveyance, and disposal facilities that existed in 2001 or are authorized, funded projects.

Description

Under No Action, without Federal drainage service, farmers and districts would not be able to discharge drainwater to receiving waters (sloughs, rivers, bays, or ocean) from drainage-impaired lands except where such discharges are currently permitted (e.g., the Grassland Bypass Project). This restriction means that 379,000 acres projected to need drainage service would not have that service available, and farmers would pursue individual actions related to (1) drainage control and reuse and (2) cropping practices. Water districts and landowners would continue to address drainage problems within institutional, regulatory, and financial constraints currently in effect and reasonably foreseeable.

Key characteristics and assumptions for the No Action Alternative are the following drainage and land management activities.

Drainage Production

Drainage-impaired lands are estimated at 379,000 acres, including 298,000 acres in Westlands and 81,000 acres in the Northerly Area. However, much of this acreage would not be producing drainage in the absence of drainage service. Only the Grassland Drainage Area (GDA) would produce drainage for disposal through 2009 (with the Grassland Bypass Project). Under the current Use Agreement, expiring December 31, 2009, the Grassland Area Farmers must meet their selenium (Se) load requirements within 20 percent of the target or pay a fine. If the target is exceeded by more than 20 percent, the Use Agreement can be terminated and allow no further discharges.

The following components of the GDA's proposed In-Valley Treatment/Drainage Reuse Facility would occur with or without drainage service from Reclamation and are included under No Action.

- Four-thousand acres of land are proposed for planting with salt-tolerant crops. Twenty-two hundred acres have already been planted, and another 500 acres are in the process of being planted. Subsurface drainage systems have been installed on a total of 900 planted acres (an additional 300 acres have subsurface drainage but are not planted).
- Without additional funding, the remainder of the 4,000 acres could not be planted, and no additional subsurface drainage systems would be installed.

• In its current condition, the reuse facility can reduce drainage discharge needs by 7,200 AF (8,100 AF applied, 900 AF discharged).

Under the No Action Alternative, the GDA would be prevented from discharging drainwater after 2009.

The remaining components of the GDA's In-Valley Treatment/Drainage Reuse Facility are not included under No Action because of the uncertainties associated with their design, operation, and funding. These remaining components include additional land acquisition (2,000 acres), additional subsurface drainage systems (for 4,800 acres), and the treatment facility/disposal units. Designs may not be completed until 2006, and the facility is planned to be operational by 2009 if funding can be obtained.

No other treatment facilities beyond small-scale pilot projects and existing reuse facilities (e.g., Integrated Farm Drainage Management projects such as Red Rock Ranch) are assumed to be operational in the drainage study area under No Action.

Lands Not in Agricultural Production

Land Retirement

Land retirement is defined as the removal of lands from irrigated agricultural production by purchase or lease for other purposes or land uses. Under No Action, Reclamation assumes 109,106 acres would be retired based on the following:

1. CVPIA Land Retirement – Up to 7,000 acres of lands are included to be retired within the study area under the existing CVPIA land retirement program (2,091 acres retired to date).
2. Westlands Settlement Agreement (*Sagouspe v. Westlands Water District*) – A settlement agreement among various classes of water users within Westlands calls for temporary retirement of land. An estimated 65,000 acres of land would be retired under this settlement agreement. Because the agreement would allow these lands to come back into production if and when Reclamation provides drainage service, Reclamation assumed these lands would be retired under the No Action Alternative (i.e., potentially all or in part under the In-Valley/Land Retirement Alternatives but not under the four Disposal Alternatives).
3. Britz Settlement (*Sumner Peck Ranch, Inc., et al. v. Bureau of Reclamation, et al.*) – An additional 3,006 acres in Westlands are being retired permanently under a settlement agreement dated September 3, 2002, between the United States, Westlands, and the Britz group of plaintiffs in the Sumner Peck lawsuit.
4. An additional 34,100 acres from the Sumner Peck Ranch et al. settlement of December 2002 would be retired.

In summary, 44,106 acres of permanently retired lands would be increased by 65,000 acres if drainage service is not provided to Westlands, for a total of 109,106 acres.

Land Fallowing

On an annual basis, 5 to 10 percent of the total cultivated acreage is often fallowed for soil fertility, normal crop rotation, and economic purposes, and this practice would continue under No Action. This fallowing acreage is in addition to the land retirement described above.

On-Farm, In-District Activities

The following management activities by individual farmers and/or districts for drainage-impaired land are assumed to occur under No Action:

• **On-farm/in-district use of existing drainage control/reuse measures** would continue, including 30,000 acres with drainage systems installed in the San Luis Unit (30,000 acres in the Northerly Area) and an additional 18,000 acres outside of the Unit. Existing drains (including plugged drains) in Westlands on 5,000 acres would not be operational due to lack of drainage service. In summary, a total of 48,000 acres would continue to be drained in the GDA and none in Westlands; no additional drains would be installed.

• **Some on-farm irrigation system improvements** would occur within Westlands to continue to manage perched water and crop practices in the absence of drainage service. Efforts to develop tilewater treatment and disposal technologies would continue. However, it is assumed that no new on-farm tile systems, collection facilities, or land disposal actions would be implemented. Limited use of existing facilities for on-farm drainwater recycling would occur.

• **Irrigation practices** remain similar to current efficiency levels. As the drainage problem expands and farmers adjust irrigation practices to high water table conditions, water use efficiency in these areas may increase but not substantially over existing conditions which are already highly efficient. Overall, irrigation practices would be expected to respond to economic conditions and would be consistent with efficiency assumptions in the *California Water Plan* (DWR 1993).

• **Any water that fallowing frees up in drainage-impaired areas would be reallocated to unaffected areas**. Water conserved because of improved irrigation efficiency, changes in cropping pattern, increased contribution to evapotranspiration (ET) from groundwater, or possible reductions in irrigated acreage would be available within the respective district to meet internal needs. The reallocated water would likely result in less groundwater pumping, as the quantity applied per acre would not increase beyond crop requirements.

• **Other drainwater reduction measures** are anticipated to be used at current or increased levels under No Action with no drainage service and include seepage reduction, drainwater recycling, shallow groundwater pumping, and shallow groundwater management.

Surface Water No Action Alternative

The No Action Alternative evaluates the effect of not conveying drainwater out of the drainage study area for disposal. This alternative is defined as what could be expected to occur in the 50-year planning period if drainage service is not provided to the Unit and related areas. It represents existing conditions for drainage management plus changes in management reasonably expected to be implemented by individual farmers and districts in the absence of Federal drainage services and not of a magnitude to require CEQA/NEPA documentation (e.g., not major new projects). The No Action Alternative includes only regional conveyance, treatment, or disposal facilities that existed in 2001, or that are authorized, funded projects. No planned use of the San Luis Drain would occur after December 31, 2009, as a new action (e.g., use agreement and CEQA/NEPA documentation) would be required.

Construction Effects

No new Federal construction would occur as part of the No Action Alternative. Therefore, no construction effects are predicted.

Operational Effects

It is not anticipated that any new water quality effects would occur except for effects on groundwater quality that could result in increased salinity and Se in the San Joaquin River due to unplanned, uncontrollable seepage discharges. Implementation of new and evolving water quality control programs such as Total Maximum Daily Loads (TMDL) should result in a gradual improvement in surface water quality in the San Joaquin River, Delta, and San Francisco Bay. However, increased water demand and competition for scarce water supplies in the absence of new storage may result in unknown and potentially adverse effects.

Drinking Water Intakes

Under No Action, some drainwater would continue to (1) flow uncontrolled into the San Joaquin River above the Merced River confluence via seepage into wetland channels from the Northerly Area due to rising groundwater levels, as discussed in the *Grassland Bypass Project Final EIS/EIR* (Reclamation 2001), or (2) flow as managed, individual farm discharges but in compliance with the TMDL requirements. Because the San Joaquin River flows to the Delta, drinking water intakes in the Delta are susceptible to drainwater contamination. This is presently a concern for Contra Costa Water District and would continue to be a concern if No Action is implemented. Under No Action, the drainwater would not receive any Se treatment and the amount that would be legally discharged would be very limited to comply with the TMDL requirements. The larger concern is the adverse effect of the unmanaged seepage of subsurface drainage into wetland channels and, consequently, into the San Joaquin River.

Groundwater Resources No Action Alternative

For the No Action Alternative, the following hydrologic conditions were simulated:

- Irrigation system improvements and practices on farmed lands in the GDA and Westlands remain the same as existing conditions. Existing recharge rates were estimated using information from Table 5 in the *Source Control Memorandum* (URS 2002).
- In Westlands, simulated annual groundwater pumping is maintained constant at 175,000 AF/year, which is equal to the average private supply reported in *Westlands' Water Needs Assessment* (Reclamation 2003). The distribution of semiconfined and confined zone pumping within Westlands was weighted based on the pumping rates reported by Belitz et al. (1993).
- In 2002, about 48,000 acres were drained within the GDA and a substantial portion of the drainwater was discharged to the San Joaquin River through the Grassland Bypass Project. After 2009, when the Grassland Bypass Project agreement ends, it is assumed that drainwater is no longer discharged to the river, but instead managed within the GDA.

In contrast, Westlands has not discharged agricultural drainwater for more than 15 years, and the No Action Alternative simulated continued undrained conditions in Westlands.

• Under No Action, 65,000 acres would be retired in Westlands.

• Without a drainage option, 38,000 acres within Westlands would be retired from irrigated agriculture as follows: 8,600 acres retired in 2002, 20,000 acres retired by 2003, and 9,400 acres retired in 2004. The retired lands were randomly distributed throughout the drainage problem area. When land is permanently retired, irrigation ceases and consequently groundwater pumpage and surface-water deliveries are discontinued. The surface water is reallocated to other farmed lands within the district. The reallocated surface water was assumed to displace surface-water supplies that would be purchased from other entities. Hence, pumpage and irrigation recharge beneath active agricultural lands is not altered as a result of land retirement and the surface-water reallocation.

• Without a drainage option, 27,000 acres would be retired through the Westlands land acquisition program as follows: 6,480 acres in 2002, 14,040 acres in 2003, and 6,480 acres in 2004. The acquired lands were randomly distributed throughout the drainage problem area. The acquired lands are not permitted to irrigate with CVP water and, therefore, deep percolation throughout Westlands is substantially reduced. The acquired lands can practice dryland farming or irrigate with a non-CVP water supply (for example, groundwater, drainwater, transfer, and so forth). Ten percent of the land area (6,500 acres) was assumed to be irrigated; the actual area and distribution of irrigated lands can vary from year to year. The average water supply is assumed to be 50 percent surface water and 50 percent groundwater.

• In 2002, about 3,000 acres of land are retired under the Britz settlement. During the period 2003 through 2005, about 34,100 acres of land would be retired under the Sumner Peck Ranch et al. settlement. It was assumed these lands are retired over a 3-year period at a rate of about 11,370 acres per year. The retired lands were randomly distributed throughout the area defined by the plaintiffs' parcels during a 3-year period. Irrigation ceases on these lands and consequently groundwater pumpage and surface-water deliveries are discontinued. The surface water is reallocated to other farmed lands within the district, and the reallocated surface water was assumed to displace surface-water supplies that would be purchased from other entities.

• As of 2002, 2,091 acres of land had been permanently retired under the CVPIA land retirement program. The remaining 4,909 acres are assumed to be retired at a rate of 981 acres per year during 2003, 2004, 2005, 2006, and 2007. The future retired lands were randomly distributed throughout the CVPIA land retirement project area. Irrigation ceases on these lands and consequently groundwater pumpage and surface-water deliveries are discontinued. The surface water is reallocated to other farmed lands within the district, and the reallocated surface water was assumed to displace surface-water supplies that would be purchased from other entities.

• No new shallow groundwater management projects are implemented.

• In the GDA, drainwater recycling continues at current levels and the planned 3,000-acre In-Valley/GDA reuse facility begins operations in 2005. In its present-day condition (2004), the In-Valley reuse facility can reduce the drainage discharge requirement by 7,200 AF. No new seepage reduction, drainwater recycling, or drainage reuse projects are implemented. After 2009, when the Grassland Bypass Project San Luis Drainage use agreement with Reclamation ends, all drainwater remains within the GDA. It was assumed that the In-Valley/GDA facility continues operation after 2009, but without a disposal outlet for the drainwater produced, drainage system sump flows would remain within the GDA. The GDA facility would reduce drainage by 15 percent, and the 14,000 AF of uncontrolled discharge would no longer be managed under the Grassland Bypass Project San Luis Drainage use agreement. The leaching fraction (27 percent) continues to contribute to deep percolation beneath the GDA facility (about 1 foot/year).

Under the No Action Alternative, groundwater changes are affected primarily by (1) the cessation of drainage discharge within the GDA after 2009 and (2) 109,100 acres of land retired in Westlands. Without drainage in the GDA, the average simulated water table beneath the drainage-impaired area rises 3 feet during the 49-year simulation period. In contrast, land retirement in Westlands lowers the water table beneath the lands retired. On the average, the simulated water table beneath the Westlands drainage problem area decreased by 4.3 feet. The bare-soil evaporation and area criteria are summarized in Table 1.

Table 1. Summary of Bare-Soil Evaporation and Shallow Water Table Area Criteria

Condition	GDA 2001	GDA 49-year simulation period	Westlands 2001	Westlands 49-year simulation period	Region 2001	Region 49-year simulation period
Bare-Soil Evaporation (feet/year)						
Existing	0.19	NA	0.18	NA	0.19	NA
No Action	0.19	0.39	0.18	0.30	0.19	0.35
In-Valley	0.19	0.13	0.18	0.09	0.19	0.11
In-Valley/Water Quality Land Retirement	0.19	0.13	0.18	0.11	0.19	0.12
In-Valley/Water Needs Land Retirement	0.19	0.12	0.18	0.10	0.19	0.12
In-Valley/Drainage-Impaired Area Land Retirement	0.19	0.12	0.18	0.10	0.19	0.12
Out-of-Valley	0.19	0.13	0.18	0.09	0.19	0.11
Undrained Area Underlain by Water Table Within 7 Feet of Land Surface (square miles)						
Existing	69	NA	261	NA	330	NA
No Action	69	74	261	212	330	286
In-Valley	69	57	261	68	330	125
In-Valley/Water Quality Land Retirement	69	51	261	30	330	81
In-Valley/Water Needs Land Retirement	69	50	261	22	330	72
In-Valley/Drainage-Impaired Area Land Retirement	69	49	261	11	330	60
Out-of-Valley	69	57	261	68	330	122

NA "not applicable"

The No Action Alternative (and other alternatives with a land retirement component) assumes that surface water reallocated from retired lands decreases the need for surface water purchased from other entities. If this assumption becomes invalid, and land retirement has the effect of increasing the overall surface-water supply to irrigated lands, it would reduce the demand for groundwater. The subsequent pumping decrease, combined with continued water table recharge, would result in an increased rate of water table rise, thereby increasing the bare-soil evaporation rate and area affected by the shallow water table.

Bare-Soil Evaporation

In the GDA, under existing conditions the simulated evaporation rate is 0.19 foot/year, and under the No Action Alternative the simulated evaporation rate increases from 0.19 to 0.39 foot/year (a net increase of 0.20 foot/year). In Westlands, the simulated evaporation rate under existing conditions is 0.18 foot/year, and under the No Action Alternative the simulated evaporation rate increases from 0.18 to 0.30 foot/year (a net increase of 0.12 foot/year). From a regional perspective, the simulated existing condition evaporation rate is 0.19 foot/year, and under the No Action Alternative the evaporation rate increases to 0.35 foot/year. By the end of the simulation period, the evaporation rate under the No Action Alternative is 0.16 foot/year greater than existing conditions, which exceeds the significance criteria of 0.10 foot/year. The No Action Alternative has adverse effects on bare-soil evaporation relative to existing conditions.

Undrained Area Affected by Shallow Water Table

In the GDA, under existing conditions the simulated undrained area underlain by a water table within 7 feet of land surface is 69 square miles, and under the No Action Alternative the undrained area underlain by the shallow water table increased to 74 square miles (a net increase of 5 square miles). In Westlands, under existing conditions the simulated area underlain by a shallow water table is 261 square miles, and under the No Action Alternative the area decreased from 261 to 212 square miles. From a regional perspective, under existing conditions the simulated undrained area underlain by the shallow water table within 7 feet of land surface is 330 square miles, and under the No Action Alternative the area decreased to 286 square miles (a net decrease of 44 square miles). The No Action Alternative therefore has a beneficial effect on the area affected by the shallow water table relative to existing water table conditions in the western San Joaquin Valley.

Groundwater Salinity

Under the No Action Alternative, increased bare-soil evaporation without drainage to remove salts would increase soil and groundwater salinity. In the GDA, without the Grassland Bypass Project San Luis Drainage use agreement, recycling and reuse would increase the salinity of the applied irrigation water and increase soil and groundwater salinity levels. For example, HydroFocus estimated a 10 percent groundwater salinity increase in the GDA after 9 years of conditions similar to the No Action Alternative (Reclamation 2001). If undiluted drainwater is applied directly, especially under undrained conditions, the expected salinity increase is more dramatic. For example, HydroFocus' calculations indicated that irrigation with undiluted drainwater caused soil salinity to more than double under undrained conditions. The above salinity increases under the No Action Alternative were considered significant adverse effects.

In Westlands, it was determined that constituent concentration levels measured in 2002 monitoring well samples were not statistically different from similar samples collected in 1984. The analysis focused on possible changes in boron, molybdenum, Se, and salinity (as represented by electrical conductivity). Groundwater levels in the sampled wells were significantly deeper during the 2002 sampling relative to the 1984 sampling. Irrigation activity clearly influences local groundwater levels. For wells surrounded by fallow or partially fallow land, average water levels were over 3 feet deeper in 2002 than 1984; and, for wells surrounded by cropped land, average groundwater levels were 0.2 foot deeper in 2002 than 1984. Reduced regional recharge rates owing to land fallowing, and regional groundwater pumping activities probably caused the water level decline. The lower water levels decreased evaporation rates and its corresponding evaporative concentration effects on dissolved solids. Furthermore, concentration decreases in wells surrounded by cropped areas may be the result of the downward displacement of shallow, poor quality water by relatively higher quality irrigation water. The No Action Alternative probably has a beneficial effect on groundwater salinity because land retirement increases the depth to water and possible dilution effects from higher quality irrigation water in cropped areas. The No Action Alternative, therefore, provides a beneficial effect relative to existing groundwater salinity conditions in the western San Joaquin Valley.

Drinking Water Supplies

For the No Action Alternative, concentrations of most contaminants are expected to continue to increase. Even though the contamination would take 100 to 400 years to travel to the wells, the migration toward drinking water sources would continue. A Se forecasting study by the USGS mentions “drainage alone cannot alleviate the salt and Se buildup in the San Joaquin Valley, at least within a century” (Luoma and Presser 2000).

The majority of municipal drinking water wells in the area of the San Luis Interceptor Drain extract their water from deep aquifers, which are protected by the thick, low permeability Corcoran clay layer and, thus, are less vulnerable to any of the action alternatives. Most likely, practices that alter the quality or quantity of the shallow groundwater would not have a significant effect on the sub-Corcoran aquifer for a century or more. However, composite wells screened above and below the Corcoran clay represent an increase risk for dissolved constituents to penetrate the clay and enter the sub-Corcoran aquifer system.

In the western San Joaquin Valley, most municipal drinking water wells are less vulnerable than shallow groundwater. In the case of City of Mendota’s Well No. 5, water quality data indicate increasing salinity trends in the late 1990s, which may be attributed to westward movement of shallow, saline groundwater.

However, changes to the No Action Alternative to include large-scale land retirement would have no significant effect compared to existing conditions. If drainage service is not provided and irrigation continues, high salinity groundwater effects to wells may increase. Relative to existing conditions, the increased salinity trends under the No Action Alternative are considered an adverse effect.

Biological Resources No Action Alternative

Terrestrial Resources

No significant construction-related effects would be expected under the No Action Alternative. Consistent with the definition of No Action to exclude unplanned or speculative projects, it is assumed that no new on-farm drainwater collection systems or disposal facilities would be constructed. Grassland Area Farmers would not complete the unfunded expansion of the Panoche reuse facility. Instead, they would maintain the existing 2,700-acre reuse facility at its current influent capacity of 8,100 AF/yr. No similar regional facilities would be developed.

Under the No Action Alternative a total of 109,100 acres of irrigated and temporarily fallowed croplands would be permanently retired, including 65,000 acres under the Westlands settlement; 34,100 acres under the Sumner-Peck settlement; 7,000 acres under the CVPIA Retirement Program (including 2,091 acres already retired); and 3,006 acres already retired under the Britz settlement. Vegetation on these lands has not yet been thoroughly inventoried so current ground cover, vegetation conditions, and habitat values are unknown. The Sumner-Peck and Britz lands under WWD ownership presumably would be managed to provide lease opportunities for dryland farming and grazing, or portions would be left temporarily fallowed. CVPIA Land Retirement Program lands under Federal ownership presumably would continue to be managed to provide wildlife habitat or to be compatible with wildlife use under the present CVPIA program. A comprehensive long-term land management plan for the Westlands settlement lands has not yet been developed.

Under the No Action Alternative, no valley-wide strategy is currently in place for coordinating management of the retired lands and, other than the CVPIA program, no current mechanism would provide for future development of wildlife habitat improvements or long-term habitat management. Retired agricultural lands converted to nonirrigated crops would continue to be periodically disturbed for cultivation and harvesting and, therefore, would not develop significant wildlife value. Production of small grains (wheat, barley) on dryland sites, though, could provide improved food and cover over existing conditions, but wildlife benefits would depend on location, parcel size, adjoining habitats, and management. Fallowed, abandoned, or grazed lands could be invaded to varying degrees by noxious weeds or other undesirable species. Some of the retired lands would continue to act as salt sinks, collecting and concentrating salts until they support limited vegetation and offer little wildlife habitat value. Retired lands occurring in large contiguous blocks would provide higher terrestrial habitat value than parcels in small, scattered, and isolated tracts. In general, in the absence of any long-term program to develop and manage retired lands for wildlife habitat under the No Action Alternative, the effect to terrestrial resources from anticipated long-term changes in vegetation and cropping patterns would be only a slightly beneficial effect. The long-term potential for minimally managed lands to increase the spread of noxious weeds, however, would be an adverse effect.

Aquatic and Wetland Resources

Under the No Action Alternative, no large (regional) drainwater collection or treatment/disposal facilities would be developed and no new surface-water impoundments (e.g., regulating reservoirs, evaporation basins) would be constructed as part of any drainage control program. Without large-scale construction projects, no aquatic or wetland habitat would be lost or disturbed. No existing jurisdictional wetlands would be drained or filled, and no stream channels or other waterways would be crossed or altered. No migratory movements of native fish would be temporarily or permanently blocked.

Under the No Action Alternative, irrigation water freed up from planned or scheduled land retirements would be reallocated to other agricultural lands and would not be made available for aquatic or wetland habitat improvement.

Under the No Action Alternative, Grassland Area Farmers would be forced to discontinue use of the northern 28 miles of the San Luis Drain to discharge GDA drainwater to Mud Slough and the San Joaquin River after December 2009. Without continued use of the Drain, substantial environmental benefits to area waterways and wetlands derived from the Grassland Bypass Project since 1996 would cease and future anticipated benefits from the planned full implementation of the Grassland Bypass Project would not occur. With discontinued use of the concrete-lined Drain segment, 28 miles of aquatic habitat would be eliminated, and any fish species present in the substantially dewatered segment would be lost or would need to be salvaged and relocated. However, because the Drain and associated canals provide only artificial habitat, loss of this marginal canal fishery would not be considered adverse.

Without the Grassland Bypass Project discharges, year-round flow in Mud Slough would decrease substantially after December 2009. The flow reduction would generally be considered an adverse effect, and the associated improvement in water quality of the receiving waters could result in a minor improvement in aquatic habitat conditions. However, the improvement in aquatic habitat would vary depending on prevailing rainfall, seasonal conditions, and the amount of uncontrolled agricultural drainage that would continue to contribute to the flow. Unmanaged drainage flows of poor quality would degrade aquatic habitat conditions. The Grassland Bypass Project currently prevents uncontrolled lateral seepage of Se contaminated drainwater and limits occasional overtopping of surface runoff (during prolonged wet periods and storm events) into a number of canals and laterals used for wildlife refuge water supplies in the Grasslands region (see the Grassland Bypass Project Final EIS, p. 6-22 [Reclamation 2001]).

Special-Status Species

No substantial adverse effects to special-status species are anticipated under the No Action Alternative. No new regional collection facilities would be constructed or put into operation through 2061. Without collection facilities, no new regional drainwater disposal facilities such as treatment plants, reuse facilities, evaporation facilities, or other costly technologies would be developed. On-farm source control measures, on the other hand, would undoubtedly expand over the 50-year period, but would have little direct effect on special-status species.

Changes in crop production could affect the character, quality, and pattern of terrestrial habitat provided by agricultural lands as farmers in drainage-impaired areas convert to more salt-tolerant crop mixes. However, no identified special-status species are known to utilize existing irrigated crop types exclusively and, thus, none would be significantly affected by any wide-scale conversions to more salt-tolerant irrigated crops. Lands converted to dryland farming would continue to be disturbed during cultivation and harvesting, and, therefore, would not develop significant wildlife value.

The amount of agricultural land removed from production (retired, temporarily fallowed, or abandoned) would continue to increase as additional drainage-impaired lands lose productivity and become uneconomical to farm. Under the No Action Alternative, planned land retirements would increase to as much as 109,100 acres by 2061, an increase of 88,600 acres over existing conditions. A portion of these lands would act as salt sinks, collecting and concentrating salts until they support little vegetation or possess little wildlife habitat value. Other abandoned lands would revert in varying degrees to undesirable invasive species. This conversion of irrigated lands to other uses would progress in a scattered, uncoordinated manner depending on site specific conditions and individual circumstances. There would be no program of planned placement of abandoned lands into alternative uses or for managing lands removed from production. However, individual farmers could manage the retired lands for dryland farming, grazing, and other agricultural uses not dependent upon CVP water sources. Portions of the 65,000 acres of land acquired by Westlands could be irrigated with groundwater or non-CVP water sources. As a result, the overall potential benefits to special-status species from alternative land use are not expected to be important.

Selenium Bioaccumulation No Action Alternative

The No Action Alternative evaluates the effect of not conveying drainwater out of the drainage study area for disposal. This alternative is defined as what could be expected to occur in the 50-year planning period if drainage service is not provided to the Unit and related areas. It represents existing conditions for drainage management plus changes in management reasonably expected to be implemented by individual farmers and districts in the absence of Federal drainage services and not of a magnitude to require CEQA/NEPA documentation. The No Action Alternative includes only regional conveyance, treatment, or disposal facilities that existed in 2001 or that are authorized, funded projects. No use of the San Luis Drain would be planned after 2009, as it would require a new action and CEQA/NEPA documentation. It is anticipated that adverse effects to surface water quality in the San Joaquin Valley wetlands would occur under the No Action Alternative, because some subsurface drainage is expected to migrate uncontrollably and laterally into wetland channels.

Refuge waterways would be adversely affected because they have benefited in recent years from declining contaminant levels. Therefore, because Se bioaccumulation is primarily dependent on water quality, adverse effects to aquatic receptors related to changes in Se bioaccumulation are anticipated under the No Action Alternative. Special-status species affected may include the giant garter snake and California red-legged frog.

Geology and Seismicity No Action Alternative

The No Action Alternative would consist of reasonably foreseeable future conditions without drainage service alternatives. Under the No Action Alternative approximately

109,100 acres of land would be retired from irrigation. Some reuse due to the existing Grassland Bypass Project would occur, and existing pilot projects that could utilize reuse and treatment systems would continue in the area.

The existing San Luis Drain would be in use until 2009 and is subject to one documented geologic hazard, land subsidence. Two types of land subsidence are most commonly encountered along the existing Drain: reduction of pore space from overpumping of groundwater resources and hydrocompaction. Subsidence due to oil extraction has been documented in southern San Joaquin Valley near Bakersfield and should not be an issue with the No Action Alternative.

Topographically, San Joaquin Valley slopes downward in elevation northward toward the Delta region; the southern portion of the Drain is located at a topographically higher elevation than the northern portion. This slope allows the existing Drain to be gravity fed and does not require uphill pumping of the agricultural wastewater. It is likely that certain portions of the existing Drain have been affected at some point by land subsidence. However, the amount of land subsidence around these portions of the existing Drain may not have been significant enough to alter the grade of the drainage route. Since the importation of surface water to this area, the rate of land subsidence has diminished and would have no effect to the existing Drain by the 2009 closure date.

The No Action Alternative may also be subject to strong earthquake shaking and the attendant affects of liquefaction, seiche, and mass wasting. The magnitude 6.4 1983 Coalinga earthquake caused extensive structural damage in and around the town of Coalinga. Other effects included damage to canals and canal linings resulting from lateral spreading and liquefaction. Similar effects can be expected for a future earthquake located along the Coastal Range-Sierran Block. A repeat of the 1857 earthquake on the San Andreas fault would also result in widespread strong shaking over much of the project area. Liquefaction would be widespread in sandy and silty materials and would be exacerbated if a large earthquake were to occur during the winter when the groundwater elevation increases due to higher precipitation. Water retention structures, including holding ponds, may also be subject to damage from seiches of impounded water and liquefaction/lateral spreading of poorly constructed earth embankments. No new collection facilities would be constructed; therefore, the likelihood of affecting geologic resources of economic or scientific value would be negligible.

Energy Resources No Action Alternative

Under No Action, farmers would pursue individual actions related to local drainage control and reuse and cropping patterns. Energy would be required for small sump pumps used to locally convey drainwater. The pumps would be located throughout the drainage study area in a dispersed manner. The evaluated drainwater reduction options are expected to result in a negligible incremental increase in local electrical energy utilization and would, therefore, have a minimal effect on the existing energy requirements.

The overall energy requirements for the limited irrigation system improvements and for ongoing drainwater reduction measures would be expected to increase within the drainage study area over time due to the general growth of the irrigation improvements program. However, because of the disbursed nature of the loads and the relatively small size of the pumps, this incremental change would be expected to have a minimal effect on the electrical power supplies in the region (i.e., project area). This minor energy demand growth could be supplied by a number of power suppliers including PG&E and the alternative generators.

Air Resources No Action Alternative

The No Action Alternative evaluates the effects of not conveying drainwater out of the basin for disposal, thus providing a benchmark against which action alternatives may be evaluated. No new construction would occur as part of the No Action Alternative. The only operational emissions would result from maintenance of existing facilities. Therefore, no effects beyond existing conditions would occur due to the No Action Alternative with regard to construction or operations and maintenance.

Land retirement is defined as the removal of lands from irrigated agricultural production to other forms of land management by means of land purchase or lease. Non-irrigated (retired) lands would be tilled to control weeds approximately twice a year. Lands could also be grazed or sprayed for weed management. This level of dust-generating activity is less than what would of this alternative would be used for wildlife habitat, dry pasture, and dryland summer fallow grain operations on 109,106 acres. Compared to the existing condition's retirement of only 20,518 acres, the reduced land preparation, cultivation, harvest activities, and vehicular travel over unpaved roads associated with this alternative's increased land retirement/fallowing activities would result in an overall air quality benefit and reduction in particulate matter less than 10 microns in diameter (PM_{10}) fugitive dust emissions from the affected agricultural lands.

The San Joaquin Valley Air Pollution Control District requires owners and operators of agricultural operations in the valley to reduce PM_{10} fugitive dust from on-farm sources. Best Management Practices (BMPs) are to be identified for each agricultural operation by December 2004 and implemented in 2005. Land fallowing is identified as one measure that reduces land preparation and cultivation activities.

Agricultural Production and Economics No Action Alternative

Northerly Area Districts

Key Assumptions

The following assumptions are used to analyze agricultural production and economics under the No Action Alternative in the Northerly Area districts:

- Drainage collected from each drained acre in the Northerly Area would be about 0.45 AF/acre/year while drains are operating (see Grassland Bypass Project assumption below).
- The current rate of recycling, 0.12 AF/drained acre, would continue in order to meet the load restrictions on discharge. For analysis, the drainwater is assumed to be recycled on all lands within the drainage-impaired area, not just lands with installed drains. This

assumption implies that 0.06 AF of drainwater/acre would be applied as irrigation water to each acre within the drainage-impaired area.

• The natural drainage rate was estimated by regional groundwater modeling for the drainage impaired areas. The rate varies across the region, averaging about 0.2 AF/acre/year by 2030, which is a regional average for the drainage-impaired lands. Mapping of natural drainage rates shows that lands most affected by drainage and salinity have a lower rate. For purposes of analysis, lands with drains installed are assumed to average a natural rate of 0.15 foot/year. The remaining lands are assumed to average 0.30 foot/year, such that the overall, acreage weighted average is about 0.2 foot/year.

• Drains are designed and operated to maintain a water table depth of between 6 and 6.5 feet.

• The Grassland Bypass Project will continue to operate until the year 2009. After that, no drainage access to the San Joaquin River will be available for this area. Initially, the effects of two assumptions were assessed regarding the response of growers in the drained area:

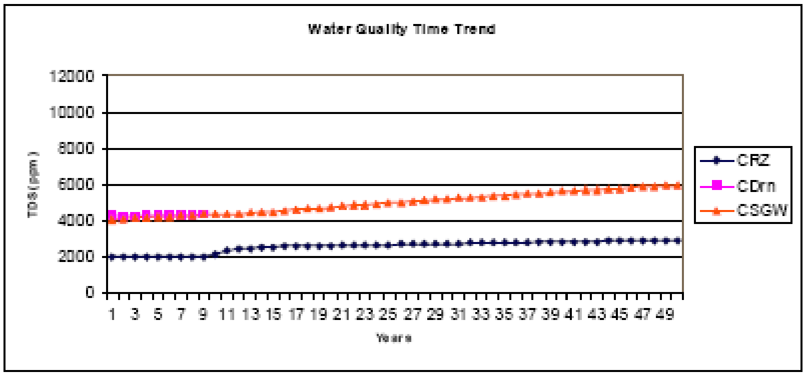
− Drains are plugged and no further drainage is collected. The shallow water table continues to build up under the cropped land, increasing the upward movement of salts into the root zone. Levels of irrigation and salinity management must improve substantially to reduce deep percolation yet maintain leaching of salts.

− Drains continue to operate, but all drain flow must be recycled within the drainage area. The shallow water table is controlled by continued operation of drains, but irrigation normal water supply. The relatively large volume of salt-laden drainwater used for irrigation resulted in steady and rapid rise in soil salinity. Therefore this option was abandoned.

• 30,000 acres of tile drains are currently installed in the San Luis Unit portion of the GDA, and another 18,000 acres are installed outside the Unit.

Results

Under current conditions, with drainage discharge to the Grassland Bypass, the salt balance and soil conditions are favorable for crop production. Drainage volume collected from field drains is estimated to be approximately 20,200 AF, including drainage from within and outside the Unit. Additional flow into sumps and collectors from shallow groundwater and surface runoff increases total annual drain flow to about 28,000 AF. However, when the Bypass is shut (by assumption), conditions worsen quickly and significantly. Figure 1 shows a 50-year trend in the root zone and shallow groundwater salinity for a representative drained area in the Northerly Area districts. The root zone is defined for analytical purposes as the soil from ground surface down to the shallow water table or simply the upper 6 feet of soil, whichever is less. The jump in soil salinity is quite clear in year 9 and later, and results from the loss of drainage and rise in the water table below those lands.



CRZ = Concentration of salts in the root zone (ppm TDS of saturation extract)
CDrn = Concentration of salts in drainwater or potential drainwater (ppm TDS)
CSGW = Concentration of salts in shallow groundwater (ppm TDS)

Figure 1. Salinity Trends in the Northerly Area, No Action Alternative

The figure shows the result under the assumption that the drains are plugged. (A side analysis was conducted indicating that the salinity increase is even more pronounced under the assumption that drains continue to operate but that 100 percent of the drainwater has to be recycled.) Soil salinity is typically measured as the electrical conductivity (EC) of a saturation extract in dS/m (deciSiemens per meter), and the ultimate root zone salinity shown corresponds to an EC of over 4.1. At this level, the mix of crops that can be grown narrows significantly.

Because a drainage outlet is no longer provided after year 9, soil salinity would rise and net deep percolation would be limited to the small amount of natural drainage that exists, estimated to be 0.15 foot/year for lands currently having drains installed. A combination of crop mix changes, rotational fallowing, and irrigation management would be needed to maintain land in production.

Crop changes can accomplish two objectives: they can reduce or eliminate crops that are sensitive to saline soil conditions; and they can reduce the overall level of water use and therefore the deep percolation needed for salt leaching. An appropriate mix of salt-tolerant crops can meet these criteria. This analysis has estimated that a mix of 30 percent rotational fallow, 35 percent cotton, and 35 percent grain crops can reduce crop ET to about 1.5 foot/year. At that level of ET, irrigation management equivalent to 85 percent seasonal application efficiency (SAE), measured here as crop ET of applied water divided by total applied water, would hold the net deep percolation equal to the natural drainage of 0.15 foot/year. A further discussion of the implications of crop mix changes and irrigation management in the No Action Alternative is included below in the analysis for the Westlands subareas.

Substantial reductions in net farm revenue would result from the cropping and irrigation changes needed to reduce net deep percolation. Results are summarized at the end of this section, and are presented as benefits (avoided costs) provided by drainage service.
Salt balance in the Northerly Area districts is favorable during the initial years when drainage is discharged through the Grassland Bypass and San Luis Drain to Mud Slough and subsequently to the San Joaquin River. Over 28,000 AF of drainwater at an average

salinity of about 4,100 ppm (parts per million) TDS (total dissolved solids) are discharged, removing more than 160,000 tons of salt annually from the area. Additional salts would migrate more slowly from the area through groundwater pathways, but no estimate of this amount has been made. After the closure of the Bypass in 2009, no salts would be removed through artificial drainage.

Westlands Water District

The drainage-impaired area within Westlands has been divided into three subareas. Many of the assumptions described below apply to all three of the subareas. Where differences exist, those are noted.

Key Assumptions

The following assumptions are used to analyze agricultural production and economics in Westlands under the No Action Alternative:

- No drainwater is currently being collected and removed from Westlands. The No Action Alternative assumes that this situation would continue. Irrigation efficiency in Westlands is currently quite high and is expected to remain so over time, consistent with projections made by the DWR (Bulletin 160-93 and unpublished supporting data, 1993). Growers may need to make additional changes in efficiency to manage irrigation in the drainage-impaired area analysis.
- Shallow water table depth would continue to be a concern in substantial areas within the district. The changes in depth to water and the acreage affected by shallow groundwater are based on groundwater modeling analysis.
- The analysis uses the current mix of crops as the starting point for a 50-year simulation of drainage and soil salinity conditions. The analysis will assess how future drainage and salinity conditions in the drainage-impaired area would affect crop selection.
- Irrigation water in the drainage-impaired area is a mix of surface supplies and groundwater. The mix can vary considerably between fields or farms, from year to year, and even within a year. For purposes of analyzing the long-term trends in salinity, irrigation water is estimated to be 88 percent surface water and 12 percent groundwater (based on unpublished estimates of future conditions in Westlands made by Reclamation, 2002). The resulting salinity of applied irrigation water is about 530 ppm TDS.
- Two categories of land retirement are considered in the No Action Alternative. The first is land retired under all alternatives, including No Action, as part of existing programs or settlements. This category totals about 44,100 acres. The second category is land assumed to be retired in the No Action Alternative, but that could remain in production under the action alternatives. A total of about 65,000 acres in the drainage impaired area of Westlands fall in this category. The exact location of these lands is not yet known. For purposes of analysis, they are distributed proportionately among the three subareas. Table 2 summarizes the lands retired and those remaining under irrigation.

Table 2. Lands Assumed Retired in the No Action Alternative

Westlands Subarea	Total Irrigated (2001 Existing Conditions)	Acres Retired in All Alternatives	Additional Acres Retired Only in No Action Alternatives	Acres Potentially Remaining in Production, No Action Alternatives
North	119,880	38,300	26,800	54,780
Central	127,260	5,800	11,800	109,660
South	129,490	0	26,400	103,090
Total	376,630	44,100	65,000	267,530

Note: Lands outside the drainage-impaired area are not included.

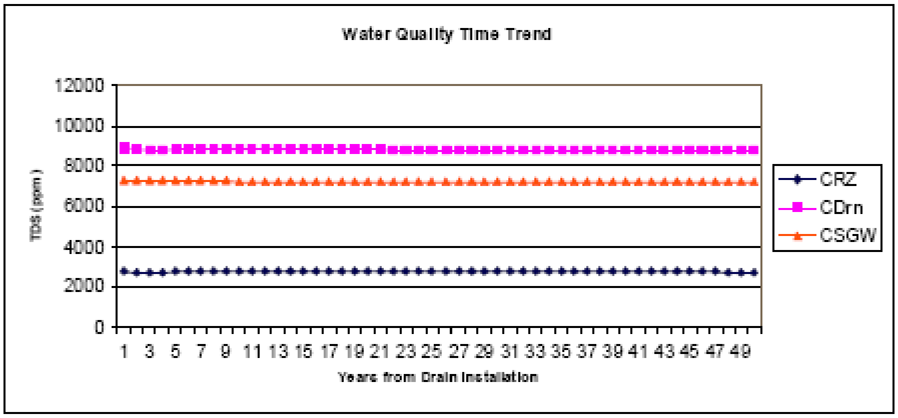
The key issues for the Westlands subareas under No Action are whether lands can stay in production given the small level of natural drainage, and if so, at what cost. The evaluation follows closely what was described above for the Northerly Area districts after closure of drainage to the Grassland Bypass. The natural drainage rate was estimated by regional groundwater modeling for the drainage-impaired areas in Westlands. The rate varies across the region, averaging about 0.25 AF/acre/year by 2030, for all of the drainage-impaired lands.

Mapping of natural drainage rates shows that lands most affected by drainage and salinity effects have a lower rate. For purposes of analysis, lands receiving drainage installation in drainage service alternatives are assumed to average a natural rate of 0.20 foot/year. The remaining lands are assumed to average 0.35 foot/year, such that the overall, acreage-weighted average is about 0.25 foot/year.

As described for the Northerly Area districts, two strategies can be used to reduce deep percolation to a level that does not exceed the natural drainage rate. First, crop mix can be changed to reduce overall water use, including changing the crops grown and increasing the frequency of fallowing. Second, irrigation management and application uniformity can be improved to reduce the deep percolation of applied water. Both strategies must be implemented in a way that can maintain adequate leaching of salts, or that at least provides enough leaching to avoid rapid deterioration of soil conditions. Estimates of current water use in the drainage-impaired area indicate that irrigation efficiencies are already quite high, especially considering the need for leaching water – SAE is estimated to average about 85 percent. Therefore, irrigation efficiencies are assumed to be maintained at this high level under the No Action Alternative. Under the No Action Alternative, no salts are removed from the irrigated area through artificial drainage; consequently, they continue to accumulate in the soil and groundwater.

Results

Results for the three Westlands drainage-impaired subareas (North, Central, South) are similar. The main difference is in the estimated starting salinity in shallow groundwater. Figure 2 shows estimated salinity conditions for the Westlands Central drainage-impaired area. Conditions appear to remain relatively stable over the 50-year horizon, but at very restrictive drainage conditions that substantially limit crop mix and profitability.



CRZ = Concentration of salts in the root zone (ppm TDS of saturation extract)
CDRN = Concentration of salts in subsurface drainwater (ppm TDS)
CSGW = Concentration of salts in shallow groundwater (ppm TDS)

Figure 2 Salinity Trends in Westlands Central, No Action Alternative

As was described for the Northerly Area districts, salt balance is not achieved in Westlands under the No Action Alternative. Although Figure 2 appears to show a balance in salt concentration, in fact a substantial mass of salt continues to percolate below the shallow water table into the deeper groundwater layers. In addition, the No Action Alternative does not provide any outlet for removing the salts that have accumulated in the soil and groundwater from past irrigation. Conditions for Westlands North and South would be similar to Westlands Central.

Discussion of Irrigation Management, Crop Mix, and Natural Drainage

The evaluation of SAE and crop mix changes to maintain land in production without artificial drainage depends critically on the estimated rate of natural drainage. Poorly drained lands have a low rate of natural drainage. If aggregate deep percolation can be kept equal to or less than natural drainage, and the deep percolation provides an acceptable leaching fraction, then long-term root zone equilibrium can be maintained. Several considerations are important for managing irrigated crop production under poor drainage conditions:

- Even if irrigation can be managed to hold deep percolation equal to natural drainage, salts would continue to accumulate in the shallow groundwater. These salts would also continue to migrate into deeper groundwater over time. Only artificial drainage that removes and disposes of salts can improve the long-term salt balance that includes both root zone and groundwater salt loads.
- Very careful irrigation management is required, which means that both SAE and distribution uniformity must be high. The cost of irrigation hardware and management is significantly higher than for irrigation under well-drained conditions.
- Lands for which revenues cannot support the higher irrigation and management costs would go out of production.
- The continued accumulation of salts in the shallow groundwater makes this situation relatively risky. Small changes in the overall water and salt balance (for example, reducing groundwater pumping that provided some portion of the natural drainage, or a change in the salinity of applied water) can result in a fairly rapid deterioration of root zone conditions.

• To keep deep percolation within the limits provided by natural drainage, the cropping pattern generally needs to be restricted to lower-ET crops. Small grains (e.g., wheat and barley) may need to play a larger role in the crop mix. Sugar beets and some forage crops can tolerate the saltier soil conditions, but their relatively high water uses may result in more deep percolation than allowed by drainage conditions.
• The net result of higher soil salinity and restricted deep percolation is a crop mix that excludes both salt-sensitive crops and high water-using crops. Small grains, salt-tolerant row crops, and a mixture of cotton with grains and/or row crops are the most feasible cropping systems. When natural drainage is very restrictive (e.g., less than 0.25 foot/year), rotational fallowing may be required to allow the shallow groundwater to subside. Again, careful irrigation management is needed to avoid excessive salinization of the soil.

The benefits of the action alternatives can be estimated as the costs avoided relative to the No Action Alternative. These avoided costs fall into three categories:
• Irrigation management costs
• Net revenue losses resulting from the restricted crop mix
• Net revenue losses from land retired
Analysis and results for the action alternatives are described later in this section.

Interaction Between Land Retirement and Irrigation Management
In the No Action Alternative, it is estimated that about 109,000 acres of land would be retired within the drainage-impaired area of Westlands. Land retirement has two effects on regional drainage conditions. First, it removes drainage-impaired land from production and, therefore, eliminates the need to provide artificial drainage on those lands. Second, the reduction in irrigation and deep percolation of irrigation water may provide some regional benefit to the shallow groundwater: lands remaining in production may benefit, because the regional water table may be lowered to some degree due to retirement. The magnitude of this second effect has not been quantified, although groundwater analysis performed as part of plan formulation has estimated the effect to be small (see PFR Addendum [Reclamation 2004]). Several combinations of land retirement and irrigation improvements were evaluated as part of the screening analysis of land retirement scenarios. Results of the screening analysis are described in the PFR Addendum (Reclamation 2004).

Sensitivity Analysis on Natural Drainage Rate
The natural drainage available to lands in the drainage-impaired area is small but significant. For the Northerly Area drained lands, it is estimated to be about 0.15 foot/year under the No Action Alternative in 2030; the corresponding estimate for most drainage-impaired Westlands' lands is 0.20 foot/year. These are regional averages estimated using a calibrated groundwater model. Actual conditions are likely to vary around the estimated average, resulting in some lands having more restricted drainage and some lands having less restricted drainage. To illustrate how small changes in the natural drainage rate can affect conditions, the drainage and salinity model was used to estimate the required net deep percolation and the resulting soil and shallow groundwater salinity over time under a range of assumed natural drainage rates. For illustration purposes, conditions in Westlands North are used, but general conclusions apply for the

other areas. Also, crop mix is held constant; and regional shallow groundwater trends are assumed to be the same as for the No Action Alternative. Table 3 summarizes the required average irrigation efficiency (defined here as seasonal ET of applied water divided by seasonal applied water) to maintain stable water table conditions. Natural drainage rate was varied between 0.1 and 0.3 foot/year.

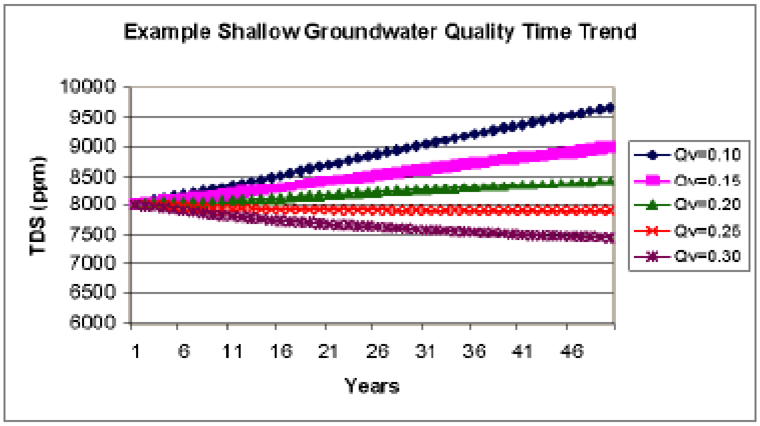
Table 3. Sensitivity Analysis on Natural Drainage

Natural Drainage (feet/year)	Applied Water (feet/year)	Necessary Seasonal Application Efficiency[1]	Estimated Salinity after 50 Years	
			Soil Salinity (EC)	Shallow GW Salinity (EC)
0.10	2.44	92%	4.9[2]	12.5
0.15	2.49	90%	4.6[2]	11.6
0.20	2.54	88%	4.3[2]	10.9
0.25	2.59	86%	4.1[3]	10.3
0.30	2.65	85%	3.9[3]	9.7

Notes:
[1] Defined as the ratio of ETAW to AW required for net deep percolation to equal natural drainage.
[2] Adequate leaching is not achieved. Soil salinity continues to rise over time.
[3] Very high distribution uniformity is required to achieve adequate leaching over entire field.

All of the drainage rates shown in the table require a high level of irrigation management to balance the need for leaching with the small amount of net deep percolation available through natural drainage. In fact, the modeling indicates that for a natural drainage rate of 0.25 foot/year, irrigation management is just able to maintain both leaching and shallow water table management, although the cost is high. At natural drainage rates of 0.20 foot/year or less, adequate leaching is not achieved and soil salinity deteriorates over time. (Note that this conclusion also depends on other assumptions and starting conditions such as TDS of shallow groundwater and applied water.) Figure 3 illustrates the effect on shallow groundwater salinity over time at different rates of natural drainage. Shallow groundwater is defined here as groundwater less than 20 feet below surface. The trend lines all start at 8,000 ppm of TDS and reflect the assumption that land is kept in production. The analysis suggests that shallow groundwater salinity can be held reasonably constant at a natural drainage rate of 0.25 foot/year, assuming irrigation and cropping patterns are managed appropriately. This does not imply, however, that salt balance is achieved: salts continue to move downward and accumulate in the aquifer below 20 feet.

This analysis indicates how drainage rates, irrigation water use, and soil salinity interact. Note that achieving the high irrigation efficiencies shown in Table 3 would be extremely difficult. A similar analysis could be conducted holding irrigation efficiency constant and estimating the average applied water (as determined by crop mix) that maintains net deep percolation at or below the natural drainage. This approach is described later and is used to estimate the change in crop net revenue from improved drainage conditions.



Qv = rate of natural drainage, in feet per year.

Figure 3. Sensitivity Analysis on Shallow Groundwater Salinity, Different Conditions of Natural Drainage

Land and Soil Resources No Action Alternative

The No Action Alternative assumes that the proposed Federal action would not be implemented to improve the drainage and salt outlet problem. Each district and the growers would continue to attempt to solve the drainage problem on their lands but no major improvements would take place. A total of 379,000 acres would be affected by shallow groundwater by the year 2050. Presumably, no new private drain systems would be installed due to the expense of on-farm reuse and salt disposal installations. The Northerly Area districts and Panoche Drainage District, in particular, would be severely impacted by the loss of their drainage outlet in 2009. Water tables in much of Panoche Drainage District are expected to rise to within 2 feet of the ground surface, making irrigated farming nearly impossible and creating several salt sink areas. Nearly the entire Panoche Irrigation District and many adjoining areas would no longer qualify as Prime Farmland due to the shallow groundwater conditions and associated soil salinity problems.

Conditions would continue to deteriorate after 2050. Salt management and disposal facilities would be installed in some current reuse areas that serve privately drained areas. Under this alternative, agricultural productivity in the area would continue to decline. A total of 109,100 acres of lands would be retired from irrigation, and soil salinity would continue to rise on drainage-impaired lands, decreasing the overall land productivity in the area. The retired lands would be used for wildlife habitat, dry pasture, and dryland summer fallow grain operations. These lands would no longer qualify for Farmland of Statewide Importance (FSI) since they would not be irrigated. Portions of the additional 65,000 acres of land acquired by Westlands (Sagouspe settlement) and retired from CVP irrigation water deliveries could be irrigated with groundwater or other non-CVP water sources. Salt-tolerant crops such as cotton, grains, and sugar beets would be grown on these lands. Irrigation of these lands with groundwater would provide some drainage relief for the entire drainage-impaired area and reduce the potential for salt sink development. These lands would still meet the criteria for FSI, but soil salinity would be too elevated for some crops. It is anticipated that between 0 and 17,000 acres of these lands would be irrigated in any given year.

The average acreage irrigated is assumed to be 6,500 acres (10 percent). It is further assumed that these acres would be rotated so that about 15,000 acres of lands would be irrigated in any consecutive 3-year period. Based on this assumption, the 15,000 acres would still qualify as FSI. Lands remaining in production in drainage-impaired areas would continue to experience soil salinity increases. Soil salinity on these lands would exceed criteria for Prime Farmland. Growers would produce mostly salt-tolerant, low-water-use crops such as cotton, barley, safflower, and winter annual dairy support crops such as triticale. The amount of fallowed lands would increase, especially in low water supply years, which would cause the water table to slowly recede in response to the slow natural drainage (<0.1–0.3 foot per year) and to use the water supplies on permanent crops and more valuable vegetable crops grown on the higher lands that are not affected by shallow groundwater. Many of these lands have been removed from consideration as Prime Farmland since 1985, and about 76,000 acres that now are considered Prime Farmland would no longer qualify based on current soil salinity and water-table trends and projections made by the APSIDE and Hydrofocus models.

The middle and upper alluvial fans would remain productive Prime Farmland under the No Action Alternative. Production on these lands may actually increase due to additional water supplies becoming available upon retirement and increased fallowing of downslope lands. When compared to the existing environment, this alternative would result in a net loss of about 76,000 acres of Prime Farmland and a loss of about 87,000 acres of FSI. The size of existing district and private salt management facilities and terminal reuse areas is expected to increase by about 160 acres during the impact analysis period.

Salt sink areas are expected to increase in the No Action Alternative relative to the existing situation, since the effects of recent groundwater transfers to upslope lands have not yet fully impacted downslope areas. Groundwater-pumping-induced drainage would also be reduced somewhat under the No Action Alternative on Area of Potential Effects lands due to land retirement. Land use would not change due to management of retired lands for related purposes: dryland farming, grazing, or fallowing. Nearly all of the retired lands are committed to preservation as agricultural lands under the Williamson Act. These lands would not be completely changed from agriculture.

Recreation Resources No Action Alternative

The No Action Alternative would consist of reasonably foreseeable future conditions without drainage service alternatives. Under the No Action Alternative approximately 109,100 acres of land would be retired from irrigation. Some reuse due to the existing Grassland Bypass Project would occur, and existing pilot projects that could utilize reuse and treatment systems would continue in the area.

With no drainage service to the drainage study area, it is probable that salts and Se could accumulate in some areas and reduce the viability of the affected lands for wildlife habitat. Recreation use could be reduced if some areas with hunting or wildlife viewing potential were put out of operation. In addition, fishing in the nearby wildlife refuges could be affected if the salts or Se levels became elevated due to uncontrolled discharges within the watershed from seepage, unplanned discharges, and/or storm events.

Cultural Resources No Action Alternative

The No Action Alternative would have both negative and positive effects on cultural resources over the 50-year planning horizon. Changes in cropping patterns would affect cultural resources in a number of different ways. Deep ripping and leveling could further degrade archeological deposits. New irrigation techniques and drainage may further disturb cultural resources. The construction or removal of agriculture-related structures may also have a direct effect on historic properties.

An increase in land retirement, abandonment, or temporary fallowing may both reduce and increase effects to historic properties. Since many operators would be forced to fallow a portion of their fields in multiyear rotations, effects to archeological resources from plowing, leveling, and other agriculture-related activities may be reduced. Abandonment of historic structures may lead to their destruction and loss. Effects to cultural resources by conversions to nonagricultural land use would vary depending upon the change.

No new collection facilities would be constructed through the 50-year project life. The likelihood of disturbing buried archeological resources would be reduced. On-farm source control measures could increase the likelihood of disturbing cultural resources. The exact nature of effects to cultural resources under the No Action Alternative would depend on the particular changes in land use which might occur. A Class I records search was not conducted for the No Action Alternative. In the absence of actual cultural resource site locations, the conservative approach would be to consider that this alternative would have adverse effects on historic properties. The No Action Alternative does not require mitigation.

Aesthetics No Action Alternative

The No Action Alternative assumes that the SLDFR project facilities would not be implemented to address drainage and water quality problems within and downslope of the SLDFR lands. Under this alternative, no new Federal drainage conveyance facilities would be constructed, nor would additional regional drainwater treatment, conveyance, and disposal facilities be developed beyond those that either existed in 2001 or are currently authorized, funded projects. Thus, visual effects would be limited to changes in existing patterns of land use within the SLDFR lands.

A total of 109,106 acres would be expected to be retired from active agricultural production under this alternative by the year 2050. Given the assumed salt buildup in the soil of these areas, it is assumed that much of this land would convert to unmanaged open space or be used for dry pasture, dryland summer fallow grain operations, fallowing, and other uses consistent with local plans and zoning. Lands remaining in production within drainage-impaired areas would likely be switched over to salt tolerant, low water use crops such as cotton, barley, safflower, and winter annual dairy support crops such as triticale. An increase would likely be seen in fallowed lands during low water supply years. This increase would be in addition to the land retirement described above. None of these changes in land use would result in the introduction of new visual elements that are not currently present within the SLDFR lands. However, these changes in land use could produce some visual effect, particularly if the retired acres are located in contiguous tracts. This effect would be potentially minor and permanent.

Certain components of the GDA's proposed In-Valley Treatment/Drainage Reuse Facility are included under No Action. These components would result in an increase in the area planted with salt-tolerant crops and serviced by subsurface drainage systems. However, in the absence of the SLDFR, none of the other components are expected to be implemented. Other on-farm, indistrict activities are assumed to occur under No Action, including ongoing use of existing drainage control/reuse measures, on-farm irrigation system improvements, changes in irrigation practices, reallocation of water from drainage-impaired areas to unaffected areas, and other drainwater reduction measures. None of these activities would alter the characteristics of viewsheds within the SLDFR lands, nor would they introduce new visual elements that are not currently present. The visual effects associated with these activities would, at most, consist of a change in cropping patterns on lands that have been historically in agricultural production. This effect would be potentially minor and permanent.

Regional Economics No Action Alternative

To estimate the regional economic effects of the various action alternatives, specific information about each alternative must be acquired and compared to the No Action Alternative. This information includes the anticipated change in irrigated acres and cropping patterns, i.e., the amount of land removed from agricultural production, the changes in types of crops grown, and changes in crop yields expected to occur if no drainage facilities are developed.

Assumptions used to analyze regional economic effects of the No Action Alternative in comparison to the existing conditions in 2002 are:

• Increased expenditures for irrigation hardware, technology, and management expertise would be required to improve irrigation efficiency and application uniformity to allow continued agricultural production on drainage-impaired lands. These expenditures are assumed to be a redistribution of expenditures made by irrigators rather than an overall increase in regional expenditures. In other words, the increased cost of implementing improved irrigation management measures is not a measure of additional money spent in the regional economy. Rather, irrigators would have less money to spend on other crop production expenses than they typically would if adequate drainage conditions existed. From a regional economic perspective, this shift in expenditures from one cost category to another should be measured to determine the economic effect within the region. However, since insufficient data exist to predict how irrigators would change specific crop production expenditures, the cost of improved irrigation management measures is not incorporated into the regional economic analysis.

• In spite of irrigation improvements indicated above, the currently existing crop mix would change to one with a lower overall water requirement and a corresponding decrease in on farm revenues. The decrease in farm revenue is incorporated into the regional economic analysis.

• Approximately 65,000 acres of land within the drainage-impaired area of Westlands would be retired from agricultural production and land retirement payments of $100 million would be paid by Westlands to compensate landowners for lost farm revenues.

Since it is expected that Westlands would fund land retirement payments by charging additional fees to the remaining irrigators within the district, these land retirement payments, like the costs of improved irrigation management discussed above, are considered to be a redistribution of regional expenditures rather than an increase in regional spending. Therefore, any land retirement payments made by Westlands are not included in the regional economic effect analysis. Estimated changes in agricultural output from switching to a salinity-restricted crop mix are caused by a regional shift to a salinity-restricted crop mix under the No Action Alternative. The projected changes in crop revenues are displayed on Figure 4. Economic effects of crop losses estimated to occur in Years 1, 10, 25, and 50 are displayed in Table 4.

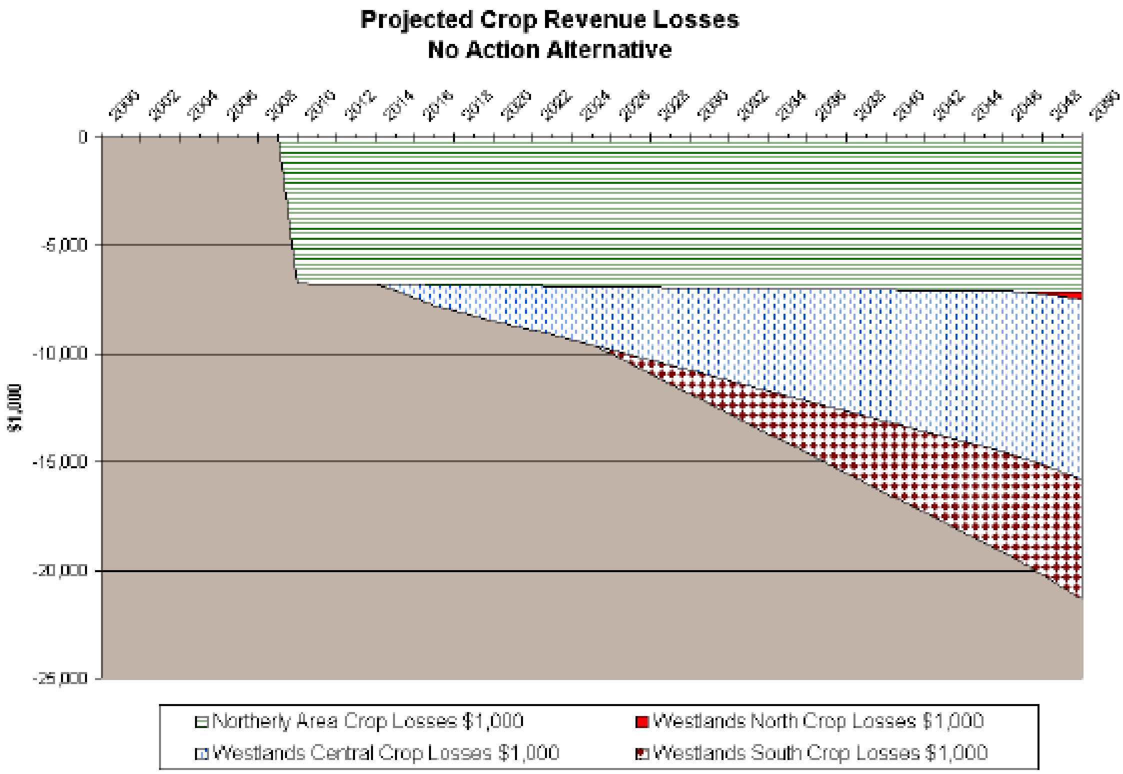


Figure 4. Projected Crop Revenue Losses Under the No Action Alternative

Table 4. No Action Alternative Regional Economic Effects of Annual Crop Revenue Losses

Year Estimated	Output Effect ($000)		Labor Income ($000)		Employment Effect (Jobs)	
	Direct	Total	Direct	Total	Direct	Total
Year 1	-2,388,000	-4,302,158	-597,275	-1,295,022	-22.5	-52.4
Year 10	-23,880,000	-43,021,574	-5,972,755	-12,950,223	-225.2	-524.4
Year 25	-38,208,000	-68,834,522	-9,556,407	-20,720,356	-360.4	-839.1
Year 50	-62,088,000	-111,856,095	-15,529,162	-33,670,578	-585.6	-1,363.5

Social Issues and Environmental Justice No Action Alternative

Under the No Action Alternative an increasing loss of jobs would occur. The estimated employment effect for the nine-county project area would be a loss of 500 jobs during years 1 through 10, a loss of about 800 jobs in year 25, and a loss of about 1,400 jobs in year 50. Since the losses are primarily due to changes in agricultural output, it is likely some of those adversely affected would be minority and low-income workers. Because the number of jobs lost is a small percentage of total minority and low-income employment, the effect is minimal.

Other Disclosure Requirements No Action Alternative

- The No Action Alternative has an adverse effect on bare soil evaporation relative to existing conditions.
- Increased bare-soil evaporation without drainage to remove salts would increase soil and groundwater salinity. In the Grassland Drainage Area, a 10 percent groundwater salinity increase is estimated after 9 years of conditions similar to the No Action Alternative that would be an adverse effect.
- The risk of introduction or spread of noxious weeds and invasive species would increase as the aerial extent of retired, settlement, temporarily fallowed, and drainage-impaired lands increases and would be considered a significant adverse effect.
- Without continued use of the Drain (as part of the Grassland Bypass Project), seepage of drainwater into the supply channels and periodic overtopping during storm events would degrade the water quality in the channels and in downstream wetlands, resulting in unavoidable effects to Federally and State-listed special-status species.
- With the No Action Alternative, additional acres of agricultural land would go out of production. Higher costs of irrigation and salinity management and restricted crop production would occur. The loss of access to the Grassland Bypass for drainage discharge would result in irrigation management and crop revenue losses.
- The No Action Alternative would result in a net loss of about 76,000 acres Prime Farmland and 87,000 acres FSI, an adverse effect and largely unavoidable.
- The increase of salt sinks due to the No Action Alternative would have an adverse, unavoidable effect.
- Land uses would change and become inconsistent with local zoning policies and general plans, resulting in an adverse effect on land use.
- With possible unplanned discharges or seepage of stormwater runoff into the existing San Luis Drain, the No Action Alternative may have an adverse effect on wildlife viewing/hunting opportunities in refuges connected to the San Joaquin River.
- In the absence of actual cultural resource site locations, the conservative approach would be to consider that the No Action Alternative would have adverse effects on historic properties. However, the No Action Alternative is not an undertaking subject to Section 106 of the National Historic Preservation Act; therefore, it does not require mitigation for adverse effects.

References

Belitz, K., S.P. Phillips, and J.M. Gronberg. 1993. Numerical simulation of ground-water flow in the central part of the western San Joaquin Valley, California. *U.S. Geological SurveyWater-Supply Paper* 2396.

Bureau of Reclamation (Reclamation). 2001. Grassland Bypass Project. Final Environmental Impact Statement and Environmental Impact Report. Prepared for Reclamation and San Luis and Delta-Mendota Water Authority by URS Corporation. May 25.

Bureau of Reclamation (Reclamation). 2003. Westlands water needs assessment table faxed to John Fio, HydroFocus, Inc., November 2003.

Bureau of Reclamation (Reclamation). 2004. Plan Formulation Report Addendum. July.

California Department of Water Resources (DWR). 1993. California Water Plan. Bulletin 160-93.

Luoma, S.N. and T.S. Presser. 2000. Forecasting selenium discharges to the San Francisco Bay-Delta Estuary: ecological effects of a proposed San Luis Drain extension. *U.S. Geological Survey Open-File Report* 00-416.

URS Corporation. 2002. Source Control Technical Memorandum. Prepared for the Bureau of Reclamation. June 17.

Appendix B – Qualitative Analysis/Discussion of Increased Contractual Deliveries

Qualitative Analysis/Discussion of Increased Contractual Deliveries - San Luis Unit

Primary Author:
Nigel W.T. Quinn PhD, PE
Berkeley National Laboratory
1 Cyclotron Road
Berkeley, CA, 94720
nwquinn@lbl.gov

Assisted by:
Mid-Pacific Region
United States Bureau of Reclamation

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TABLE OF CONTENTS

1.0 PURPOSE OF PAPER

This paper provides additional information in response to the hypothetical question, what impacts may result if factors limiting contract deliveries to contractors in the San Luis Unit are removed, so that contractors receive the maximum amount of water authorized under their contracts, and no federal drainage solution is implemented within the San Luis Unit during the term of the renewal contracts?

1.1 Background

Appendix A describes the affected area in more detail and provides relevant background material that more fully expounds on the nature of irrigated agriculture in a saline environment and the chronology of water supply development and drainage service in the western San Joaquin Valley.

2.0 GRASSLANDS AGRICULTURAL SUBAREA

2.1 Continued drainage management by local entities.

The Grasslands agricultural subarea (Figure 1) is bounded by the Delta-Mendota Canal to the north, California Aqueduct to the west, and San Joaquin River on the east. Soils in the subarea are nearly level to gently sloping, and moderately to poorly drained and most are derived from low alluvial fans emanating from the Coast Range. The original source of irrigation water in the area was groundwater. However, because of the poor quality and limited quantities of groundwater, the agricultural water districts in the subarea began receiving project water from the San Joaquin River in the 1940's under interim contracts. Contract negotations began with United States Bureau of Reclamation (USBR) for the CVP water in the late 1940's, and long-term contracts were established in the mid-1950's allowing for delivery from the Delta-Mendota Canal. In the 1960's, contracts were amended to permit delivery of water from the newly constructed California Aqueduct to new areas. Irrigators in the subarea came to rely on relatively small CVP supplies (approximately 2.4 acre feet per acre at 100% deliveries) to the near exclusion of saltier groundwater. The subarea receives a yearly average of nine inches of precipitation, most of which falls during the months of November through March and at times and quantities that very little of this rainfall can be applied as beneficial use for cropping. Of the approximately 100,000 acres in the Grasslands agricultural subarea, less than half are in the San Luis Unit. These include lands within the Panoche Water District (approximately 38,000 acres), the Pacheco Water District (approximately 4,400 acres) and drainage areas within the San Luis Water District (approximately 5,100 acres). Tables 1 and 2 summarize water use of Panoche Water District and Pacheco Water District, respectively.

PANOCHE DISTRICT WATER SUPPLY								
Water Year	CVP Allocation %	Net CVP 94000 (AF)	Net Transfers	Grower Well water estimates	Total Delivered ** (AF)	Acres Farmed	Total Water Applied	AF/AC
1988	100%	99,308	1,450		97,858	33,645	97,858	2.91
1989	100%	93,958	7,919		86,039	35,661	86,039	2.41
1990	50%	43,919	9,072	6,000	52,991	32,681	58,991	1.81
1991	27%	38,519	1,690	18,000	36,829	27,173	54,829	2.02
1992	27%	32,672	494	4,500	32,178	27,920	36,678	1.31
1993	54%	81,098	8,257	6,078	80,413	32,536	86,491	2.66
1994	43%	47,998		15,914	65,379	30,301	81,293	2.68
1995	100%	64,796		3,000	79,669	32,707	82,669	2.53
1996	95%	69,911	7,236	4,000	79,640	35,805	83,640	2.34
1997	90%	63,204	11,712	5,000	77,949	35,849	82,949	2.31
1998	100%	52,685	10,000	4,000	65,063	36,130	69,063	1.91
1999	70%	58,054	5,536	6,000	73,131	36,197	79,131	2.19
2000	65%	57,081	2,242	8,500	77,834	35,249	86,334	2.45
2001	49%	54,087	1,798	2,000	69,626	26,205	71,626	2.73
2002	70%	62,856	449	10,000	80,336	37,764	90,336	2.39
2003	75%	60,245	8,297	10,000	76,900	38,886	86,900	2.23
2004	70%	56,112	6,824	8,500	76,740	37,143	85,240	2.29
2005*	85%	53,445	931	7,000	70,525	37,324	77,525	2.08
		USBR Deliveries			Total District Deliveries			
* deliveries through December 05				Blanks indicate no data available				
** Includes CVP, transfers In , District Non-CVP acquisitions, and drain water recycled.								

Table 1. CVP water supply allocation to Panoche Water District showing use of transfers, groundwater conjunctive use and in-district reuse to offset CVP shortages (Panoche Water District, 2006).

The majority of agricultural acreage in Grasslands agricultural subarea is used to produce melons, cotton, alfalfa and tomatoes. The five major irrigation methods in the subarea (in order by highest to lowest acreage) are sprinkler (hand move), graded furrow (¼ mile length with siphon tube), drip (surface and subsurface), and furrow (¼ mile length with gated pipe). Irrigated acreage within the Grasslands agricultural subarea is relatively constant from year to year though land fallowing has occurred with a consequent reduction in irrigated acreage during drought and below-normal years when CVP water deliveries have declined to less than 50% of contract supply. Tables 1 and 2 show that during years when CVP water allocation is less than 100% water districts within the Grasslands agricultural area rely on local sources such as water transfers from other water districts, including the Exchange Contractors, groundwater pumping and both surface and subsurface drainage reuse to supplement their contract water supply.

Drainage water from the subarea was discharged historically through the Grassland Water District, and diverted into either Mud or Salt Sloughs in transit to the San Joaquin River. In 1996 the drainage water was rerouted through a newly constructed channel that bypassed the Grassland Water District, along 29 miles of the former San Luis Drain into Mud Slough and the San Joaquin River (Appendix Figure A2). The Grasslands Bypass Project had been conceived almost a decade earlier as a means of limiting waterfowl exposure to potentially toxic selenium in the agricultural drainage passing through almost 90 miles of wetland channels and improving operational flexibility within Grassland Water District, which had to flush canals of selenium drainage water before making wetland deliveries.

PACHECO DISTRICT WATER SUPPLY							
Calendar Year	CVP Allocation %	Net CVP 10080 (AF)	Net Transfers	CCID Contract	Total Delivered ** (AF)	Acres Farmed	AF/AC
1988	100%						
1989	100%						
1990	50%						
1991	27%				9,137	4,060	2.25
1992	27%				8,784	4,060	2.16
1993	54%				10,106	4,060	2.49
1994	43%				10,133	4,060	2.50
1995	100%	7,902		4,533	11,215	4,064	2.76
1996	95%	8,610		5,078	12,908	4,064	3.18
1997	90%	6,741		4,837	11,430	4,072	2.81
1998	100%	5,228		1,563	6,691	4,072	1.64
1999	70%						
2000	65%	4,734	32	5,667	9,657	4,243	2.28
2001	49%	6,023	396	5,066	11,106	4,243	2.62
2002	70%	6,249	499	5,623	10,974	4,243	2.59
2003	75%	7,229	706	5,260	11,597	4,242	2.73
2004	70%	8,272	908	5,821	12,292	4,243	2.90
2005*	85%	5,656		4,012	10,133	4,243	2.39
		USBR Deliveries			Total District Deliveries		

* deliveries through December 05 Blanks indicate no data available
** Includes CVP, transfers In , District Non-CVP acquisitions, and drain water recycled.

Table 2. CVP water supply allocation to Pacheco Water District showing use of transfers and how a contract with the Central California Irrigation District (CCID) is used to offset CVP shortages (Pacheco Water District, 2006). Total water delivered includes in-district reuse.

When the Grassland Bypass Project was implemented in 1996, Reclamation made the project proponents' use of the federally owned San Luis Drain contingent on compliance with strict monthly and annual selenium load targets and the formation of a regional drainage management authority. The monthly and annual load targets for the 100,000 acre drainage service area (the majority of the Grasslands agricultural subarea) were established through a lengthy negotiated process between the water districts, State, Federal and local agencies, and private environmental organizations. Negotiated selenium load targets were set each month based on average monthly selenium loads from the project area - annual load targets were set at 6,600 lbs per year, less than the sum of the monthly load targets. The annual selenium load targets were reduced by 5% per year in the last 3 years of the 5 year project. Renewal of the project further reduced post-project with eventual compliance with Mud Slough selenium water quality objectives of 5 ppb slated for 2009.

Incremental drainage incentive fees of up to $250,000 were to be levied for exceedence of either annual or mean monthly selenium load targets above 20%. In order to meet load targets and avoid financial penalties local farmers and water districts implemented the most aggressive source control and drainage management program ever conceived in the Central Valley coupled with a subarea-wide drainage flow and water quality monitoring program. In the first few months of the project continuous flow meters were installed at each of the main discharge points. A monitoring program was developed to measure drainage discharge and selenium load for each district. Telemetered water quality sensors were installed allowing real-time access to each district's contribution to overall drainage flow. Water meters were retrofitted on drainage sumps and discharge points within each district in order to estimate the drainage flow contribution from each sump and the mass contribution to each District's selenium load. With this knowledge individual water districts were able to develop their own internal load targets based on correlations between selenium loads and monthly flows at individual sumps.

Water districts also mandated drainage management policies throughout the subarea such as prohibition of tailwater return flows in the District owned drain. The water districts worked with individual farmers to design and construct tailwater return systems so as to blend tailwater returns with surface water deliveries. Some deep drains were also retrofitted with in-line control weirs to allow selenium drainage discharges to be regulated. In the case of tile systems that discharged to sumps, sump pump control sensors were raised to allow discharge only when water tables in the field rose to within 5 feet of the ground surface. Similarly, shallow groundwater levels were assessed through the construction of field water level indicators, color coded floating risers that protruded from shallow monitoring wells observable from the roadside that revealed the red colored band of the riser when water levels were sufficiently high to affect crop yields from rise of salts into crop root zone. This clever device, publicly visible, provided indirect peer pressure to those landowners whose water management practices allowed excessive deep percolation after irrigation and was very effective at improving on-farm drainage source-control practices. In the case of drains that discharged directly to open ditches - some main lines were severed and weir control structures installed at the outlet to help store more drainage water beneath each field prior to discharge to the District's drainage system.

Tiered water pricing for water deliveries had been in place for several years in some districts prior to the Grasslands Bypass Project. With the project, more districts adopted tiered pricing or modified policies to further encourage drainage reduction. In particular, water district policies of implementing separate tiered pricing for pre-irrigation addressed the propensity for lower on-farm irrigation efficiencies at the beginning of the irrigation season. Districts have installed regional recirculation systems, where subsurface drain water was collected and pumped back into the regional irrigation system. Irrigation water quality was closely monitored, and TDS levels within district canals were not allowed to exceed 600 mg/L.

Other drainage management activities include a 4,000-acre drainage reuse project, developed on lower quality ground outside the San Luis Unit service area that lacks a surface water supply. In the project, subsurface drain water is applied to irrigate salt tolerant crops, such as Jose wheat grass, paspalum grass, pistachios, eucalyptus trees, asparagus, and other pasture grasses. The area is being developed with subsurface tile systems and pumping facilities, to allow collection and reapplication of increasingly saline drainage and to protect against groundwater recharge. Full development of this area is anticipated by 2007. The water districts and Reclamation are also supporting research into drainage treatment using reverse osmosis, crystallization of solids for reclamation of usable byproducts and/or land disposal, and the production of reusable water.

The success with which the Grasslands Area farmers have reduced selenium discharges from the project area is shown in Figure 2. Figure 2 compares cumulative plots of selenium loads for the first eight years of the project (1997- 2003) and previous water years (1986 - 1996). Although selenium drainage targets were exceeded in January, February and April in the first year of the project this was not unexpected owing to the flooding that occurred due to El Nino conditions owing to higher than usual precipitation. The selenium load targets were based on mean monthly selenium loads recorded over a nine year period from 1985 - 1994, which included a sequence of drought years in the San Joaquin Valley and which was without any major flood events. Despite the challenges of the 1997 and 1998 El Nino years - average reductions of 60% compared to the pre-project mean monthly selenium load were achieved over a nine year period. A unique feature of the Grasslands Bypass Project was the spirit of co-operation being shown between water districts in this novel program. Rather than attempt to legally define each water district's share of the collective selenium discharge target load, the participants have chosen to work as one unit in meeting goals allowing participating water districts to strive to implement best management practices at their own pace. The advances made in the past 9 years were an intensive learning experience for water districts within the subarea and individual growers alike as they sought ways to sustain agriculture while complying with discharge reduction goals defined by the Grassland Bypass Project Use Agreement to improve water quality conditions in the San Joaquin River.

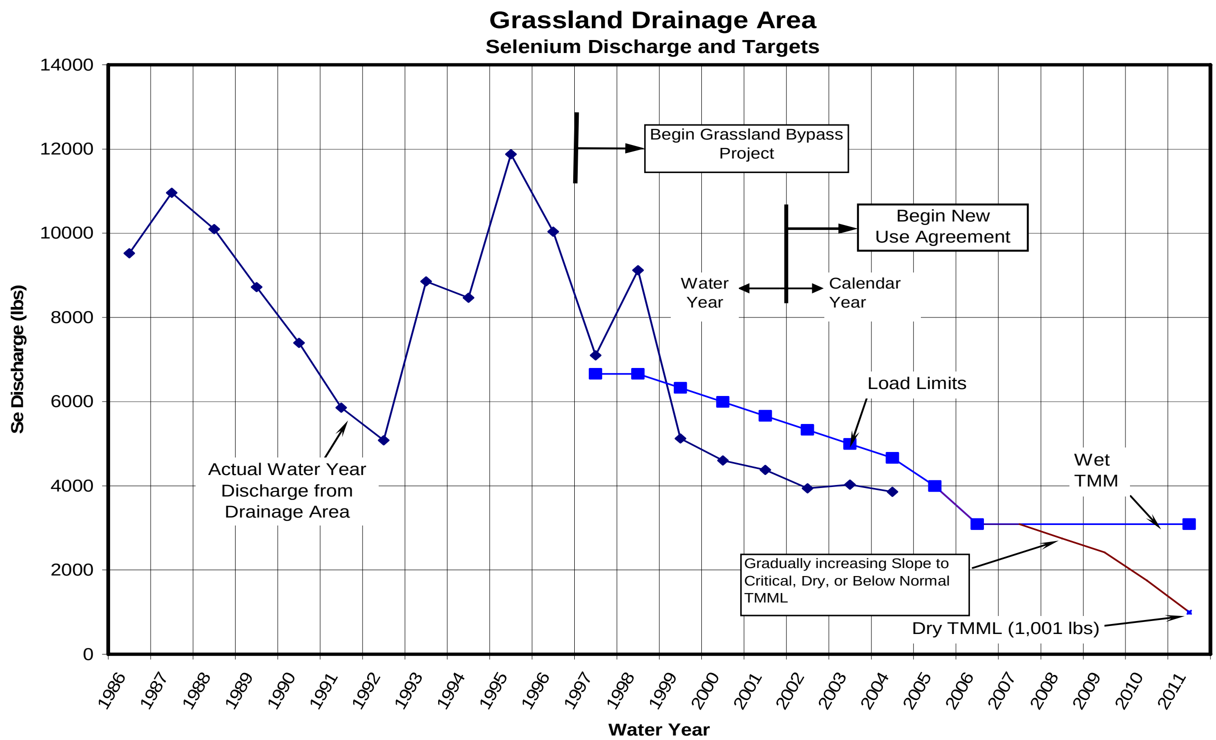


Figure 2. Comparison of pre-project and post-project selenium and salt loads showing the success of the Grasslands Bypass Project for management of subsurface drainage and demonstrating the potential for real-time water quality management of the San Joaquin River Basin.

As indicated in Figure 2, after 2010 the Dry Year Selenium objective in Mud Slough, into which the Bypass Waters are released, is 5 ppb. This is in addition to the required selenium load reduction to approximately 1100 lbs to meet San Joaquin River selenium objectives. Despite the success of the Grasslands Bypass Project, which showed that real-time water quality management is a viable option for improving San Joaquin Basin water quality, the selenium objective cannot be met in drainage discharges with current technologies. The Grassland Bypass Project contemplated the possibility of constructing a pipeline to carry drainage water below the Mud Slough compliance point. However, construction expense, the uncertainty of environmental review and permit requirements, potential public opposition and the concern that future regulations would nonetheless preclude drainage discharges to the San Joaquin River have prompted participants to instead adopt a plan that calls for the elimination of all subsurface drainage discharge to Mud Slough and the San Joaquin River by 2010.

This plan requires the acquisition and development of approximately 2,000 additional acres dedicated to subsurface drainage reuse, for which water districts within the Grasslands agricultural area are presently preparing environmental review documents and developing local and outside funding strategies. In order to reduce the scale of the reuse facility these water districts have continued to implement innovative source control measures, have invested in improvements in conveyance facilities to reduce system losses, pumped shallow groundwater in problem areas, fallowed lands within Broadview Water District, and experimented with new drainage treatment technologies to produce reusable water and dispose of solid salts. The current dedicated reuse facility and expansion target reuse areas are located on marginal agricultural lands located outside of the San Luis Unit service area that do not have CVP contract supplies and therefore do not retire prime agricultural land within the San Luis Unit. This facility will be intensively managed in order to maintain a root zone salt balance to allow sustainable cultivation of salt tolerant agricultural crops. This facility is being equipped with shallow, closely spaced tile drains to prevent water logging and the evaporative build-up of salts in the crop root zone and allow the sophisticated salt management required for sustainability and keep saline and selenium contaminated drainage from migrating offsite. A more detailed explanation of this concept is provided in Appendix A.

Should continued technical advances provide a breakthrough selenium remediation technology that is cost-effective – implementation of this technology could ultimately lead to use of the San Joaquin River as a legitimate drainage outlet. Under this scenario drainage discharges could be made under a real-time monitoring and management program up to the limit of assimilative capacity for salinity, consistent with terms of the TMDL recently adopted by the State Water Resources Control Board.

2.2 Increased CVP contract deliveries without implementation of a federal drainage management plan

In the selenium-affected portion of the Grasslands agricultural subarea (including Panoche, Pacheco, the Charleston Drainage area of San Luis in the San Luis Unit, together with Widren, Firebaugh and , the Camp 13 Unit of CCID and the Broadview Water Districts) **-** farm irrigation water management activities are tightly constrained by current environmental regulations and by continuing limitations in CVP contract allocations. Despite these dual constraints, cropped acreage and therefore, total water demands have remained relatively constant and have been satisfied by a combination of CVP contract allocation, water transfers, landowner groundwater pumping, and recycling of subsurface drainage. The local planning for drainage management facilities has taken this level of agricultural demand and resulting drainage demand into account.

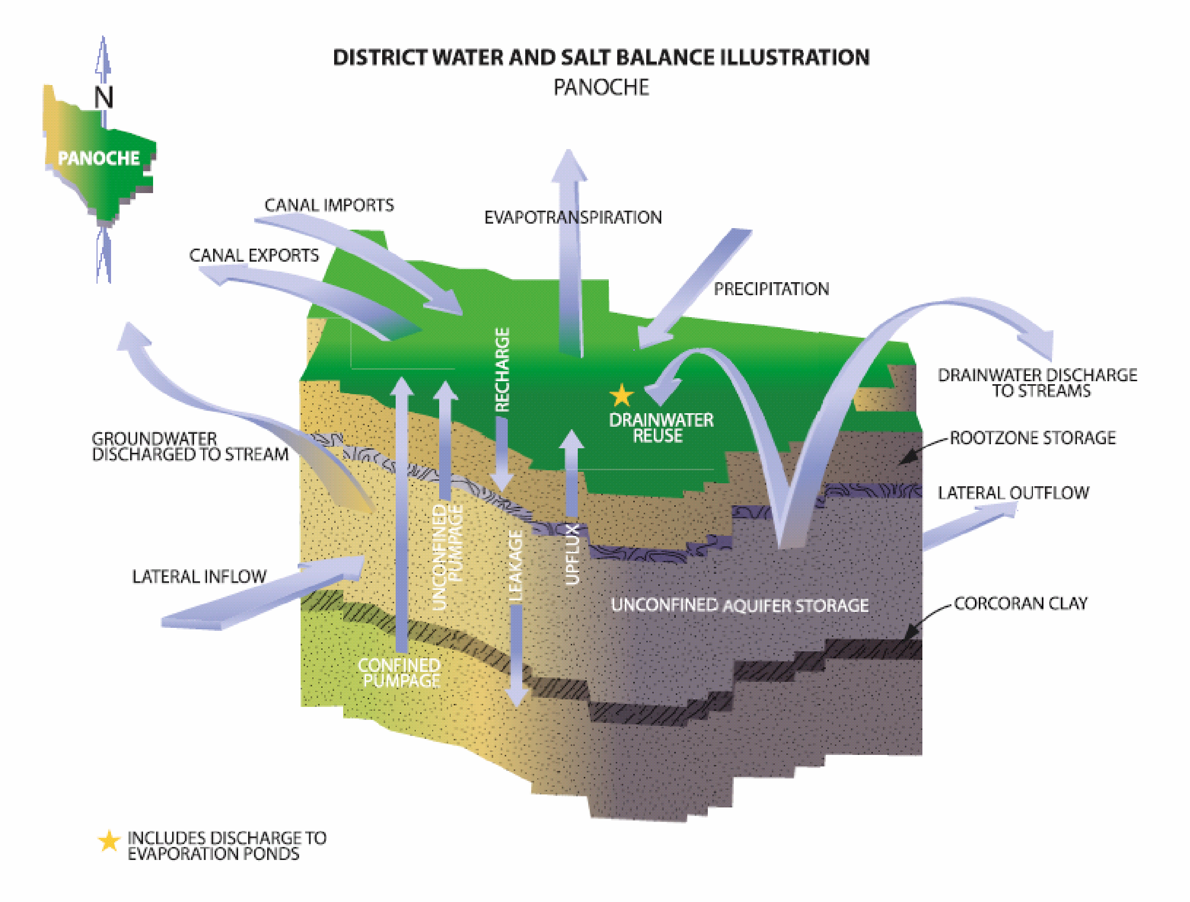


Figure 3. Water and salt balance components for the Panoche Water District which is located in the selenium affected area of the Grasslands agricultural subarea.

In Appendix A of this report there is a detailed description of the Basin hydrogeology and which shows how the Corcoran Clay layer restricts natural drainage in the Grasslands agricultural subarea. This section also explains how groundwater pumping, and both surface and subsurface drainage reuse reduce the amount of water required to meet the evapotranspiration needs of the growing crops. Figure 3 shows in diagrammatic form various components of the subarea water and salt balance for Panoche Water District and illustrates the fate of surface applied water which includes (1) loss to the processes of evaporation and evapotranspiration; (2) loss to groundwater which can contribute to (3) regional groundwater outflow from the district, (4) surface drainage return flows and/or (5) subsurface tile drainage.

If farmers receive a higher percentage of their contract supplies, they will be able to meet their crop needs with this additional CVP water supply and therefore will decrease their reliance on water transfers from other water districts. Most transfers are from other CVP contractors who are also served by the San Luis or Delta-Mendota Canal. This transfer water retains the same salinity attributes as the basic contract supply. Increased CVP contract allocation is also likely to substitute for groundwater conjunctive use given the poorer water quality of groundwater pumpage and the higher costs of pumping. This substitution may help to improve root zone salt balance in those areas which received a larger component of groundwater pumpage in their water supply. In Panoche Water District groundwater pumped into the District system and subsurface drainage recycled water is typically blended with the CVP water supply to equitably distribute the salinity impacts of the poorer quality water within the water district. Some groundwater is retained on-farm. The drainage reuse facility, previously described, is being sized to manage discharges from the irrigation of, what was shown in Tables 1 and 2, to be a relatively stable crop base. Hence any shift in the source of the water supply to the Grasslands agricultural subarea would not be expected to increase the applied water or drainage generated. The water districts are also likely to continue the current practice of adjusting contract allocations to crop demand and installed drainage management technologies using annual water transfers, that have been permissible under previous contracts with Reclamation's consent and which are subject to environmental review. Such transfers may be used to further curtail groundwater pumping or to meet crop needs in districts without access to groundwater or where drainage management constraints are less and where even full contract allocation is inadequate to meet the water demands of permanent crops.

Alternatively, if the agricultural water districts serving the Grasslands subarea apply additional water supply up to their full contract amount and continue to pump groundwater or accept transfers beyond current crop demand, they must still abide by the requirements of laws regulating water quality in discharges. Consistent with current local drainage management trends, they would need to acquire additional land that would be dedicated to subsurface drainage reuse and salt disposal. If the additional land is served with CVP supply, its dedication as a reuse facility would effectively retire it from commercial agriculture and the land would be dedicated to salt tolerant crops of lower economic value, such as Jose wheat grass, mixed pasture grasses, paspalum grass and eucalyptus.

Another scenario could see the Grassland agricultural subarea embrace the recommended drainage plan in the San Joaquin Valley Drainage Program final report (SJVDP, 1990) which called for extension of the San Luis Drain to Newman Wasteway (which eliminates the Mud Slough selenium drainage constraint of 5 ppb) and the implementation of real-time salinity management as a means of disposing of a portion of the annual salt load generated in the subarea using the assimilative capacity of the San Joaquin River. Under real-time salinity management, as currently defined (Quinn and Karkoski, 1998; Quinn, 1999), allowable drainage salt load is defined in terms of the Vernalis salinity objective and the mass loading of additional salt that could be safely discharged without violating the objective. Given that the current salinity objective is a 30-day running average EC – this provides a certain safety factor to accommodate inexact forecasts – reducing the averaging period to weekly or daily would optimize use of the River's assimilative capacity. Implementation of a real-time salinity management program would reduce significantly the drainage constraint that might limit utilization of a full contract water supply. In normal or wet years real-time water quality management might allow safe disposal of most of the drainage water generated by a full contract supply provided some short-term storage of drainage was permitted either on-farm or in District managed detention basins. However, as noted earlier, this future drainage management plan has not been adopted by the landowners and water districts within the Grasslands agricultural subarea largely because of the uncertainty associated with undertaking such a program, the monitoring costs and the suspicion that future environmental regulation or regulation of a different contaminant might further constrain their allowable discharge.

2.3 Summary

2.3.1 Continued drainage management by local entities

- Continue ongoing development of increased irrigation efficiencies, system improvements
- Fully develop drainage reuse areas with salt-tolerant crops, tile and pumping systems to collect and reapply subsurface drainage and protect groundwater, reduce drainage for ultimate treatment to produce reusable water and/or dispose of solids to land
- Soil salinity banked below reuse area lands
- Additional requirements for land dedicated for reuse areas to implement zero discharge
- Retirement of land without CVP supplies to provide salt balance for CVP-irrigated land, avoid increased salination of soil or groundwater to which CVP supplies are applied.

2.3.2 Increased CVP contract deliveries without implementation of a federal drainage management plan

- Continued emphasis on drainage reduction and management
- Meet steady crop demand with increased CVP contract supplies, decreased reliance on water transfers, groundwater pumping and drainage reuse.
- Lower rate of soil salinity accumulation beneath reuse area lands
- Continue to use water transfers to adjust annual supplies to meet crop demands.
- Potential future use of real-time management to allow discharge of low-selenium water - reduced constraints on drainage production, possible increased use of CVP contract water during wet years

3.0 WESTLANDS SUBAREA

3.1 Continued drainage management by local entities.

WWD is the largest water district in the nation with an area of approximately 650,000 acres, dominating the Westlands subarea. The Coast Range, which is the origin of soils within the subarea, is composed predominantly of sandstones and shales of marine origin that contain salts, as well as trace elements such as selenium. The texture of the marine deposits depends on the relative position on the alluvial fan and ranges from coarse sand and gravel to fine silt and clay. The fine textured soils are characterized by low permeability and increased concentrations of water soluble solids, primarily salts and trace elements. The Corcoran Clay formation ranges in thickness from 20 to 200 ft, underlying most of the subarea and dominates the subsurface hydrology. A more complete description of the hydrogeology of the Westlands subarea can be found in Appendix A.

The Westlands subarea receives a yearly average of seven inches of precipitation, most of which falls during the months of December through March. Approximately 60 different crops are grown in the Westlands subarea – the majority with irrigation. In the year 2000, cotton, tomatoes, wheat, and almonds comprised almost 64% of the 564,200 acres of the Westlands Water District (WWD) within the subarea. In WWD irrigation water sources include groundwater and Delta water through the conveyance system of the Central Valley Project (CVP). Westlands will typically make up for water supply deficiencies through increased district and private landowner groundwater pumping and by acquisition of supplemental water supplies from water districts to the north such as the Exchange Contractors and smaller state and federal water districts (Table 3). Some landowners in Westlands Water District often also farm properties in the smaller federal districts. Water wheeling is typically used to effect water transfers and are recorded by Reclamation’s Operations and Finance Divisions. In the 2004, approximately 25% of all crop acreage was irrigated by surface systems (furrow and/or border irrigation), approximately 36% was irrigated by pressurized systems (sprinklers and/or drip irrigation), and approximately 39% was irrigated by a combination of surface and pressurized systems. Groundwater sources are more saline than surface water deliveries – groundwater salinity of less than 1500 uS/cm is uncommon while surface water typically has an EC of less than 500 uS/cm.

District Water Supply

Water Year	CVP Allocation %	Net CVP (AF)	Groundwater (AF)	Water User Acquired (AF)	Additional District Supply (AF)	Total Supply (AF)	Fallowed Acres
1988	100%	1,150,000	160,000	7,657	97,712	1,415,369	45,632
1989	100%	1,035,369	175,000	20,530	99,549	1,330,448	64,579
1990	50%	625,196	300,000	18,502	(2,223)	941,475	52,544
1991	27%	229,666	600,000	22,943	77,399	930,008	125,082
1992	27%	208,668	600,000	42,623	100,861	952,152	112,718
1993	54%	682,833	225,000	152,520	82,511	1,142,864	90,413
1994	43%	458,281	325,000	56,541	108,083	947,905	75,732
1995	100%	1,021,719	150,000	57,840	121,747	1,351,306	43,528
1996	95%	994,935	50,000	92,953	172,609	1,310,497	26,754
1997	90%	968,408	30,000	94,908	261,085	1,354,401	35,554
1998	100%	945,115	15,000	54,205	162,684	1,177,004	33,481
1999	70%	802,398	60,634	178,632	114,786	1,156,450	37,206
2000	65%	691,624	225,000	198,294	137,802	1,252,720	46,748
2001	49%	608,200	215,000	75,592	138,106	1,036,898	73,802
2002	70%	776,526	205,000	106,043	64,040	1,151,609	94,557
2003	75%	855,306	160,000	107,958	40,362	1,163,626	76,654
2004	70%	793,383	210,000	96,872	51,728	1,151,983	70,367
2005 est.	85%	977,479	140,000	115,000	57,000	1,289,479	70,367

Definitions:
Water Year - March 1 to February 28
CVP Allocation - Final CVP water supply allocation for water year (100% = 1,150,000 AF)
Net CVP - CVP Allocation adjusted for carry over and rescheduled losses
Groundwater - Total groundwater pumped (see District's Deep Groundwater Report)
Water User Aquired - Private Landowner water transfers
Additional District Supply - Surplus water, supplemental supplies, and other adjustments.
Fallowed Acres - Agricultural land out of production

Table 3. Westland Water Supply 1988-2005 showing CVP allocation and estimated groundwater pumping within the District (Westland Water District web site : www.westlandswater.org).

The closure of the San Luis Drain and Kesterson Reservoir in 1995 required plugging of close to 5,200 acres of land with tile drains in the north-west section of the WWD. The end result has been to exacerbate the areal extent of shallow groundwater in the district, which has compounded problems associated with waterlogging and evapoconcentration of salts in the shallow aquifer and crop root zone. Groundwater levels are typically highest in April after pre-irrigation and lowest following the cropping season in October after crops have been harvested.

The Westlands subarea has no drainage discharge to the receiving waters of the State, therefore it is not directly affected by the current salinity and boron TMDL which limits discharge into the San Joaquin River. However, these actions have an indirect impact on the hydrology of the Basin owing to regional groundwater flow from Westlands into the Grasslands subarea. Although Quinn and others, using two USGS models that overlay the boundary between the Westlands and Grasslands agricultural subareas (Belitz and Phillips, 1993 and Fio and Deverel, 1992) have estimated this migration at less than 3% of the deep percolation in any of the downslope, impacted water districts – the implementation of water conservation, drainage recycling and other drainage reduction best management practices in the Westlands subarea is a benefit to drainage management and disposal in the Grasslands agricultural subarea by reducing imported groundwater from upslope.

Westlands Water District has been a leader in research and development of innovative source control. This district offers an irrigation guide providing real-time crop ET information including actual daily water use for the past 28 days and a 10-day forecast of crop water use. A Water Management Handbook (WWD, 1999) is also available for education and training of irrigators. The District poured considerable resources into searches for cost-effective treatment technologies for removal of selenium from agricultural drainage. The first technologies assessed such as the Binnie process adapted conventional activated sludge reactor technology to reduce incoming selenate-selenium to less mobile reduced forms of the metalloid with subsequent unit processes to separate the selenium from the biological floc. These experiments at Adams Avenue Research Facility in WWD were followed by various physical-chemical processes such as the Harza iron-filing process and algal-bacterial pond system developed by Oswald at UC Berkeley within the Panoche Water District (PWD) of the Grasslands Agricultural subarea, a co-leader in drainwater treatment technologies. None of these technologies was able to consistently meet the selenium objectives of less than 5 ppb effluent water quality nor were they able to provide selenium load reduction at an affordable cost. The District also experimented with Deep Well Injection but neither the underground formations nor the cost of disposal merited further development.

A promising source control technology outcome of these years of research by the Westlands Water District has been Integrated Farm Drainage Management (IFDM). This technology was laid out conceptually in the final report of the San Joaquin Valley Drainage Program (SJVDP, 1990) and is a controlled reuse system whereby drainage is reused on progressively more salt tolerant crops with the final effluent discharged into a solar evaporator for later offsite disposal. Areas of each irrigated crop are carefully calculated and drainage carefully managed to ensure complete reuse at each step in the process. The IFDM system only works if all components are carefully tuned to keep root zone salts in check and to ensure adequate flushing of the crop roots. It achieves a salt balance by removing the salt from the productive land and storing it on farm.

Research conducted over the past 20 years in WWD and PWD has provided a laboratory for drainage management in subareas to the north of the WWD as they adapt to increasingly restrictive TMDL's that make it more difficult for farmers to achieve salt balance on their farmed lands. Soil salination is a slow, progressive and inevitable process if salt balance is not achieved over the long term (Schoups et al., 2005). Then, the only responses to TMDL drainage restrictions or the lack of a drainage outlet are in-valley disposal options or land retirement. Since 2001, approximately 81,000 acres have been fallowed within WWD resulting as a result of the Sumner Peck Settlement which permanently removed approximately 35,000 acres from irrigated agricultural production, and from WWD acquiring 46,000 acres that were severely drainage impacted. It is possible that when drainage service is provided, the 46,000 acres could again be irrigated. Currently, these acquired lands are dryland farmed, grazed, being developed for some habitat uses, or dedicated to drainage reuse areas, similar to those discussed for the Grassland agricultural area. Declining crop yields and loss of crop land to irrigated agriculture will result in declining regional economic conditions on the west-side of the San Joaquin Valley. Because of the multiplier effect agricultural income has on the economy as a whole, jobs will likely be lost as income per capita in western Fresno and Tulare Counties declines.

3.2 Increased CVP contract deliveries without implementation of a federal drainage management plan

WWD has a CVP water allocation of 1,150,000 acre-ft which is insufficient to meet the district's agricultural demands. This can observed in Table 1 and in Figure 4 which show the relative amounts and sources of supplemental water supply the District has used to meet the demands of its farmers. Even in 1995, when the CVP allocation was 100% and the District received 1,021,719 acre-ft of CVP water there was approximately 150,000 acre-ft of groundwater pumped, 57,840 acre-ft was acquired by water users and 121,747 acre-ft was acquired from water transfers from outside the District. In 1995 CVP water constituted only 75% of the water supply and farmers within the District fallowed 43,528 acres. As previously described, the Westplains region of WWD has always received an allocation of 50% of its average demand and has relied water transfers from within WWD, from outside WWD, and on some groundwater.

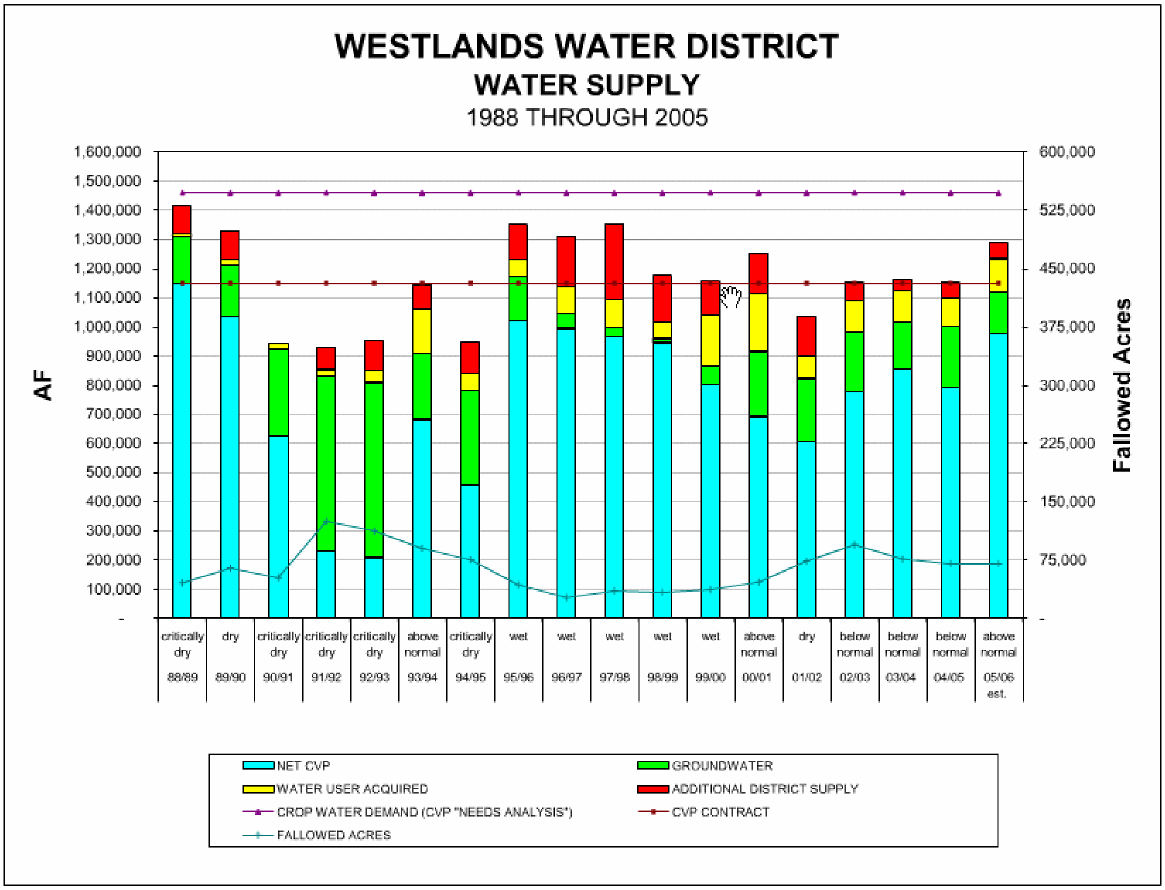


Figure 4. Sources of supplemental water acquired by WWD by water year for the period 1988 through 2005.

The provision of a full CVP water supply would most likely just replace some of the water transfers and relieve some of the stress placed on the regional aquifer system through groundwater pumping. In the past overpumping of the regional groundwater system has led to extensive land subsidence especially around the town of Mendota and the hamlet of Five Points where land subsidence of more than 20ft has been recorded. Provision of the full CVP water supply may reduce the risk of similar episodes in the future.

The Integrated Farm Drainage Management (IFDM) technique has shown to be effective in drainage problem areas although the problem of salt disposal from solar evaporators is still an unresolved problem. The costs of implementing an IFDM system are substantially higher than routine irrigation management and may limit its application within the drainage problem area.

If the supplemental CVP water supply to full contract delivery is used to offset water reuse rather than groundwater pumping – the result will be improved root zone soil salinity, as discussed in Appendix A, with long-term improvement in crop yields. If used to substitute for water transfers there is no net impact except on net farm income. CVP water supplied directly by Reclamation will be delivered at a lower cost than water transferred from other water districts or wheeled using CVP facilities. Hence the primary benefit of the full CVP supply is economic.

The long-term cost of the lack of an implemented drainage solution will be found in declining soil fertility and crop yields. As discussed above, approximately 81,000 acres (and 9,000 acres in Broadview Water District) have been fallowed and are not being irrigated. The water supply that has been relinquished from these lands will be applied to help offset the current deficit between irrigation demand and supply to the District. Over the long term it is anticipated that increasing areas of Westlands Water District located on the east-side along the basin trough (Appendix : Figure A3) will go out of production as crop yields decline and the costs of production exceed agricultural revenue.

4.3 Summary

4.3.1 Continued drainage management by local entities

- Long-term build-up of salts in soils and groundwater
- Additional requirements for land dedicated to salt management – IDFM approach
- Land fallowing from irrigated agriculture
- Some decline in rural economy in western Fresno and Kings counties

4.3.2 Increased CVP contract deliveries without implementation of a federal drainage management plan

- Full utilization of CVP contract water to offset in-district reuse, purchases of supplemental water from outside the district and groundwater pumping beyond safe yield
- Improved shallow groundwater quality
- Financial gain to landowners with reductions in water transfers and groundwater pumping
- Short-term stimulus to local economy – longer term decline in agricultural revenue in eastern margins of water district.

4.0 REFERENCES (In Report Body and Appendix A)

Alemi M.M. and J. Faria. 2000. Salt Balance in the San Joaquin Valley. Water Facts No. 20. Department of Water Resources, Sacramento, CA.

Aragues, R., K.K. Tanji and J. Faci. 1990. Conceptual irrigation return flow hydrosalinity model, in Agricultural Salinity assessment and Management, K.K. Tanji (Editor), American Society Civil Engineering, Manuals and Reports of Engineering Practice, No. 71

Ayars, J.E., R.B. Hutmacher, R.A. Schoneman and S.S. Vail. 1990. Long-term use of saline water for irrigation. Third National Irrigation Symposium, Phoenix, Arizona. American Society Agricultural Engineering Publication 04-90. 368-373.

Belitz, K. 1988. Character and evolution of the ground water flow system in the central part of the western San Joaquin Valley, California. United States Geological Survey, Open File Report 87-573. 34p.

Belitz, K. 1990. Character and evolution of the ground water flow system in the central part of the western San Joaquin Valley, California. United States Geological Survey, Water Supply Paper, 2348, 28 p.

Belitz, K. and S.P. Phillips. 1993. Simulation of water table response to management alternatives, central part of the western San Joaquin Valley, California, United States Geological Survey, Water Resources Investigation Report, 91-4193, 41 p.

Belitz, K., S.P. Phillips and J.M. Gronberg. 1991. Numerical Simulation of Groundwater Flow in the Central Part of the Western San Joaquin Valley, California, United States Geological Survey Open File Rept., 91-535, 71 p.

Burt C.M., R.E. Walker, P. Canessa and K. Robison. 1992. Irrigation and Drainage in the Grassland Area of the Westside of the San Joaquin Valley, California Polytechnic State University,. San Luis Obispo, California.

California Department of Water Resources. 1961. Bulletin No. 66-59. Quality of ground waters in California, 1959, Part I, Northern and Central California.

California Department of Water Resources. 1976 – 1990. Crop Water Use Reports for the Southern San Joaquin Valley.

California Department of Water Resources. 1993. Bulletin No. 260-93. California Water Plan.

CRWQCB. 1998. Compilation of Electrical Conductivity, Boron, and Selenium Water Quality Data for the Grassland Watershed and San Joaquin River – May 1985- September 1995. California EPA Regional Water Quality Control Board Central Valley Region. February 1998.

Deverel, S.J. and J. Fio. 1991. Groundwater flow and solute movement to drain laterals, Western San Joaquin Valley, California, 1. Geochemical assessment, Water Resources Research, 27 (9),2233-2246.

Deverel, S.J. and R. Fujii. 1987. Processes affecting the distribution of selenium in shallow groundwater of agricultural areas of western San Joaquin Valley, California. United States Geological Survey, Open File Report., 87-220.

Deverel, S.J. and S.K. Gallantine. 1988. Relation of salinity and selenium in shallow ground water to hydrologic geochemical processes, western San Joaquin Valley, California. United States Geological Survey Open File Rept., 88-336. 231 p.

Doner, H.E., R.G. Amundson and B. Liliehom. 1989. Comparison of Se and As concentrations in the soils of the western San Joaquin Valley, California, 1946-1985, Arid Soil Research and Rehab., 3, 315-325.

Dubrovsky, N.M., J.M. Neil. M.C. Welker and K.D. Evenson. 1991. Geochemical relations and distribution of select trace elements in ground water in the northern part of the western San Joaquin Valley, California, United States Geological Survey, Open File Rept., 90-108.

Dubrovsky, N.M., J.M. Neil, R. Fujii and R.S. Oreland. 1990. Influence of redox potential on selenium distribution in ground water, Mendota, western San Joaquin Valley, California. United States Geological Survey, Open File Rept., 90-138.

Fio, J.L. and S.J. Deverel, 1991. Groundwater flow and solute movement to drain laterals, Western San Joaquin Valley, California, 2. Quantitative hydrologic assessment, Water Resources Research, 27(9), 2247-2257.

Gilliom Robert J. 1980. Preliminary assessment of sources, distribution, and mobility of selenium in the San Joaquin Valley, California. San Joaquin Valley Drainage Program., Geological Survey (U.S.), National Regional Aquifer Systems Analysis Program (U.S.) Sacramento, Calif. : U.S. Geological Survey, 1989. WRI no.88-4186. p. 124-129

Grimes, D.W. and D.W. Henderson. 1986. Crop water use from a shallow water table. American Society Agricultural Engineering paper No. 86-2060.

Grismer, M.E. and R.C. Woodring. 1987. Assessment of lateral groundwater flows in the SJV., California Agriculture, March-April, 22-23.

Gronberg, J.M., K. Belitz and S.P. Phillips. 1990. Distribution of wells in the central part of the western San Joaquin Valley, California. United States Geological Survey. Water Resources Investigations Rept., 89-4158.

Hatchett, S.A, N.W.T. Quinn, G.L. Homer and R.E. Howitt. 1989. Drainage Economics Model to Evaluate Policy Options for Managing Selenium Contaminated Drainage. Proc. of the International Committee on Irrigation and Drainage. Toxic Substances in Agricultural water Supply and Drainage - An International Perspective. Ottawa, Canada.

Hilgard, E. 1889. Irrigation and alkali in India, College of Agriculture, University of California, Report to the President of the University. Bull. No. 86, California State Printing Office, Sacramento, California.

Kruse, G., L. Willardson and J.E. Ayars, 1990. On-farm irrigation and drainage practices, in Agricultural Salinity Assessment and Management, K.K. Tanji (Editor) American Society Civil Engineering, American Society Civil Engineering, Manuals and Reports on Engineering Practice No. 71, 349-371.

Letey, J. and K. Knapp. 1990. Crop-water production functions under saline conditions, in Agricultural Salinity Assessment and Management, K.K. Tanji (Editor), American Society Civil Engineering, ASCE Manuals and Reports on Engineering Practice, No. 71, 305-326.

Mendenhall W.C., R.B. Dole and H. Stabler. 1916. Ground Water in the San Joaquin Valley, California. USGS. Water Supply Paper 398.

Narasimhan, T.N. and N.W.T Quinn. 1996. Agriculture, Irrigation and Drainage on the West Side of the San Joaquin Valley, California: Unified Perspective on Hydrogeology, Geochemistry and Management. Earth Sciences Division. Lawrence Berkeley National Laboratory. Topical Report No. 38498.

Orlob, G.T. 1991. San Joaquin salt balance: Future prospects and possible solutions, in The Economics and Management of Water and Drainage in Agriculture, A. Dinar and D. Zilberman (Editors) Kluwer.

Pacheco Water District, 2006. Water allocation table. Personal communication.

Panoche Water District, 2006. Water allocation table. Personal communication.

Poland, J.F. and G.H. Davis. 1969. Land subsidence due to withdrawal of fluids, Reviews in Engineering Geology, 2, Geological Society of America, Boulder, Colorado.

Presser, T.S., W.C. Swain, R.R. Tidball and R.C. Severson. 1991. Geologic sources, mobilization and transport of selenium from the California coast ranges to the western San Joaquin Valley: A reconnaissance study. United States Geological Survey, Water Resources Investigations Report., 90-4070. 66 p.

Preston, W.L. 1979. Land and life in the Tulare Lake Basin, California, Ph.D. dissertation, University of Oregon.

Quinn, N.W.T. (1999). A Decision Support System for Real-Time Management of Water Quality in the San Joaquin River, California. 3rd International Symposium on Environmental Software Systems (ISESS'99), August 30-September 2, 1999, Dunedin, New Zealand.

Quinn N.W.T. and J. Karkoski. 1998. Potential for real time management of water quality in the San Joaquin Basin, California. Journal of the American Water Resources Association, Vol. 36, No. 6,

December.
Quinn, N.W.T., J. McGahan and M. Delamore. 1998. Innovative drainage management techniques to meet monthly and annual selenium load targets. California Agriculture, Vol. 52, No. 5, September-October. 1998
Quinn, N.W.T., Chen, C.W., Grober, L.F., Kipps, J. and Cummings, E.. (1997). Real-time management of water quality in the San Joaquin River. California Agriculture, Sept/Oct issue.
Quinn N.W.T. 1996. Compliance monitoring program for use and operation of the Grasslands Bypass to remove agricultural drainage from Grassland Water District channels. Lawrence Berkeley National Laboratory Report, LBNL-39052, Earth Sciences Division, Berkeley, California.
Quinn N.W.T. 1992. Computer-based decision support tools for evaluation of actions affecting flow and water quality in the San Joaquin Basin and the Sacramento - San Joaquin River Delta. Lawrence Berkeley Laboratory Report, LBNL-34076, Berkeley, California.
Quinn N.W.T. 1991. Environmentally sound irrigated agriculture in the arid west: new challenges for water resources planners and environmental scientists. Proceedings of the Conference on Environmentally Sound Agriculture, Orlando Florida, April 16-18. Lawrence Berkeley Laboratory Report No. 30836, Earth Sciences Division, Berkeley, California.
Quinn N.W.T. 1991. Assessment of ground water pumping as an option for water table management and drainage control in the western San Joaquin Valley. In "The Economics of Water and Drainage in Agriculture". Editors A. Dinar and D. Zilberman. Kluwer Academic Publishers.
Quinn N.W.T. 1990a. Assessment of ground water pumping as a management option in drainage problem areas of the western San Joaquin Valley. Technical Information Record. August. San Joaquin Valley Drainage Program, Sacramento, CA 95825.
Quinn N.W.T. 1990b. Analysis of the long-term sustainability of water quality for irrigation from pumping wells used to manage high saline water tables. Technical Information Record. San Joaquin Valley Drainage Program, Sacramento, CA 95825.
Quinn N.W.T and D.G. Swain. 1990. San Joaquin Valley Hydrologic and Salt Load Budgets. Technical Information Record. San Joaquin Valley Drainage Program, Sacramento, CA 95825.
Quinn N.W.T et al. 1990. Overview of the use of the Westside Agricultural Drainage Economics Model (WADE) for plan evaluation. Technical Information Record. October 1989/August 1990. San Joaquin Valley Drainage Program, Sacramento, CA 95825.
Quinn N.W.T, S.A. Hatchett and D.G. Swain. 1989. Evaluating policy options for management of selenium contaminated drainage and drainage - related problems in the San Joaquin Valley. Toxic Substances in Agricultural Water Supply and Drainage. Proceedings of the Second Pan American Regional Conference on Irrigation and Drainage, Ottawa, Ontario, June 8-9.
Salinity and Drainage Task Force. 1992. Principal Accomplishments. 1985-1990, Division of Natural Resources, University of California, 95 p.
San Joaquin Valley Drainage Program. 1990. A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Western San Joaquin Valley, 183 p. San Joaquin Valley Master Plan, 1990. Sacramento, CA.
San Joaquin Valley Drainage Program., 1988. San Joaquin Valley Hydrologic and Salt Load Budgets. Authors : G. Davids, N.W.T. Quinn and D.G. Swain. Sacramento, CA. October 1998.
Schmitt K.D. 1997. Groundwater conditions in and around the Central California Irrigation District. Ken Schmitt and Associates, Fresno, CA.
Schoups, G., Hopmans, J., Young, C.A., Vrugt, J.A., Wallender, W.W., Tanji, K.K., and Panday, S. (2005). Sustainability of Irrigated Agriculture in the San Joaquin Valley, California. Proceedings of the National Academy of Sciences 102(43): 15352-15356.
Southard, R.J., G.L. Huntington, M.J. Singer and W.E. Wildman. 1986, Sources and distribution of salts and trace elements in soils of the San Joaquin Valley, 1985-1986 Technical Progress Report, Univ. of Calif. Salinity amd Drainage Task Force, 17-20.
Stroh C and N.W.T Quinn. 1990. Assessment of land retirement as a management option for drainage reduction. Technical Information Record. June. San Joaquin Valley Drainage Program,

Sacramento, CA 95825.
Suarez, D.L. and J. Simunek. 1993. Modeling of carbon dioxide transport and production in soil, 2. Parameter selection, sensitivity analysis and comparison of model prediction to field data, Water Resources Research, 29(2), 499-513.
Tanji, K.K. 1990. Nature and extent of agricultural drainage, in Agricultural Salinity Assessment and Management, K.K. Tanji (Editor), American Society Civil Engineering Manuals and Reports of Engineering Practice, No. 71, 1-17.
Tanji, K.K. and F.F. Karajeh. 1993. Saline drain water reuse in agroforestry systems, American Society Civil Engineering, Journal Irrigation & Drainage Engineering, 119(1), 170-180.
State Water Resources Control Board. 1987. Regulation of Agricultural Drainage to the San Joaquin River, Final Report WQ 85-1, Sacramento, CA.
US Bureau of Reclamation. 1973. Groundwater conditions of sub-Corcoran piezometric levels, January 1972 to February 1973, San Luis Service Area, Central Valley Project, California. Geology Branch, US Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA.
US Bureau of Reclamation. 2005. San Luis Drainage Feature Re-evaluation. Draft Environmental Impact Statement. US Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA. May 2005.
US Department of Agriculture. 1946. The Salt Problem in Irrigation Agriculture. United States Regional Salinity Laboratory, Riverside, CA. USDA, August 1946.
US Geological Survey. 1908. Preliminary report on the ground waters of San Joaquin Valley, California. By Walter C. Mendenhall. Water Supply Paper 222. Government Printing Office.
US Geological Survey. 1959. Ground-water conditions and storage, San Joaquin Valley, Geological Survey Water-Supply Paper 1469. Plates. Government Printing Office.
US Geological Survey. 1963. Description of wells in the Los Banos-Kettleman City area, Merced, Fresno, and Kings counties, California. By R. L. Ireland. Geological Survey.
US Geological Survey. 1969. Ground-water pumpage on the west side of the San Joaquin Valley, California, 1962-66. By William Ogilbee and Maxine A. Rose. Water Resources Division, Menlo Park, California. Geological Survey.
US Geological Survey. 1975. Land Subsidence due to ground-water withdrawal in the Los Banos-Kettleman City area, California, Part 1. Changes in the hydrologic environment conducive to subsidence. Geological Survey Professional Paper 437-E. Government Printing Office.
US Geological Survey. 1975. Land subsidence due to ground-water withdrawal in the Los Banos-Kettleman City area, California, Part 2. Subsidence and compaction of deposits. Geological Survey Professional Paper 437-F. Government Printing Office.
US Geological Survey. 1975. Land subsidence due to ground-water withdrawal in the Los Banos-Kettleman City area, California, Part 3. Interrelations of water-level change, change in aquifer-system thickness, and subsidence. By William B. Bull and Joseph F. Poland. Geological Survey Professional Paper 437-G. Government Printing Office.
US Geological Survey. 1985. Dissolved constituents including selenium in waters in the vicinity of Kesterson National Wildlife Refuge and the West Grassland, Fresno and Merced counties, California. Water Resources Investigations Report 85-4220. Geological Survey.
Westlands Water District. 1984. The Drainage Problem in the Western San Joaquin Valley, 16 p.
Westlands Water District. 1999. Water Management Plan: 1999. September 1999.
Westlands Water District. 2003. Analysis of Economic Impacts of Land Retirement in Westlands Water District, Westlands Water District, Fresno, CA.
Willams C.T. Brombaugh, M.M. Alemi and N.W.T. Quinn. 2002. Approximate salt budget for the western San Joaquin Valley, California. US Committee on Irrigation and Drainage, San Luis Obispo, CA. July 2002.
Williamson, A.K., D.E. Prudic and L.A. Swain. 1985. Ground-water flow in the Central Valley. California, United States Geological Survey., Open File Report, 85-345, 203 p.

APPENDIX A

BACKGROUND INFORMATION ON IRRIGATED AGRICULTURE IN THE WESTERN SAN JOAQUIN VALLEY

A.1 Surface Water Resources

The San Joaquin Valley extends roughly NNW to SSE, descending from the foot of the Tehachapi mountains, northwards to its confluence of the Sacramento River in the Sacramento-San Joaquin Delta. The Valley is about 250 miles long and about 50 miles wide (Figure 1), bounded on the east

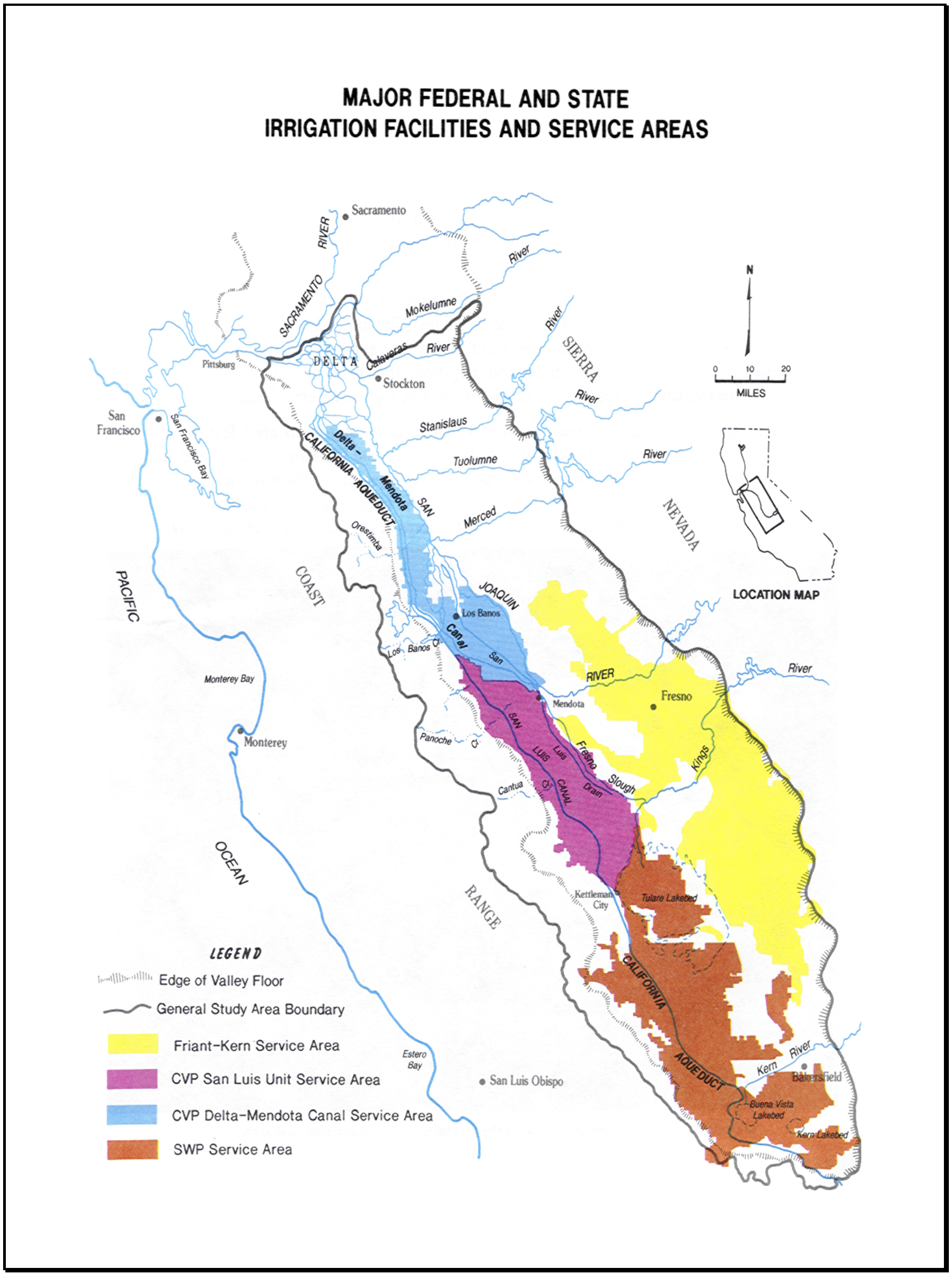


Figure A1. The San Joaquin Valley showing the Federal San Luis and Delta Mendota service areas. The San Luis service area contains Westlands Water District and water districts located immediately to the north that produce tile drainage high in selenium and other harmful salts.

by the Sierra Nevada Mountains and on the west by the California Coast Ranges. Physiographically, the San Joaquin Valley can be divided into two parts. On the southern extremity, the Tulare Basin extends from the foot of the Tehachapi Mountains northwards to a divide located to the north of Los Gatos Creek and the Kings River. The Tulare Basin is an isolated depression which contributes water to the San Joaquin Basin only during years of extreme flooding. Fresno Slough connects the Tulare Basin with the San Joaquin River, across the topographic rise. Depending on severity of floods, water may flow either way in this channel. A fresh water lake, the Tulare Lake, occupied this depression at the turn of the century (Preston, 1979) and has since been converted to agricultural lands. The Kings River, the Kaweah River and the Tule River drain into the Tulare depression. Further south, the Kern River empties into the smaller Buena Vista Lake. Lake Isabella is a reservoir on the Kern River, east of Bakersfield. Pine Flat Reservoir is located on the Kings River. To the north of the Tulare Basin lies the San Joaquin River Basin which drains to the Sacramento-San Joaquin Delta and the Pacific Ocean.

The San Joaquin Valley can be divided institutionally into State and Federal project service areas as shown in Figure A1. The Federal service area in the San Joaquin Basin can be further subdivided into two major units – the Delta Mendota Canal Unit and the San Luis Canal Unit which were combined administratively in the mid 1990's through the formation of a joint powers authority, the San Luis and Delta Mendota Water Authority which performs all operation and maintenance work associated with the management of the facility.

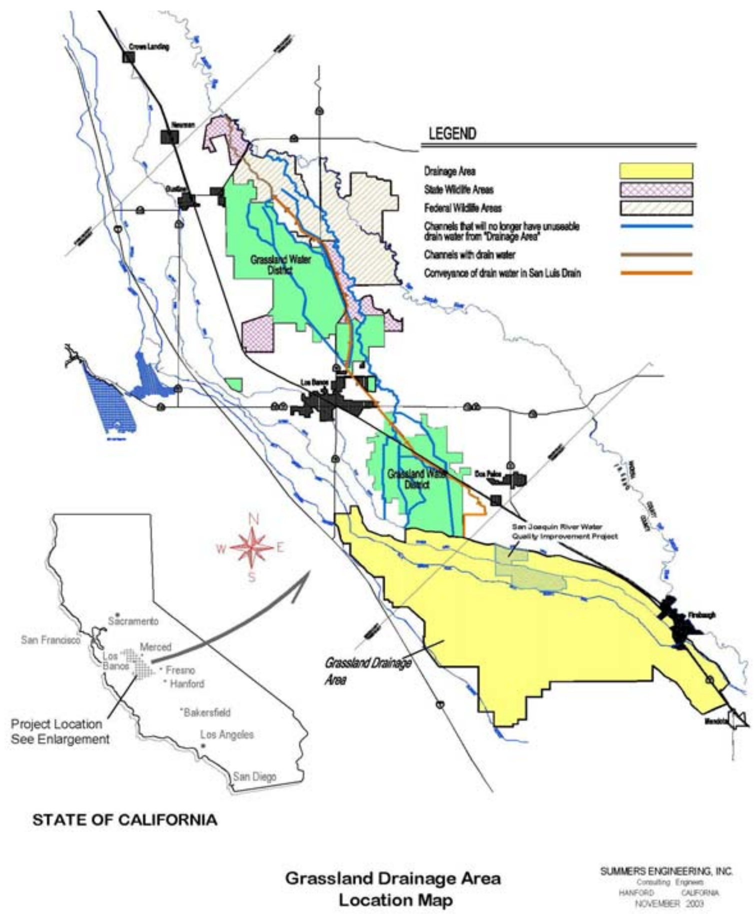


Figure A2. Map showing both the Grasslands agricultural subarea (shown in yellow) and the Grasslands wetlands subarea, commonly referred to as the Grasslands Ecological Area.

This is comprised of : Grassland Water District (green), the State Wildlife Management areas (hatched purple) and the federal and Luis Refuge Complex (hatched brown).

The San Luis Unit can be further subdivided into two subareas the Grasslands agricultural subarea (distinguishing it from the Grasslands Ecological Area – a 130,000 acre area of managed wetlands within the Grasslands subarea) and the Westlands subarea, comprising mostly Westlands Water District (WWD). The Grasslands agricultural subarea (Figure A2) comprises approximately 97,000 acres of agricultural lands within the selenium affected alluvial fans. This area has an historic drainage outlet to the San Joaquin River. The Grasslands agricultural subarea, which after 1985 was no longer allowed to dispose of subsurface drainage water on managed wetlands within the Basin, was shown to be gaining both water and salt at a rate of 1900 AF per year (Quinn and Swain, 1990). This is a small increase in semiconfined aquifer storage and is equivalent to less than 0.05 ft/year of water table rise. Annual salt storage was estimated at 110,000 tons per year – approximately 1 ton/acre-yr.

South of the Grasslands agricultural subarea, located between the towns of Mendota and Kettleman City and to the west of the Basin trough, is the Westlands subarea dominated by WWD (Figure A3). This district, which contains over 640,000 acres of irrigable acreage, has no natural drainage outlet save Fresno Slough which drains into Mendota Pool in the north-east corner of the District. WWD contains two of the largest west-side alluvial fans, the Panoche and Cantua Creek alluvial fans, which both contain high concentrations of native selenium.

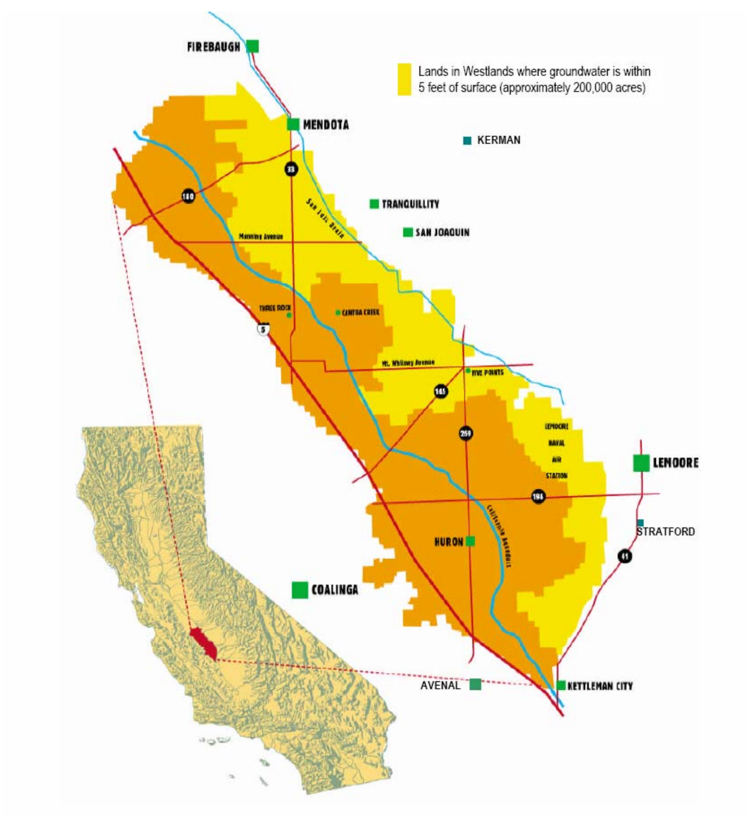


Figure A3. Map of WWD which dominates the Westland subarea. Map shows areas of shallow groundwater. (Source: Westlands Water District, 2003).

The Westlands subarea was shown to have a 25,000 AF gain in semiconfined aquifer storage – equivalent to a 0.3 ft/year increase in water table (Quinn and Swain, 1990). Annual salt storage for

Westlands was also considerably higher than that in the Grasslands agricultural subarea at 670,000 tons per year.

The major tributaries of the San Joaquin River, from the south, are the Fresno, the Chowchilla, the Merced, the Tuolumne and the Stanislaus Rivers (Figure 2). Many surface water impoundments have been constructed across the tributaries of the San Joaquin River for both flood control and irrigation. As is shown in Figure A4, these include, from the south, Friant Dam (across the San Joaquin), Hensley Lake (across the Fresno), Lake McClure (the New Exchequer Dam across the Merced), the New Don Pedro Dam (across the Tuolumne) and the New Melones Dam (across the Stanislaus). On the foothills of the Coast Ranges, the San Luis Reservoir is a man-made surface water storage facility on the California aqueduct.

Prior to the construction of the CVP and the Delta Mendota Canal, water from the San Joaquin River was used to irrigate lands in the central portion of the west side, near Fresno. However, with the construction of the CVP, water from the San Joaquin River at Friant Dam was diverted to the Tulare Lake Basin through the Friant-Kern Canal and water from the Delta Mendota Canal was made available for irrigating lands throughout the west side on agricultural land between Mendota and the CVP Tracy pumping plant. Although some areas of WWD could be served from the Delta Mendota Canal direct diversions from the California Aqueduct created a gravity pressurized water distribution system without the need for additional irrigation lift pumps. Mendota Pool is a storage reservoir on the Delta Mendota Canal, north of Fresno. The construction of the surface water reservoirs on the east side of the San Joaquin Valley, in particular the Friant Dam and the subsequent southerly diversion of water along the Friant-Kern Canal, caused the annual outflow of the San Joaquin River at Vernalis to decline by about 1.3 million acre feet.

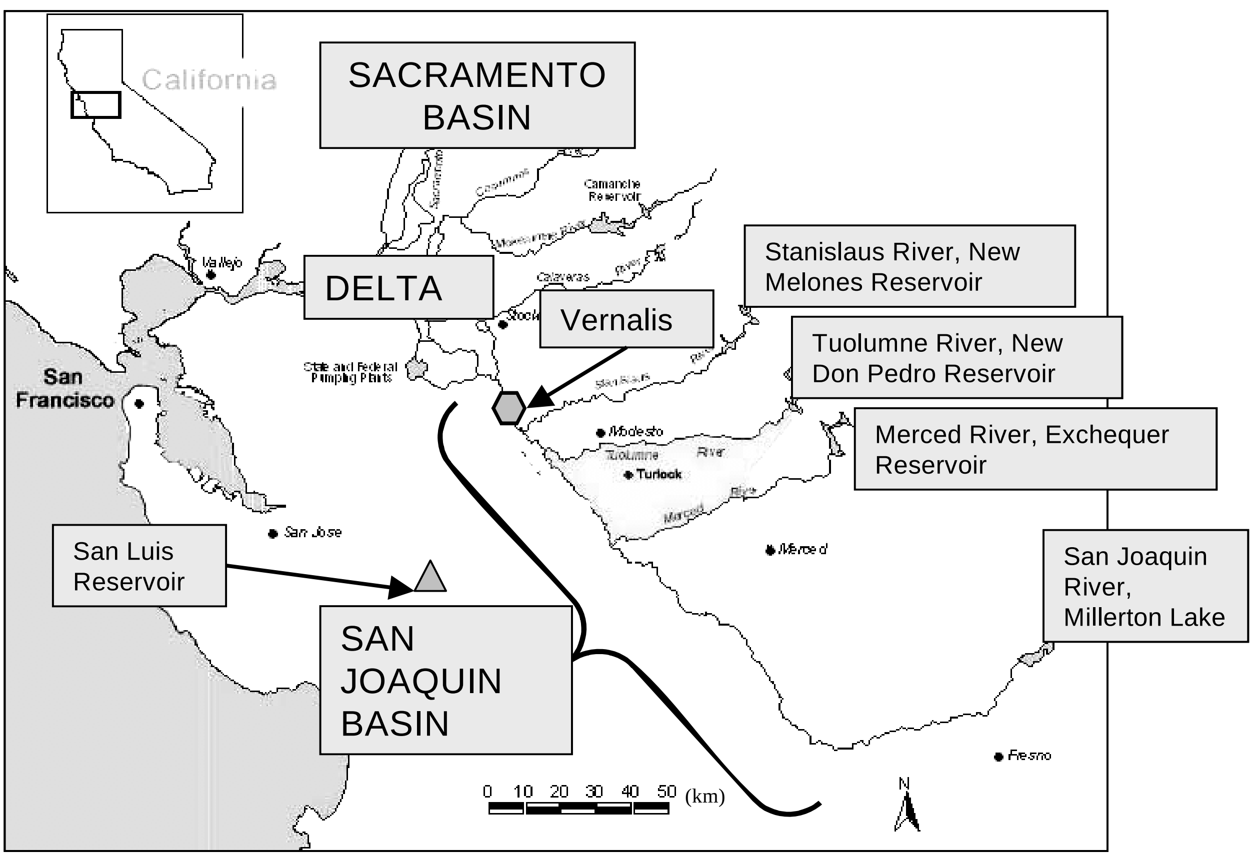


Figure A4. The San Joaquin Basin showing the major east-side tributaries and reservoirs

Scheduled discharges and flood releases from the many reservoirs play an important role in controlling water quality in the San Joaquin River. Water releases from these reservoirs determine the amount of salt load that can be added to the river via drainage discharges (assimilative capacity) without exceeding State Water Resources Control Board salinity objectives, set at Vernalis. Exports of salt from the San Joaquin Valley are much smaller today than imports into the San Joaquin Valley by way of the Delta-Mendota Canal and the California Aqueduct. Imported salt accumulates in the soil or in the groundwater aquifers beneath agricultural land on the west-side. A study of the San Joaquin Basin surface water salt balance Orlob (1991) analyzed historic data to understand the state of balance between salt import and salt export into and from the San Joaquin Valley. At the present rate the net import of salt annually would be about 2 million tons by the year 2007. Orlob (1991) has estimated an average salt accretion to the San Joaquin Basin through the Delta Mendota Canal of between 1,000,000 and 1,300,000 tons of salt per year.

Since the completion of the CVP's Delta-Mendota Canal, over 16 million tons of salt have been imported into the Valley through water deliveries. Water pumped into the Delta Mendota Canal is generally inferior in water quality and higher in total dissolved solids (TDS) than water in the California Aqueduct owing to the proximity of the Tracy pumping plant to the San Joaquin River. Typical salinity of the Delta Mendota Canal is in the range of 300 - 500 mg/l TDS.

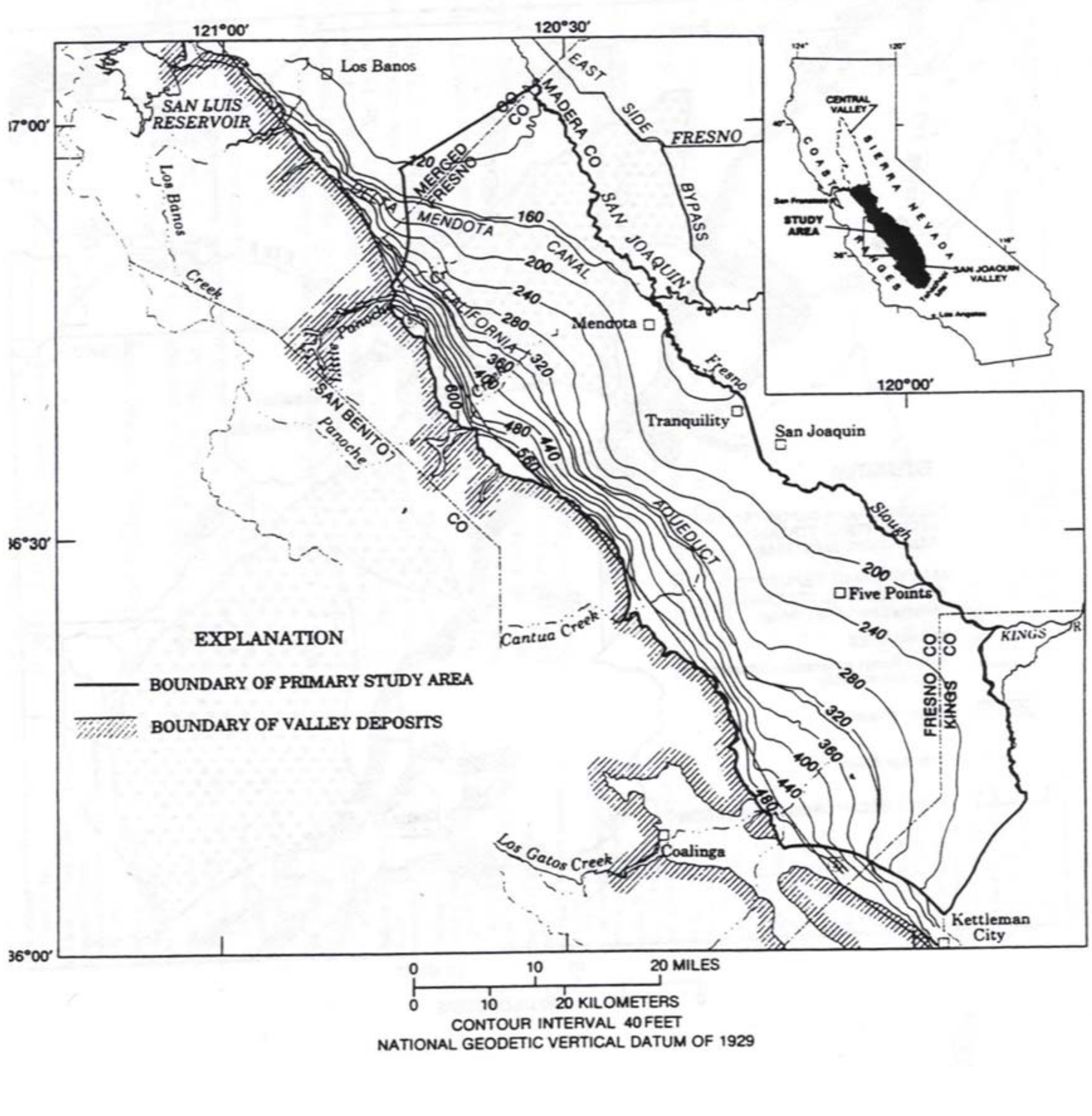


Figure A5. Topographic contour map of the west-side of the San Joaquin Valley (from Belitz, 1990)

A2 Groundwater Resources

The groundwater system beneath the west side of the San Joaquin Valley has been in state of disequilibrium since the advent of irrigated agriculture. Belitz (1988) provides an account of the state of the groundwater system as it existed at the turn of the century and how its character has changed to the present time. The regional groundwater system is driven by gravity, hence the physiography and geomorphology of the Basin play a decisive role in determining its character (Narasimhan and Quinn, 1996). The west-side is characterized by a fairly simple topographic pattern; an easterly sloping flank of the Coast Ranges extending for over 80 miles in the NNW-SSE direction (Figure A5).

The distance from the boundary of the Valley deposits to the San Joaquin River varies slightly around 20 miles. Over this distance, the elevation declines from about 600 feet to about 160 feet above sea level. The upper slope (comprising alluvial fans), from 600 feet to about 300 feet, tends to be steeper than the lower slopes. Four intermittent streams, from south to north, the Los Gatos Creek, the Cantua Creek, the Panoche Creek and the Little Panoche Creek have created important geomorphic features of the Valley by virtue of their well-developed alluvial fans (Figure A6).

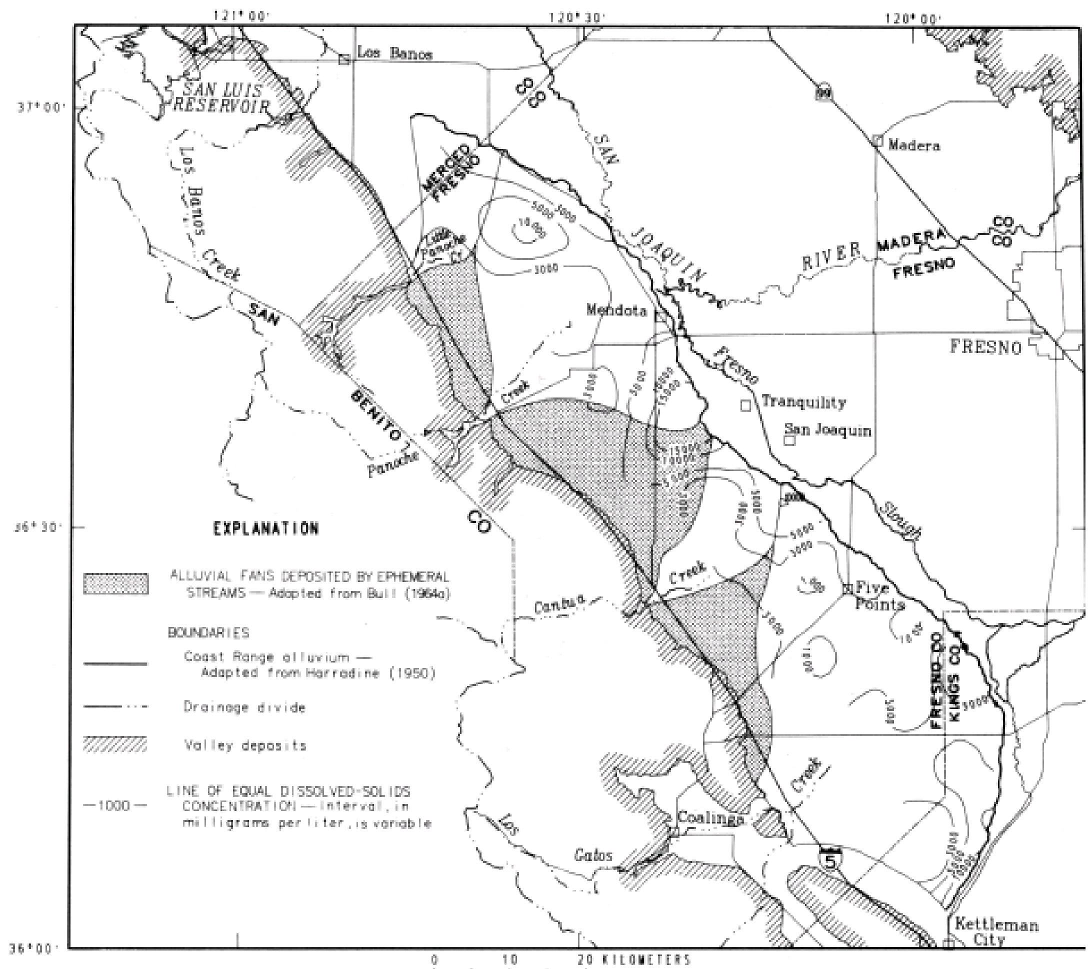


Figure A6. Alluvial fans and intermittent streams of the western San Joaquin Valley (from Deverel and Gallantine, 1988).

A3 Surface And Subsurface Geology

Sediments of recent alluvium deposited by the action of the west-side ephemeral streams cover much of the west-side, from the flanks of the Coast Ranges to the vicinity of the river. On the upper slopes and in the prominent alluvial fans, the sediments tend to be coarse-grained, having been deposited by episodic, high-energy stream flows. In the inter-fan areas and in the lower slopes of the Valley, the sediments show a flood-plain depositional character and consist of fine-grained materials. Mass-wasting, mud flows and surge flows associated with the high energy sediment transport of ephemeral and intermittent streams appear to play a very important role in controlling the physical- as well as the chemical properties of the sediments. Marine sediments, ranging in age from Jurassic to Miocene age are exposed along the ridge crest of the Coast Ranges (Presser et al., 1990). Two members of this sequence, the Moreno Formation (upper cretaceous to paleocene) and the Kreyenhagen Formation (eocene to oligocene) are exposed over a 20-mile stretch of the Moreno Ridge. Despite their limited extent these formations play an important geochemical role because of their high salt and selenium content. Following the miocene, during pliocene and pleistocene periods the marine conditions gave way to continental and lacustrine conditions. The Tulare formation of pliocene to pleistocene age underlies the alluvium over much of the west-side.

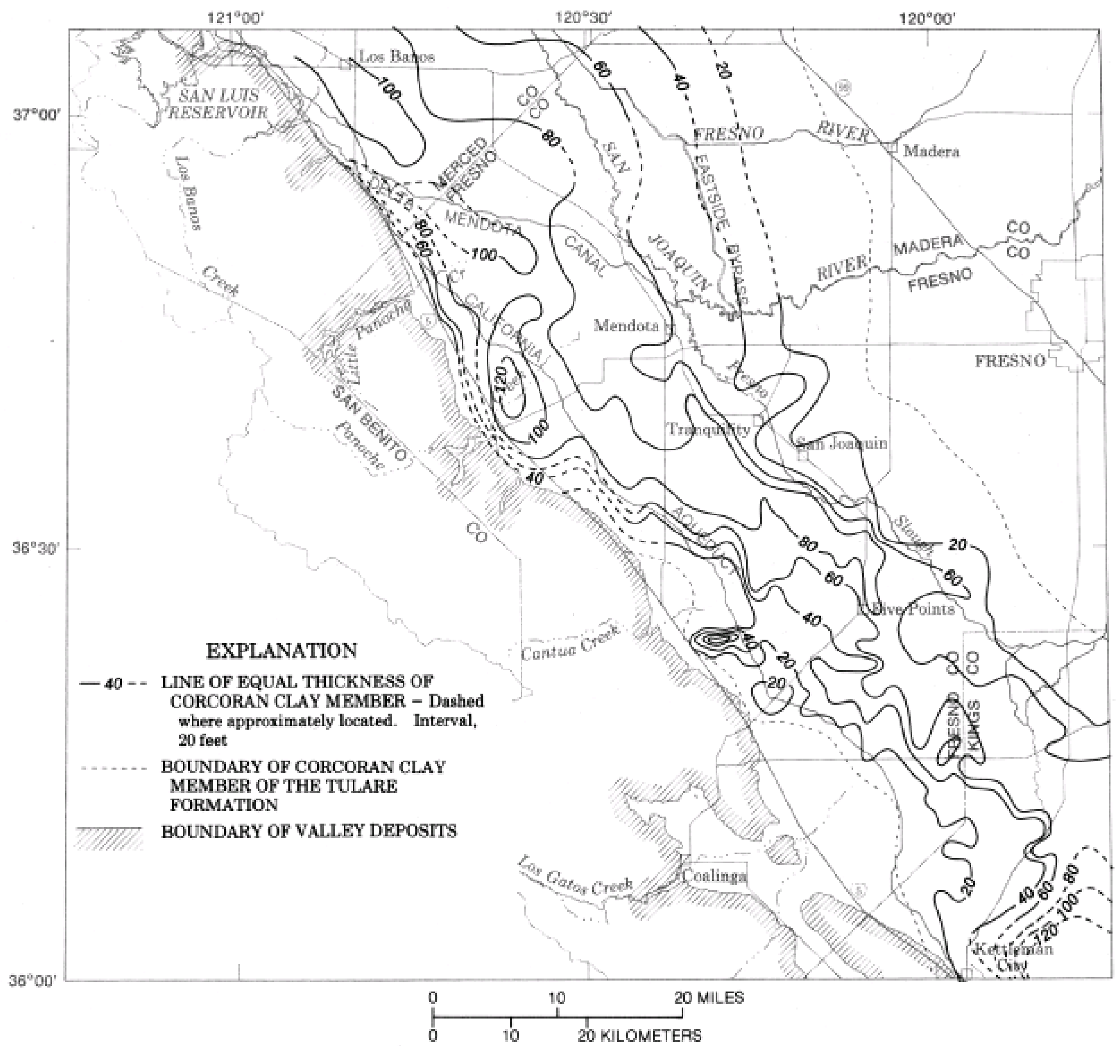


Figure A7. Thickness of the Corcoran Clay layer (E-Clay) beneath the San Luis Unit in the western San Joaquin Basin (from Belitz, 1990).

The Corcoran clay of the Tulare formation, approximately 100 feet thick, constitutes an extensive marker horizon beneath the west-side. The alluvial sediments overlying the Corcoran clay decrease in thickness from a maximum of about 800 feet on the Valley margins to less than 100 feet in the vicinity of the San Joaquin River (Figure A7). In the Valley trough, the coast range alluvium, characterized generally by fine-grained sediments, gives way to the alluvial Sierran sands derived from the Sierra Nevada mountains. The coarser Sierran sands contain water with chemical characteristics distinct from the sediments of the Coast Ranges alluvium. The alluvial sediments overlying the Corcoran Clay are frequently referred to as the "semi-confined" zone.

A4 Regional Groundwater Flow

The Coast Range mountains constitute the natural groundwater recharge area for the west-side. At the turn of the century, before intense pumping commenced in the 1920s, the piezometric heads in the deep aquifers underlying the Valley floor were reportedly so high that free-flowing artesian wells were common along a long, narrow zone along the river (Figure A8). The physical disposition of the artesian zone, extending parallel to the trend of the Coast Ranges, is an indication that the regional groundwater system is driven by recharge from the Coast Ranges. Based on stable isotope data of water samples from wells located above and below the Corcoran clay, Dubrovsky et al. (1991) suggested that groundwater may also be leaking vertically through the Corcoran clay and recharging the deep aquifers, both due to pervasive flow through the formation and due to the several hundred wells which are screened in horizons above and below the Clay.

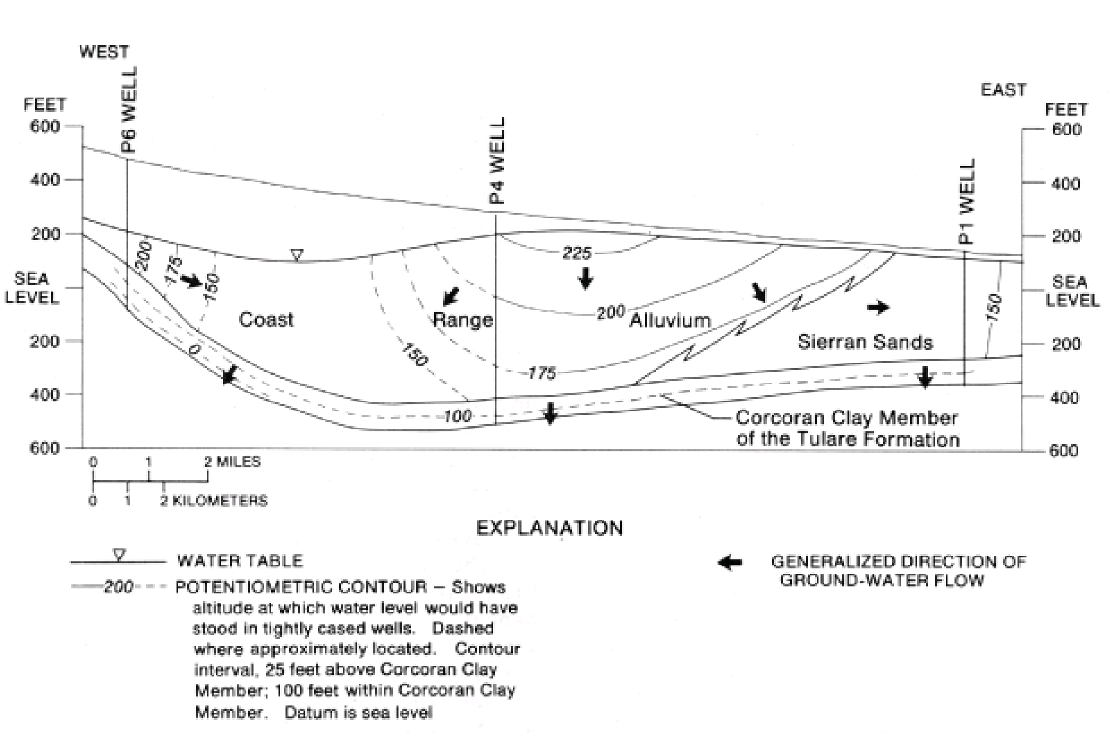


Figure A8. Generalized hydrologic cross section and approximate flow patterns in the semi-confined aquifer for the San Joaquin Basin. (from Belitz, 1990).

The development of the western San Joaquin Basin for irrigated agriculture and the advent of deep-well turbine pumps in the 1920s drastically changed the groundwater flow system. Groundwater became an important component of irrigation water and, responding to post-second-world-war boom in the economy, groundwater pumpage increased by a factor of four, reaching a maximum of about a million acre-feet per year between 1950 and 1970. Most of this pumpage was from the confined aquifer below the Corcoran Clay (Figure A8). However, pervasive land subsidence over the west side and increased cost of pumping necessitated a reduction in groundwater pumpage and importation of water through the San Luis Canal. Surface water deliveries to WWD that have continued since the first contract deliveries were made in the 1967 have caused water tables to rise throughout the water district except in the western sector of the District, formerly known as Westplains, where water allocation has been restricted to about 1.5 acre-ft/acre. The resulting water table surface is shown in Figure A8. The zone separating the areas impacted by shallow saline water tables has migrated to the west over time – however the region below the Westplains sector of WWD, which still relies on groundwater pumpage for up to 50% of its water supply, continues to show a deep water table more than 250 ft below the ground surface. This condition is important to the analysis in Section 3 in the main body of this report.

A5 Groundwater Pumping

Groundwater pumping on the west side of the San Joaquin Valley has been responsible for much of the present day hydraulic condition and hydrochemistry of the Basin. Gronberg et al. (1990) provide a summary of the distribution of wells on the west-side. Although nearly 6,000 wells are known to exist in the Valley, useable information is available only with respect to about 2,550. Nearly two-thirds of these wells are completed in the semi-confined zone overlying the Corcoran clay. Due to the general poor water quality within the shallow part of this zone (< 50ft from land surface), most of the wells in the shallow, upper portion are passive, observation wells. Production wells in the semi-confined zone are typically greater than 50 feet in depth. The Coast Ranges alluvium in the semi-confined zone generally comprises fine-grained sediments. Because of the larger surface area of contact between water and solids in these sediments and longer residence times, these sediments tend to contain waters of poorer quality compared, for example, with waters of the Sierran sands to the east

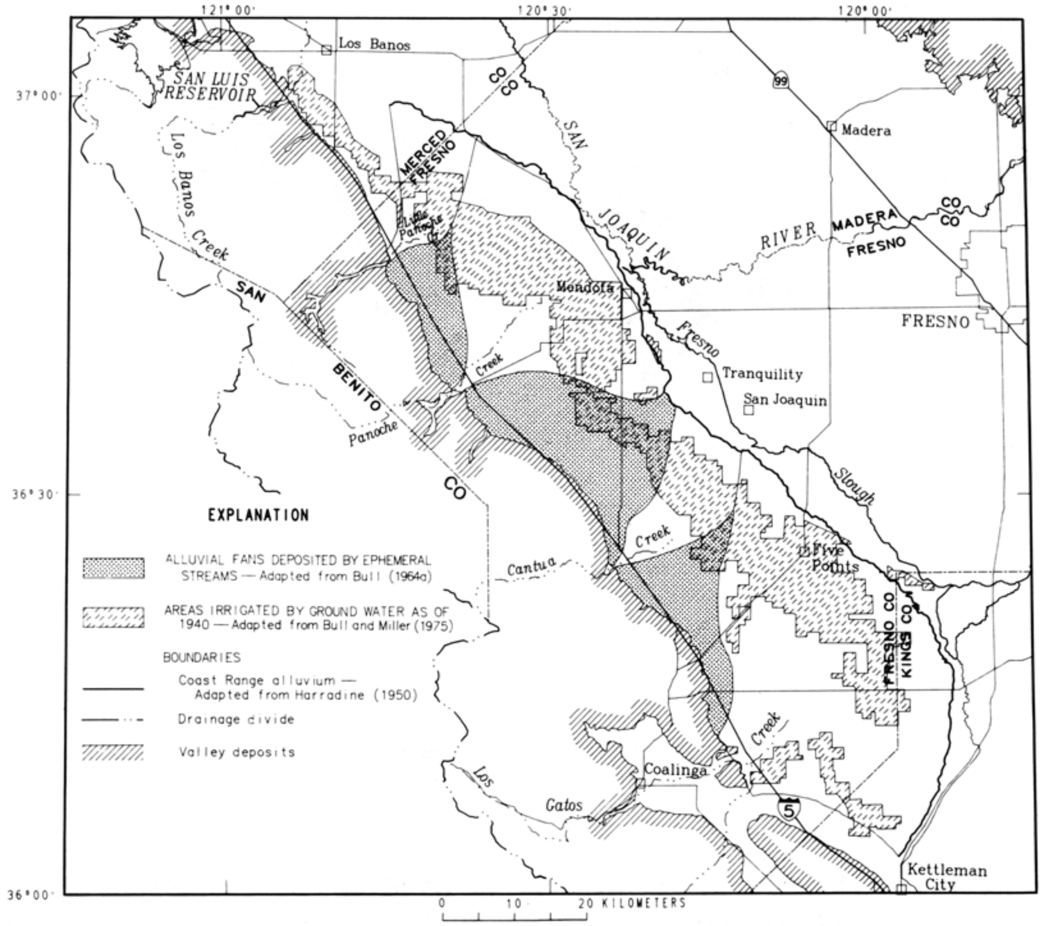


Figure A9. Map of the west side of the San Luis Unit showing the groundwater drainage divide and the areas irrigated by groundwater pumping in the 1940's (from Belitz, 1990)

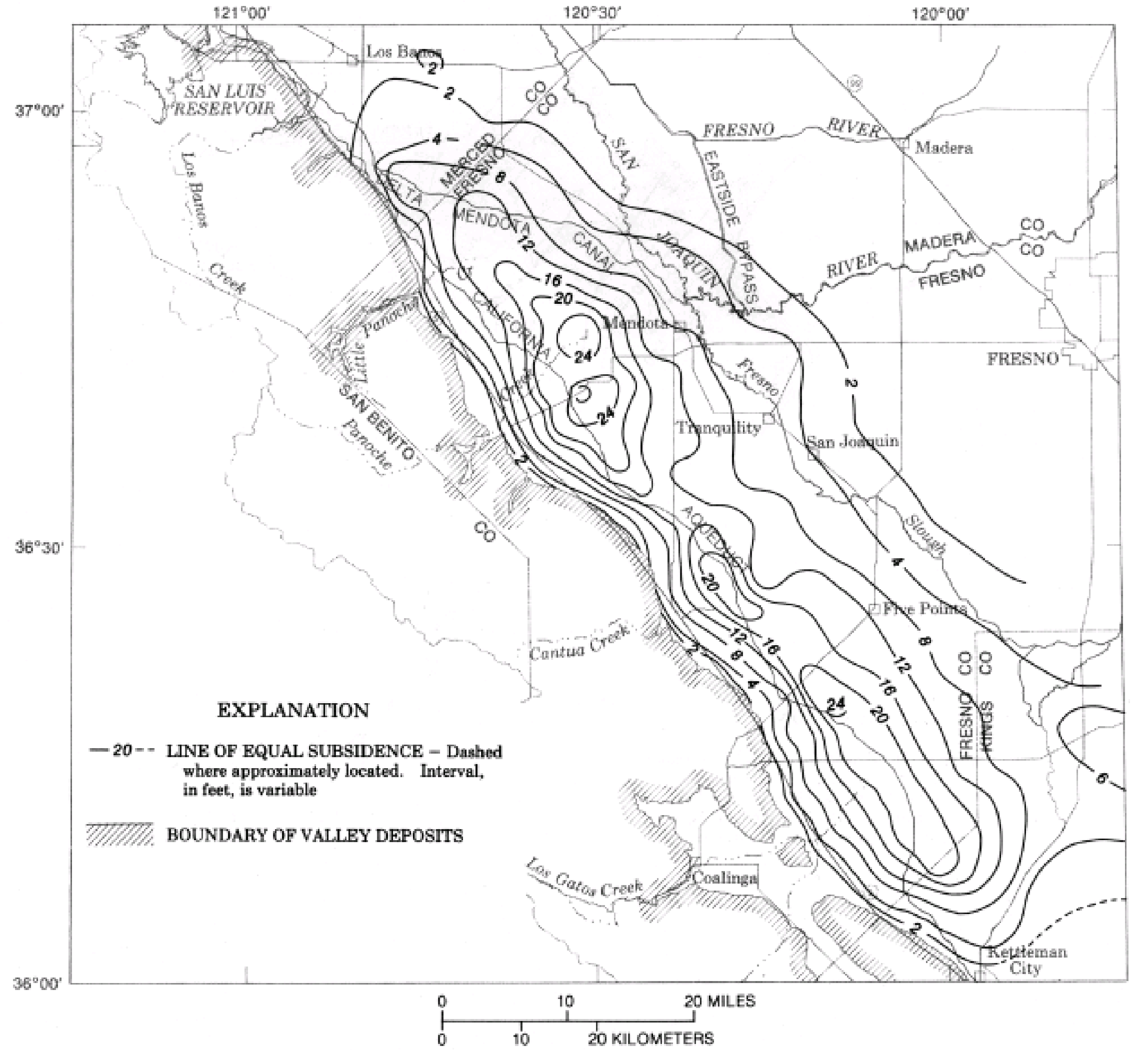


Figure A10. Land subsidence induced by excessive groundwater pumpage in the San Luis Unit (from Belitz, 1990)

of the San Joaquin River. Therefore, in the Valley trough and the margins of the alluvial fans, irrigation wells in the confined zone tap aquifers in the Sierran sand which contains coarser, cleaner sands and better quality water. Wells in the semi-confined zone have screens typically ten feet or more in length. Some 533 wells reportedly tap aquifers in both the semi-confined zone and the confined zone. In addition to providing irrigation water supply, these wells probably cause water within the two aquifer systems to mix. The extent to which such mixing has occurred so far is as yet to be quantified.

Wells penetrating the confined zone below the Corcoran Clay are generally restricted to the upslope areas at the head of the alluvial fans beyond the extent of the Sierran sands. Gronberg et al. (1990) counted 410 wells that tap the confined zone with open screen intervals in excess of 100 feet. Examination of water table data and potentiometric data for 1984 by Belitz (1988) showed the existence of a pronounced groundwater divide approximately midway between the Valley trough and the Coast Ranges. This divide, shown in Figure A9, has presumably occurred due to overdraft of groundwater by pumpage to the west and by leakage from the Aqueduct. Clearly the pre-development areal distribution of recharge and discharge areas of the west-side has been significantly modified by pumpage, with resulting physical and geochemical consequences.

Ken Schmidt and Associates (Schmidt, 1997) have performed comprehensive studies of groundwater resources of the western San Joaquin Basin. They found that wells located near Gustine and in areas east of Dos Palos, where these groundwater wells tapped strata above the Corcoran Clay, water levels were relatively constant. However, for areas within the north-east corner of WWD and between Firebaugh and Mendota - water tables were generally rising over time. The majority of pumping in most west-side water districts takes place in strata immediately above the Corcoran Clay and immediately below the Corcoran Clay or in both.

A6 Irrigation and Subsidence

Irrigation-induced salination of land had already been observed and documented by Hilgard (1889), who drew attention to the long-term consequences of irrigated agriculture. In the 1920's the development of the deep-well turbine pump helped to draw high-quality water for irrigation from deep aquifers, lying at depths of 2,000 feet or more. By the 1930's, the negative effect of this large-scale pumping began to manifest itself in the form of land subsidence over the more actively pumped regions of the San Joaquin Valley. Water was being mined from soft sediments such as clays and silts at rates far exceeding their groundwater recharge. At some locations on the west-side, land had subsided by as much as 25 feet by the middle 1970s (Figure A10). Moreover, the declines in water levels ensuing from excessive pumping added significantly to the cost of lifting water. A desire to arrest land subsidence and a consideration for reducing pumping costs led to the importation of surface water supplies from the Delta to the north through the Federal pumping plant of the Central Valley Project (CVP) into the San Luis and Delta Mendota Canals. Water deliveries from the Delta-Mendota Canal (of the CVP), which began in 1951, helped reduce subsidence and contributed to the gradual recovery of fluid pressures in the aquifers to pre-pumping levels over the next two decades. Although groundwater pressures in the confined aquifers recovered more or less completely, only about 10 per cent of the total subsidence recovered because of the plastic deformation properties of the sediments. The remaining 90 percent constitutes groundwater storage that has irreversibly been lost.

A7 Cropping Practices

The total irrigated area on the west side of the San Joaquin Valley is about 2.3 million acres (Tanji, 1990), of which 0.89 million acres are affected by salinity and sodicity, 0.61 million acres by high water table and 0.93 million acres by poor groundwater quality (Figure A9). Cotton is the major crop grown (over 49% of the irrigated area) on the west-side, with lesser areas planted with tomatoes and melons. Commodity prices and expected crop revenues have a significant impact on long-term cropping practices on the west-side.

The only drainage outlet from the San Joaquin Valley to the ocean is the San Joaquin River. Subsurface tile drains have been installed to control seasonally high water tables and to dispose of salts flushed out from the root zone. To manage the application of irrigation water to cropland, a variety of irrigation methods are employed. Pre-plant irrigation and irrigation scheduling during the growing season are commonly practiced to improve irrigation water-use efficiency and maximize crop yields. Crop rotations are practiced on some lands to sustain soil fertility and control crop pests.

Administratively, the west-side is divided into water and drainage districts. The largest water district on the west-side is the WWD which historically has been without a natural drainage outlet.

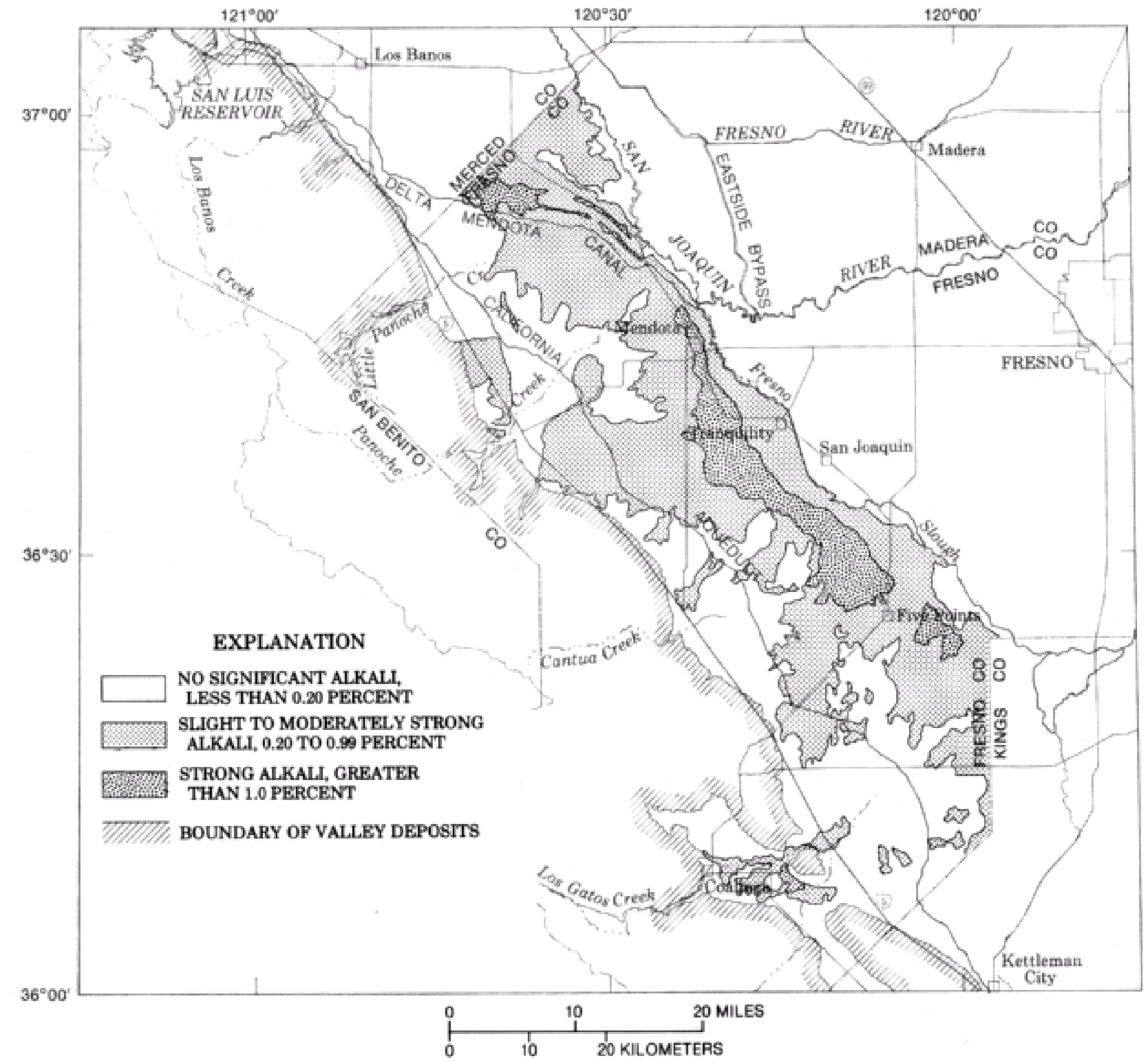


Figure A11. Subareas within the western San Joaquin Basin affected by natural salinity and sodicity (from Belitz, 1990).

A8 Irrigation Hydrology

Irrigation activities on the west-side have interacted with and modified the pre-existing groundwater flow patterns by changing areas of recharge and discharge (Narasimhan and Quinn, 1996). Application of irrigation water causes the potentiometric head to increase at the land surface, leading to an increased vertically downward movement of water. In areas of natural groundwater recharge, the irrigation deep percolation directly contributes to a rise in the water table elevation. In areas of natural groundwater discharge if the downward gradients are maintained for prolonged periods of time, such areas could become areas of recharge and lead to a rise in the water table. Because of the large areal extent of applied irrigation water on the west side, the resulting artificial recharge has significantly exceeded natural groundwater recharge by rainfall and stream flows. Williamson et al (1985) estimated that between 1961 and 1977 irrigation recharge was as much as 40 times that of the natural recharge over the entire west-side of the San Joaquin Valley.

Applied irrigation water directly affects the shallow groundwater system. In turn, the dynamics of water flow and water table fluctuations in the shallow aquifer are intimately related to local topographic variations. Tile drains capture significant quantities of resident groundwater in the shallow semi-confined aquifer as well as deep percolation from the crop root zone immediately above the drain. Although the majority of flow from irrigation applications is downward through the soil profile into the groundwater system, researchers have sometimes observed groundwater flow in an upward direction from about 50 feet below land surface downwards to about 100 feet, based on piezometer data to a depth of 100 feet. Below this depth flow is again downwards. In some downstream locations a horizontal groundwater divide seems to exist below 100 feet depth. It is not clear, however, whether the upward flow observed by them is a manifestation of the regional flow pattern. During periods of irrigation the gradient is reversed, causing the flow direction to change in the shallow zone, leading to downward migration of salts and soluble trace elements leached from the root zone (Narasimhan and Quinn, 1996). Grismer and Woodring (1987) investigated the importance of lateral flows to drains on the west side from the regional groundwater flow system and concluded that the problem has to be studied on the scale of a township (intermediate scale). Later studies by Fio and Deverel (1991), who observed both downward and upward groundwater gradients in a study area that included the Panoche Drainage District, provided confirmation.

A9 Groundwater Chemistry

The regional hydrogeochemistry of the San Joaquin Valley is governed by the regional groundwater flow system and by the character of the source rocks. According to Davis and Coplen (1989), the constituents present in the groundwater beneath the west side can be understood in terms of two distinct geochemical units. The deep aquifers below the Corcoran Clay with thickness varying from 1000 ft to 2500 ft contain very old waters (615,000 to 725,000 years before present). These sodium sulfate waters are thought to be mixtures of waters derived from the Sierra Nevada mountains as well as the Coast Ranges. Fairly well isolated by the poorly permeable Corcoran Clay, these waters are known to have a fairly uniform composition.

The aquifers above the Corcoran Clay contain waters which are distinctly different in composition from that of the deeper aquifers. Much richer in mineral content, the waters of the shallow aquifers exhibit a great deal of spatial variability in chemical composition. The waters of the shallow aquifers can be divided into Coast Range waters and Sierran waters. Groundwater in the Coast Ranges alluvium differs markedly from that in the Sierran sands. The former contains significant quantities of nitrate, boron and selenium while that in the latter is significantly higher in arsenic, molybdenum and manganese (Dubrovsky et al., 1991).

Reconnaissance studies by Presser et al. (1990) showed that selenium, which occurs mostly in a reduced elemental state in the marine shales, is oxidized to more soluble selenite and selenate forms. From these observations the inference can be made that groundwater in recharge areas are characterized by an oxidizing environment. In the distal parts of the fans, soluble selenates may occur with sulfate and other salts in evaporite deposits. These evaporite deposits are typical of groundwater discharge areas, where salts are moved to the land surface by upward-moving groundwater and subjected to evaporative concentrations (Narasimhan and Quinn, 1996).

As groundwater moves down-gradient into the Valley trough, its oxidation potential tends to decrease. Also, Ca tends to precipitate gradually in the form of calcite (calcium carbonate) and gypsum (calcium sulfate) (Doneen, 1967). Thus, groundwater in the Valley trough, in the vicinity of the San Joaquin River tends to be richer in NaCl and Na_2SO_4 and is characterized by lower oxidation potential as compared with upstream areas. Dubrovsky et al. (1990) carefully studied the vertical variations in groundwater chemistry at a site near the Mendota airport where oxidizing irrigation waters have displaced native groundwater to depths in excess of 50 feet over a protracted period of time. They found that prior to irrigation, the Sierran sand aquifer was part of a regional discharge area, characterized by low oxidation potentials and enriched in dissolved iron and manganese. Prior to irrigation, selenium had been evaporatively concentrated in the near-surface soils at this site over a long period of time. Due to vigorous pumpage of the Sierran aquifers for irrigation, the water table declined dramatically between the late 1950s and the middle 1970s. This water table decline presumably led to a seasonal down-ward movement of groundwater and the downward transport of salts and trace elements. As the displacement proceeded, mobile selenium was removed from the aqueous phase by reduction to Se^o, absorbed and/or precipitated in the vicinity of the interface between the two waters of contrasting redox states. Deverel and Fujii (1987) have provided evidence to show that selenium has been evaporatively concentrated with other salts in areas of regional groundwater discharge and that NaCl and Na_2SO_4 waters are being displaced by waters rich in $CaCO_3$ and $CaSO_4$. These findings suggest that surface- and groundwater transients and redox conditions play a significant role in determining soil and groundwater chemistry in the near-surface soils and groundwater aquifers.

Hydrogen isotope concentrations on groundwater have been used as a marker to estimate the depth penetration of irrigation deep percolation after the completion of the CVP facilities in the 1960's. These data have also been interpreted to estimate the regional depth distribution of salts and trace elements in the semi-confined aquifer. Gilliom (1991) has suggested that , in the vicinity of the Panoche Creek alluvial fan most salts and trace elements leached from the near-surface soils are contained in a zone between 30 feet and 150 feet below the land surface.

The chemical nature of soils in the west-side is known to be significantly related to regional geologic setting and groundwater chemistry. Southard et al. (1986) found that in the upper parts of the alluvial fans selenium content in the soils decreased with depth, suggestive of the important role played by sediment transport on soil chemistry. In the medial and distal parts of the fans selenium content increased with depth, presumably indicating that the element was being displaced downwards by irrigation water. The selenium variation with depth also indicated that the rate of downward displacement decreased with depth as oxidation potential decreased until reductive immobilization occurred in the vicinity of the interface with Sierran sands of low redox potential.

Doner et al. (1989) carried out a comparative study of archival (1946) and contemporary soils in the west-side with special focus on selenium and arsenic. The soils derived from the Coast Ranges sediments were found to be richer in selenium and arsenic than those derived from the Sierran sediments in the axial trough of the west-side. It was found that selenium in its oxidized form of selenate tended to be mobilized and leached from the soil. Therefore, contemporary soils in the irrigated areas were found to contain less soluble selenium than the unirrigated soils. Doneen (1967) carried out a study of sediments collected from bore holes at 19 different locations along the then-proposed alignment of the San Luis Drain. Samples were collected from depths varying from 50 feet to 500 feet. The samples from the axial trough of the valley (derived from the Sierran sediments) were found to have lower salt content than those of the fans (derived from the Coast Range sediments). Virgin soils were found to contain more salts than irrigated soils, suggestive of active leaching. Depth profiles in the medial and upper parts of the fans were found to contain significant amounts of gypsum. The relatively fine-grained nature of the Coast Ranges sediments as well as their origin in the chemical weathering of marine sediments contribute to the higher salt content of the soils derived from them. This, combined with the oxidation state of the system plays an important role in the trace element of groundwater chemistry of the west-side.

A10 Irrigation And Soil Salinity

The depositional nature of the sediments on the west-side has been such that the alluvial soils, especially those in the Valley trough at the medial and distal ends of the alluvial fans, are prone to salinity due to water-logging and rising water tables. For decades, the chief problem confronting crop yield the San Joaquin Valley was increasing salinity due to the accumulation of soluble salts in the root zone and toxicity due to trace elements such as boron. As salts build up in the root zone, the plants must expend extra energy to overcome osmotic forces and extract fresh water and nutrients from the soil. Thus, high root-zone salinity was correlated with high water-stress to the plants. To reduce this stress, the perceived solution was to flush the root zone of excess salts, normally accomplished by leaching with irrigation water, applied in excess of the crop's water requirement. In addition, networks of subsurface tile drains have been installed to remove these flushed salts and to control the proximity of the water table to crop roots. Maintenance of a water table 6 feet or more below the ground surface was found to reduce evaporative concentration of salts in the root zone, which typically increases as water tables rise above an extinction depth of approximately 7 feet. This extinction depth, defined as the limit of evaporative concentration of salts, depends on soil texture and capillarity.

A11 Crop Root Zone Salt Balance

Agricultural productivity and profitability determine on-farm decisions on the west-side of the San Joaquin Valley. Clearly, a key to sustaining high crop yields is to manage the moisture content, aeration and salinity of the root zone. Except for some phreatophytes, most crops cannot tolerate waterlogging of the root zone for extended periods; rather they require unsaturated conditions in which moisture and circulating air coexist in the root zone. Given such an environment, plants extract water and selected salts from the soil for their growth and sustenance. Although much remains to be understood about the mechanisms of uptake of water and nutrients by plant roots, it is generally believed that the uptake of water and salts by the plant roots is controlled by physical- and chemical driving forces. In the unsaturated soil, water is held in the pores by capillary forces stemming from the affinity of water to bind to the surface of the soil particles. Capillary forces progressively become large with decreasing moisture content. Hence, to take water from the soil, plants have to expend energy to overcome capillary forces and gravity. Moreover, when water in the root-zone has high salinity, osmotic potentials come into play and plants also have to spend additional energy to extract fresh water. When they are forced to expend excessive energy because of high root zone salinity, plants become "stressed". When moisture content in the root zone is relatively low, water is held in small pores under high capillary pressures, requiring plants to expend large amounts of energy to obtain the water necessary to meet transpiration needs and retain turgor pressure within the plant tissue. When turgor pressure declines plants wilt, the most visible early signs of plant stress. To achieve maximum crop yields, water content in the root zone should be at an optimal level over the entire crop growing season (neither too high to impair oxygen circulation nor too low to require high expenditures of energy to extract water). Salinity in the root zone must not rise above a certain, crop-specific, threshold level for an extended period of time. Certain crops such as cotton, wheat and sorghum exhibit greater tolerance to salinity than shallower rooted vegetable crops such as melons and tomatoes.

The amount of water required for growth of a crop is referred to as the crop's ET requirement. This quantity also varies from crop to crop. Based on years of field experience (Westlands Water District, 1984) the ET requirement has been shown to vary from less than 1 acre-foot per acre for melons and peas to as much as 4.2 acre-feet per acre for alfalfa (hay). Many field-scale, multi-year experiments have contributed to current knowledge of the ability of plants to tolerate stress and salinity. Although most plants do not like stress, some specific plants such as cotton may stand stress without adverse effects on yield during some part of the growing cycle (Ayars et al., 1990). Certain crops such as cotton can presumably benefit from stress applied at critical times during the growing season which can help to stimulate seed production.

A12 Crop Root Zone Leaching

Maintaining optimal salinity in the root zone necessarily implies that excess salt must be removed from the root zone. On the west-side, excess salinity in the root zone poses a particularly challenging problem requiring deliberate management interventions. A common strategy to salinity management is to preirrigate the field during the winter or early spring months to flush salts from the root zone. Growers with unused water supply allocations at the end of the water contracting year have been known to apply large volumes of water to attempt to “bank” water in the shallow groundwater aquifer for the following irrigation season. In the western San Joaquin Valley, dispersion of fine particles and surface sealing of soils decreases infiltration capacity of soils and makes it difficult to meet crop evapotranspiration (ET) needs in the latter part of the irrigation season. Practices such as this, abetted institutionally by the timing of the water contracting year, has exacerbated saline shallow groundwater and drainage problems on the west-side. It has been estimated (Salinity and Drainage Task Force, 1992) that deep percolation arising from pre-season irrigation applications alone may have been as great as 0.5 - 1.0 acre-ft/acre of water per year during normal or wet water years. Irrigation engineers have long recognized the need to provide a certain amount of "excess" water to flush accumulated salts from the root zone. Here the word "excess" refers to the amount of water exceeding the ET requirements of the plant. Two important parameters, leaching required and leaching achieved, are used quantitatively by irrigation engineers.

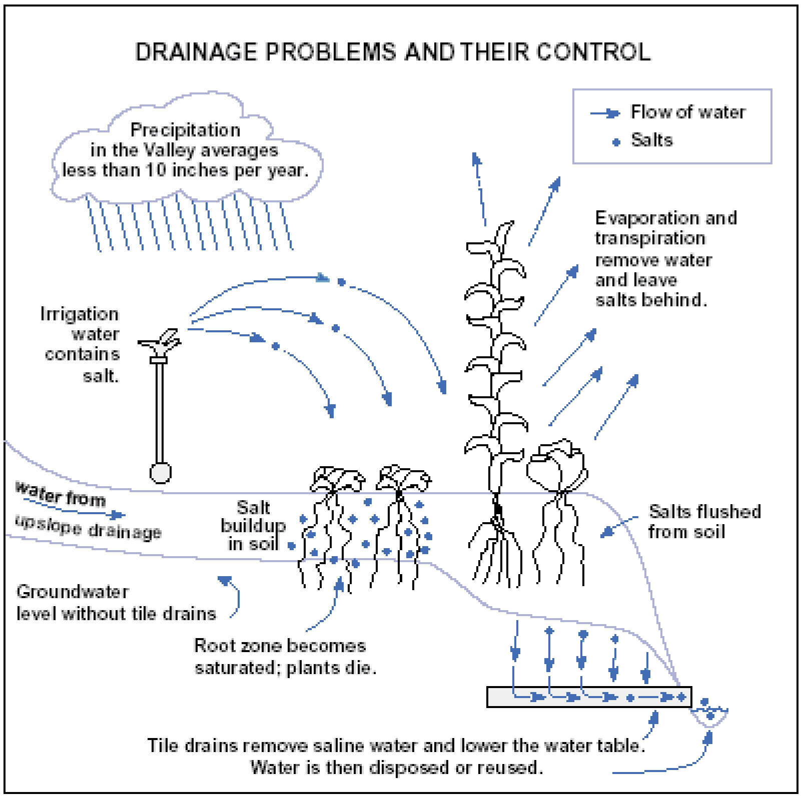


Figure A12. Illustration of the importance of soil leaching in maintaining salt balance (Alemi, 2000)

Closely related to the notion of leaching requirement is that of irrigation efficiency. Irrigation efficiency has been defined in many different ways for both practical and policy reasons. One definition of irrigation efficiency is the ratio of the irrigation water applied to the crop to the amount of water beneficially used by the crop. Beneficial use is commonly defined as the annual crop ET or crop water requirement. Some irrigation consultants and agricultural water districts have a broader definition of crop beneficial use which includes a minimum leaching requirement and an allowance for certain cropping practices such as frost protection. The addition of these other factors produces higher estimates of irrigation efficiency since beneficial use is the denominator in the equation. Irrigation efficiencies greater than 100% have been reported by WWD in areas where shallow groundwater is utilized by the crop to satisfy a portion of crop ET. In such areas the irrigation efficiency, if computed for each irrigation event, shows an increase over the irrigation season as crop roots develop and become extensive enough to intercept capillary water from the shallow ground water table. Calculated irrigation efficiencies are typically lower for individual irrigation events than for the irrigation season as a whole. It follows therefore that depending on whether one considers a single furrow, a single farm or a whole water district or whether one considers a single irrigation event, irrigation over an entire season, or irrigation over the calendar year irrigation efficiency is a concept subject to spatial as well as temporal scale variations.

Maximizing water use efficiency may not be in the best interests of the grower in circumstances where soils are heterogeneous in their hydraulic properties and where it is difficult to obtain high distribution uniformity of irrigation applications. Burt (1993) has suggested a practical maximum distribution uniformity of 80% for most furrow irrigation systems. With poor distribution uniformity, high irrigation water use efficiency is not possible if all parts of the field are to be provided with water sufficient to meet crop ET requirements. In some circumstances, such as those which exist in the western San Joaquin Valley, where selenium contaminated drainage is produced in proportion to the excess irrigation applied to the crop, it may become more cost effective to maximize water use efficiency and minimize drainage discharge. This has been demonstrated by Hatchett et al. (1989) using the Westside Agricultural Drainage Economics Model (WADE) where increasing costs of drainage disposal led to reductions in irrigation applied water. In these circumstances some portion of the field receives less than an optimal water supply - reduced ET then leads to a reduction in crop yield. During the recent drought, water deliveries to growers were reduced by as much as 75% during 1992, which led to a large reductions in irrigated acreage .

Salts that are flushed from the root zone will migrate downwards to the water table. The migrating salts displace and mix with resident groundwater and generally act to freshen water quality at the interface between the saturated and vadose zone. Refluxing of shallow groundwater by the processes of evaporative concentration and irrigation flushing increases the salinity of this water over the irrigation season. Where subsurface tile drains are present, part of the saline percolating water is intercepted by the drains and transported into sumps and surface drainage ditches . Should strong lateral groundwater flow exist below the water table, groundwater salinity may not change significantly because percolating water would continually dilute and displace resident saline water which in turn would migrate and disperse in the direction of the groundwater gradient. However, in the vicinity of the Valley trough where groundwater gradients are minimal and lateral groundwater motion is sluggish, the shallow groundwater system refluxes the solubilized salts and as a result becomes increasingly saline.

Because groundwater is a valuable natural resource in itself, concerns are being raised about the long term viability of the groundwater aquifer as a source of good quality irrigation water. Downward migrating irrigation deep percolation displaces better quality groundwater - the rate at which this occurs in the upper aquifer is a function of groundwater pumping in the deep semi-confined and lower confined aquifers, which in turn affects the vertical hydraulic gradient in the upper aquifer. To address concerns about irrigation induced salination of the aquifers, it is necessary to evaluate the relative magnitudes of the effect of practices such as over-irrigation and groundwater pumping (Quinn, 1991). The first step towards achieving this end consists of reducing irrigation deep percolation by minimizing the leaching requirement through effective irrigation scheduling, choice of irrigation technology and tailoring crop ET needs. In addition, one may manage to maintain as high as possible salt levels in the root zone as will be tolerated by the plants. Letey and Knapp (1990) provide an account of how dynamic programming methods can help in designing irrigation schedules. There are two measures of performance of irrigation application. The first is irrigation efficiency and the second is distribution uniformity as previously discussed. Both these measures of performance can be affected by the choice of irrigation technology (i.e. furrow; drip etc.) as well as irrigation water management that describes the manner in which growers use the technology. Ayars et al. (1987) described strategies to improve irrigation water use efficiency which include improved irrigation methods, reduction of pre-planting water application, reduction of irrigation as crop nears maturity, partial re-use of drain water and use of on-farm indicators to dynamically guide water application. On the west-side, a variety of water application methods are used, including furrow- corrugation-, basin- and border irrigation methods as well as micro-irrigation methods comprising surface- and subsurface drip irrigation and subirrigation (Kruse et al., 1990). Sprinkler irrigation systems can be divided into permanent, moved, side roll and center pivot. Burt et al. (1992) makes the point that without deliberate attempts to improve irrigation management, adoption of new technologies by themselves may do little to improve irrigation water use efficiency.

A13 Water Table Management

Plant roots may draw water either from above (from applied irrigation water) or from below (by capillary suction from the water table). Consequently, shallow water table can be an important source of water to satisfy crop ET needs. Water tables that were too shallow lead to water logging of the plant root and limit the depth of penetration of roots. Grimes and Henderson (1986) found that in areas of shallow perched water tables, 50 to 60 percent of the crop ET could come from below the root zone directly from the water table. The actual uptake by the plants depends on the salinity and depth of near-surface groundwater. In order to manage the water table efficiently as a source of crop ET needs, site-specific monitoring and data collection are necessary and a tile drain system should be in place to allow some control of the upward capillary flow.

One of the deleterious effects of supplying water to the root zone from the water table is that salts will be inevitably transported upward to the root zone and subsequently concentrated by evaporative processes and plant water uptake. These salts add to the total mass of soluble salts that must be periodically flushed from the root zone to sustain crop yield. The ability of water to transport nutrients as well as salts is a fundamental natural process. Therefore, the direction and magnitude of water movement (as governed by hydraulic conductivity) as well as the change in water storage in the root zones (as governed by the hydraulic capacitance of the soil) dictate the rate of removal of salt from the root zone.

The correlation between continued irrigation, rising water table and salinity on the west-side is well established. Researchers who have carefully studied the performance of subsurface tile drains in the west-side (Deverel and Fio, 1991; Grismer and Woodring, 1987) have shown that drains can capture water by upward movement from substantial depths. Since the major zone of salt contamination on the west-side lies between 30 feet and 150 feet below the soil surface (Gilliom, 1989) flow paths intercepting water at depths greater than 30 feet can contain elevated levels of salt and trace elements such as Se and B.

In considering the linkage between irrigation water and the water table (which represents the local shallow groundwater system) it is necessary to recognize that local groundwater flow need not necessarily be horizontal (lateral flow). Indeed, as a consequence of regional groundwater hydraulics the local groundwater flow field below the water table could, at places, be more vertical than horizontal. In addition, zones of stagnation will exist within the flow system. The hydrodynamics of the shallow groundwater system may have significant importance in regard to long-term salinity changes, local hydrogeochemistry and the performance of subsurface drains.

A14 Subsurface Drainage

Perhaps the most recognized method of controlling and managing the water table is to install subsurface drains to intercept irrigation deep percolation and transport the saline water away from the field. Subsurface drains are no longer made of ceramic tile; rather they are made of perforated flexible plastic and are typically placed at depths varying from 6 to 10 feet below the land surface on the west-side of San Joaquin Valley. The physical nature of the drainage process is such that each drain intercepts water from a zone of influence defined by the soil properties and the depth and spacing of the drains. To intercept a maximum fraction of deep percolation, a system of drains must be laid down at shallow depths at appropriately close spacing. Drainage networks requiring several hundred miles of drain lines will be needed if irrigated lands on the order of several thousand acres are to be drained. As one should expect, drains are most commonly installed in natural groundwater discharge areas and in areas where the water table lies very close to the land surface. Areas with installed subsurface drain networks occupy only parts of each water district. Growers commonly continue adding to drainage networks by placing new laterals between existing laterals until the desired effect on the groundwater is achieved.

In order to mitigate potential salinity problems, Federal and State governments began, as early as 1957 to draw plans for a master drain to collect and transport subsurface agricultural drainage from the west-side to Suisun Bay in the Delta. However, the State of California withdrew support for the project in 1968 and the U.S. Bureau of Reclamation proceeded with the first stage of construction of the San Luis Drain. The first stage, about 85 miles long, was completed in 1971, originating on the eastern boundary of the Westlands Water District and terminating adjacent to a series of shallow, excavated flow regulating ponds that were subsequently named Kesterson Reservoir. Only 1280 acres of the 5,900 acres of land acquired by the Federal Government for the regulating reservoirs received agricultural drainage water. In 1976, with the passage of the amended National Wildlife Refuge System Administration Act, all wetlands managed by the Fish and Wildlife Service were incorporated into a national wetlands system. Kesterson Reservoir and the adjacent 4,620 acres were subsequently incorporated into the Kesterson National Wildlife Refuge. Between 1972 and 1978 Kesterson Reservoir received fresh water inflows. Discharge of agricultural drain water from about 5,300 acres of the Westlands Water District commenced in 1979 and by 1981, inflows into the Kesterson Reservoir consisted exclusively of agricultural subsurface drainage water. By 1982 all inflow to Kesterson was from subsurface drains. The San Luis Drain, with its terminus at Kesterson Reservoir, provided drainage relief until 1986 to only 5,300 acres of irrigated land within a 42,000 acre area in the north-east corner of Westlands Water District.

The discovery in 1983 of reproductive failure of waterfowl and deformities in waterfowl embryos at Kesterson Reservoir, both attributed to selenium poisoning, resulted in Federal action that eliminated discharge of subsurface drain water from the Westlands Water District in 1986. As a result, farmers have been forced to find local solutions to the problem of drainage management and salt disposal within the District. More than one third of the water district is so affected (Figure 3). One strategy that has resulted from this search is the sequential use of progressively salt-enriched drainage waters and the final disposal of unusable brine into solar salt ponds as recommended by the San Joaquin Valley Drainage Program (1990). For the past 20 years field experiments have been conducted on various reuse systems by which subsurface drainage water from salt-sensitive are crops used to irrigate salt-tolerant crops, followed by salt-resistant trees such as eucalyptus and finally, halophytes (plants which thrive on salt water). Although these trees help lower the water table over the first few years, the gradual build up of salts inevitably follows, diminishing the abilities of these plants to extract water from the saline soil environment (Tanji and Karajeh, 1993). Water from the halophytes are fed into small, lined experimental evaporation systems to recover salts, primarily sodium sulfate which has some commercial value.

Although the on-farm tile drains in Westlands that discharged through collector drains into the San Luis Drain were plugged in early 1986, on-farm drains in water districts north of Westlands in the Grasslands Basin that deliver salt and selenium-contaminated water to the San Joaquin River continue to operate.

To address the salination, drainage and drainage related problems on the west-side of the San Joaquin Valley, the following measures have been investigated and, in many cases, implemented:

- Reduction of "deep percolation" losses to the water table through the adoption of water conserving irrigation technologies and practices, better irrigation scheduling and changes in cropping practices.
- Reuse of drain water, through the use of salt-tolerant crops.
- Manipulation of the water table to meet part of the crop evapotranspiration requirements.

- Conjunctive use of groundwater to meet a portion of crop needs.
- Improved instrumentation and monitoring systems to produce accurate and timely information and improve access to this information by growers.
- Develop and install monitoring systems to progressively evaluate changes in soil and water quality in the terrestrial and aquatic ecosystems over time.

A15 Summary

The west-side of the San Joaquin Valley contains some of the most productive agricultural land in the nation. Sustainability of this resource will depend on the success with which the custodians of the resource manage salt. In the past decade significant advances have been made in environmental monitoring and in the formulation of models and decision support systems to help farmers achieve root zone salt balance, and maintain agricultural productivity. These techniques are becoming more main-stream as west-side agriculture continues to adapt to environmental regulation of non-point source pollution.

Appendix C – CVPIA 10 Year Progress Report Summary

CVPIA

10 YEARS OF PROGRESS

IMPLEMENTATION OF THE CENTRAL VALLEY PROJECT IMPROVEMENT ACT

10 YEARS OF PROGRESS

Fiscal Years 1993-2002

February 2005

**U.S. Department of the Interior
Bureau of Reclamation
Fish and Wildlife Service**

Contents

Figures

Appendix A - Administrative Processes

Appendix B - Contracting and Improved Water Management

Appendix C - Anadromous Fish - Habitat Restoration

Appendix D - Anadromous Fish - Structural Measures

Appendix E - Refuges and Waterfowl

Appendix F - Other Fish and Wildlife

Appendix G - Monitoring

Appendix H - Studies, Investigations and Modeling

Abbreviations and Acronyms

ACID	Anderson-Cottonwood Irrigation District
Act	Central Valley Project Improvement Act
AFRP	Anadromous Fish Restoration Program
AFSP	Anadromous Fish Screen Program
BLM	Bureau of Land Management
CALFED	California-Federal (as in CALFED Bay-Delta Program)
CAMP	Comprehensive Assessment and Monitoring Program
CD-ROM	compact disc read-only memory
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento-San Joaquin River Delta
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
EA	environmental assessment
EIS/EIR	environmental impact statement/environmental impact report
EWA	Environmental Water Account
FONSI	finding of no significant impact
FY	fiscal year
GCID	Glenn-Colusa Irrigation District
Interior	U.S. Department of the Interior
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NWR	National Wildlife Refuge
O&M	operations and maintenance
PEIS	programmatic environmental impact statement
PG&E	Pacific Gas and Electric Company
RBDD	Red Bluff Diversion Dam
RCD	Resource Conservation District
Reclamation	U.S. Bureau of Reclamation
Restoration Fund	Central Valley Project Restoration Fund
Service	U.S. Fish and Wildlife Service
SWP	State Water Project
SWRCB	State Water Resources Control Board
TCC	Tehama-Colusa Canal
TCD	temperature control device
USBR	U.S. Bureau of Reclamation
VAMP	Vernalis Adaptive Management Plan

Implementation of the Central Valley Project Improvement Act
10 Years of Progress Report

Fiscal Years 1993-2002

PART I - INTRODUCTION

Purpose of 10 Years of Progress Report

This report is a summary of the actions taken in the 10 fiscal years, 1993-2002, by the Department of the Interior (Interior) to implement Title 34 of Public Law 102-575, the Central Valley Project Improvement Act (CVPIA or Act). The CVPIA was passed by Congress and signed into law by the President on October 30, 1992. The Secretary of the Interior (Secretary) assigned primary responsibility for implementing CVPIA's many provisions to the U.S. Bureau of Reclamation (Reclamation) and the U.S. Fish and Wildlife Service (Service). This report is intended to provide the general public, as well those more familiar with the Act and Interior's efforts to implement it, with an overview of what has been accomplished since passage of this landmark legislation. Greater detail on any of the programs and projects described herein can be obtained by contacting Reclamation or the Service directly at the address listed on the inside front cover of this document.

CVPIA activities are being implemented and reported through other instruments as well. For example, there are CVPIA Annual Work Plans for each of the sections of the CVPIA, CVPIA Annual Financial Reports, and CVPIA Annual Accomplishment Reports. Many of these documents can be retrieved via the internet (www.mp.usbr.gov).

Reclamation and the Service have given the highest priority to implementation of CVPIA and significant progress has been made. Programs to carry out all of the Act's key provisions are either in place or have been completed. This report summarizes that progress. The following part (Part II) of this report describes the approach Reclamation and the Service have used in this massive undertaking, how actions were prioritized, and how coordination with other programs and the various stakeholders that would be affected by CVPIA implementation was achieved. Part III of the report summarizes the actions taken by the U.S. Department of the Interior (Interior), both by category of action and by specific CVPIA provision.

The results and relative success of those actions are evaluated and presented in Part IV. Appendices also are provided in order to present more detailed information on the status of individual programs.

Reclamation and the Service coordinated the planning and preparation of a draft of this report with the Restoration Fund Roundtable* and other stakeholders. Comments from all were considered and used in the development of the draft report. The draft was subsequently advertised for review in the Federal Register and responses were received from 13 entities. Many of the comments were on the content or format of the report: others were of a more general nature or asking for information of a much more detailed nature than intended for this report. The text the 10-Year Report has been revised as appropriate to incorporate the comments received from the public. Comments relating changes and/or results after fiscal year 2002, or those requesting very detailed financial information, will be answered in Annual Accomplishment Reports or in detailed CVPIA Financial Reports. Any remaining questions or comments will be addressed directly in meetings and/or correspondence with the concerned entities.

The Central Valley Project's Role in California's Water Resources

For more than 60 years, California has depended on the Central Valley Project (CVP) for a large part of its water needs, particularly for agriculture. Plagued by consecutive years of drought, often followed by wet years bringing floods, the State relies heavily on dams and reservoirs to help balance and control its water resources. Its climate and geography make California equally dependent on extensive water distribution systems to match water supplies with regional needs.

* The Restoration Fund Roundtable was formed by interested stakeholder groups in California and represents some of the interests of agriculture, municipal and industrial groups and the environmental community. It provides comment to Interior on various components of planning and implementation associated with the CVPIA.

Much of the State's water originates in the north and is conveyed southward, primarily through the Sacramento River system. Some water is diverted along the way, and the rest flows into the Sacramento-San Joaquin River Delta (Delta), where CVP water co-mingles with other supplies, such as those of the State Water Project (SWP). About half of the water entering the Delta is pumped south: the remainder discharges to San Francisco Bay and the Pacific Ocean. Because of the way water is captured and moved through the system, the CVP affects, and is affected by, the many unresolved water issues in California involving ecosystem balance in the river systems and the Delta.

The sensitive ecosystems of the Delta estuary and San Francisco Bay are affected by water diversions, particularly in drought years, and the courts have intervened to ensure that adequate fresh water enters this system. Compliance with Endangered Species Act (ESA) and water quality requirements mandate releases from CVP dams to regulate water temperatures and instream flows, and constrains water diversions when necessary to protect listed fish species from the effects of pumping. These factors have greatly increased the competition for existing water supplies, and have focused scrutiny on the ways that water resources are being used.

Conditions have greatly changed since the CVP began in 1930. Population growth and development have increased farm, urban, and industrial water demands. Stocks of fish and wildlife have declined, and some species are listed as endangered or threatened due to severe habitat losses from various developments over the last century, including water projects. There is a new imperative for resource management that includes ecological stewardship.

These competing demands for water create complex issues that only can be resolved cooperatively, involving the public and all stakeholders in the process. Whenever water is gained for one purpose, it is frequently lost for another. Innovative approaches to water use and re-use, developed through negotiation and compromise, are vital to reduce conflicts and improve water management for all needs.

The CVPIA Mandate

The CVPIA addressed the importance of the CVP in California's water resources picture and made significant changes in the policies and administration of the project – more than any other legislation in the project's 70-year history. The CVPIA has redefined the purposes of the CVP to include the protection, restoration, and enhancement of fish, wildlife, and associated habitats; and to contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin River Delta Estuary. Overall, the CVPIA seeks to "achieve a reasonable balance among competing demands for use of [CVP] water, including the requirements of fish and wildlife, and agricultural, municipal and industrial, and power contractors."

The Central Valley Project

Beginning in 1930, the Federal government built the Central Valley Project (CVP) in California to control floods and to store and distribute water for the agricultural development of the great Central Valley. Today, the CVP delivers about 20 percent of California's developed water to farms and communities, and generates about 5 billion kilowatt-hours of hydroelectric power. The CVP supplies about 7 million acre-feet of water to its customers throughout the valley, transported via canals, aqueducts, and the river systems themselves.

(One acre-foot is the amount needed to cover the size of a football field in water 1 foot deep. One acre-foot—about 326,000 gallons—will supply all the water needs of an average family of five for a year, or drip-irrigate about 1 acre of grape vines).

PART II - INTERIOR'S IMPLEMENTATION APPROACH

Implementing the CVPIA

Immediately upon passage of the CVPIA, Interior began to develop procedures to implement the specific provisions of the Act.

Interior first developed a set of procedural objectives designed to achieve the stated goals while providing the greatest public benefit and minimizing adverse impacts. These objectives placed a high priority on forming partnerships and coordinating with other efforts and in using CVPIA funds in the most cost-effective manner.

Interior immediately adopted the three fish and wildlife restoration goals prescribed by the Act. One of the most ambitious goals was to make all reasonable efforts to double the natural production of six species of anadromous fish, species believed to have been most affected by CVP construction and operation. Another goal was to supply much-needed water to Federal and State refuges and other migratory waterfowl habitats in the Central Valley. The third was to mitigate impacts of the CVP to other fish and wildlife, impacts that are not specifically addressed in other provisions of the Act and that had not been previously offset. In addition to these fish and wildlife goals, Interior has embraced the goal of improving the operational flexibility of the CVP in order to more effectively balance and meet the many competing demands for project water and power supplies.

Implementation Priorities

Several factors are considered in establishing priorities for implementing CVPIA actions. These include: the importance of the action to achieving program goals; the planning or readiness needed for implementing the action; coordination with other ongoing programs; and funding. Some sections of the Act direct specific actions: others call for studies or investigations or relate to administrative matters, such as authorization of funds and compliance with State and Federal laws. Because the Act specified compliance dates for some provisions, implementation in those cases was responsive to the prescribed dates.

Most of the programs established to address specific CVPIA provisions had the same initial steps in common. All required an administrative structure, opportunity for public and stakeholder involvement, and coordination with potential partners to develop program plans. There were large differences in the amount of time and effort required to complete these steps for the various programs, primarily dependent upon the relative complexity of the issue and degree of public interest or controversy. For some programs, plans were developed within the first year while, for others, plans are still being completed.

Interior is generally implementing the Act to provide immediate response to the needs of the most threatened species of fish and wildlife, while taking care to involve all stakeholders in the development and implementation of all CVPIA programs.

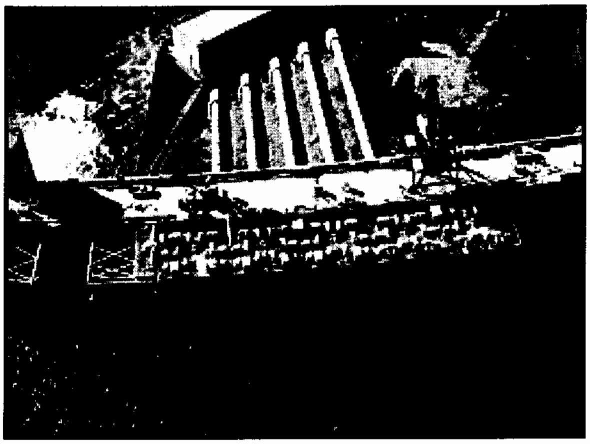
To prioritize activities and the expenditure of funds, Interior has developed biological focus areas. These focus areas are based on integration of three parameters: the species of greatest concern, factors most influencing the populations of those species, and the geographic areas or habitats critical to those populations. Interior channeled its efforts to areas where the three parameters overlap to focus funds and gain the greatest biological benefit.

An Urgent Priority: Shasta Temperature Control Device

In some cases, urgency gave a project high priority. Interior was responsive to such an exigency in the planning and construction of the Shasta Temperature Control Device (TCD). Millions of dollars in power revenues were being lost in summer and fall when cold water had to be released from low outlets at Shasta Dam to help meet the needs of the Federally listed winter-run Chinook salmon. A solution was needed that would send cold water downstream without interrupting power generation. Reclamation began research to solve this problem in 1989.

The solution was an $84 million steel frame structure that allows the selective withdrawal of water from different reservoir depths without bypassing power generation. The 8,000-ton, 300-foot-tall structure is connected to the upstream face of the dam. It has been compared with building a 25-story steel skyscraper under water.

Construction required a team of divers using a diving bell and a pressurized living chamber at the surface to allow "saturation diving" at depths to 300 feet.



Despite the technological challenges of this pioneering and unique project, planning and design were completed within 2 years after CVPIA passage. Construction began in November of 1994 and the TCD was operating in February 1997. Since then, the TCD has operated to reduce temperatures in the upper Sacramento River, while allowing power generation. Although this project required a large commitment of CVPIA funds, the revenues from otherwise-lost power generation will eventually exceed the cost for this project.

Coordination with Other Programs

To facilitate coordination and communication within Interior, each section of the Act was assigned a program manager from each of the two agencies, Reclamation and the Service. Generally, one is designated the lead agency, but both have equal responsibility to work together to develop a program plan and to involve other agencies and interested groups in its development and refinement.

Cooperation through partnerships is very important to the success of the CVPIA. Interior has developed numerous partnerships and extensive coordination linkages with local, State, and Federal agencies, and private groups. There are partnerships with many previously existing programs, as well as new programs and groups formed specifically to carry out specific provisions of CVPIA. CVPIA implementation is closely coordinated with existing and ongoing restoration efforts such as the State of California's efforts to restore salmon and steelhead populations, the State Water Resources Control Board's Water Quality Control Plan for the Sacramento-San Joaquin River Delta, and the California Bay-Delta Authority's efforts to develop long-term solutions to Central Valley and Delta problems. Interior encourages potential partners to enter into cooperative relationships to implement appropriate CVPIA measures or to help achieve CVPIA goals and objectives through their own programs. Through various mechanisms, Interior can provide funds and services to these partners, allowing for the completion of pre-approved restoration actions. The CVPIA (Section 3407(e)) provides the Secretary with the flexibility to use several mechanisms for funding non-Federal entities.

Some of the concurrent programs affecting CVPIA are the Coordinated Operation Agreement between the CVP and the SWP to meet Delta water quality and flow standards, and the California Bay-Delta Authority's programs. These include an Ecosystem Restoration Program, an Environmental Water Account, and a scientific expert review and advisory program to guide restoration efforts.

MAJOR PROGRAMS INFLUENCING CVPIA IMPLEMENTATION

Coordinated Operation Agreement
USBR-DWR agreement defining responsibilities of CVP and SWP to meet Delta water quality and flow standards set by State Water Resources Control Board (SWRCB). (SWRCB is in the process of determining contributions of other water right holders.)

California Bay-Delta Authority (formerly CALFED)
A consortium of State and Federal agencies (appointed by the Secretary of the Interior and the Governor) working with other urban, agricultural, fishery and environmental representatives to solve Delta water quality and reliability problems. The Authority has developed plans for a long-term solution to many of these problems. Their Ecosystem Restoration Program is also working on fish and wildlife habitat restoration projects upstream and in the Delta.

CALFED Record of Decision (ROD)
The ROD represents the culmination of the National Environmental Policy Act and the California Environmental Quality Act process. The ROD reflects the final selection of a long-term plan that includes specific actions to fix the Bay-Delta, describes a strategy for implementing the plan, and identifies complementary actions the associated agencies will also pursue.

Linkage with the Ecosystem Restoration Program (ERP) is a very significant factor in the implementation of the CVPIA. Many of the ERP actions have the same or similar objectives, and address most of the same natural resource and water management problems, as actions under CVPIA. Close coordination and a focus on functional integration of CVPIA and ERP have been necessary to achieve common goals and avoid duplication. To ensure coordination in the prioritization of fund expenditures and implementation of CVPIA projects, Interior has worked extensively with ERP staff and stakeholder groups. An example of this coordination is Interior's willingness and effort to have ERP scientists provide "expert level" review and comment on proposed CVPIA programs and actions. This review assists in the selection of the most worthy projects for achieving CVPIA goals and is expected to lead to a more broad-based ecosystem management strategy that more effectively addresses fish and wildlife mitigation, restoration, and enhancement.

In addition to the Ecosystem Restoration Program, program and project coordination has also been achieved, and funding partnerships formed, with other entities, both public and private. Among the most notable examples are the establishment of watershed work groups on many Central Valley rivers and streams. These groups, comprised of affected interests within each watershed, assist Interior's efforts to restore anadromous fish populations by developing workable solutions to the problems specific to each watershed.

PART III - SUMMARY OF ACCOMPLISHMENTS

Organization of CVPIA Implementation Actions

Interior has grouped the actions in individual sections of the CVPIA into eight categories for administration and budgeting purposes. These action categories are also commonly used in partnering and public involvement discussions. Each one involves several individual programs and actions. These categories were used to group related actions for the narrative discussion of accomplishments that follows.

CVPIA ACTION CATEGORIES

- Administrative Processes
- Contracting and Improved Water Management
- Anadromous Fish - Habitat Restoration
- Anadromous Fish - Structural Measures
- Refuges and Waterfowl
- Other Fish and Wildlife
- Monitoring
- Studies, Investigations and Modeling

A Summary Table of Accomplishments at the end of this part presents the major accomplishments of CVPIA implementation for each of these action categories in a concise tabular form. Aquatic and terrestrial restoration activities associated with these accomplishments are shown in Figures 6 through 9 following the Summary Table. More detailed information on each individual program is provided in the Appendices, in the same order as the action categories.

Administrative Processes

The administrative element of implementing the CVPIA has been extremely challenging for all the agencies involved, and has required a large commitment of resources over the past 10 years because of the many comprehensive programs to be implemented. Many of the programs have required extensive documentation and reports for environmental compliance, in addition to the required Programmatic Environmental Impact Statement (PEIS). Public involvement and partnering arrangements have also been extensive.

Because of Interior's strong commitment to implementation, and the enthusiastic cooperation of partnering agencies, including the State of California, many of the programs have advanced rapidly: others are nearing completion of the administrative groundwork. In view of the complexity and controversial nature of the CVPIA to CVP contractors and other stakeholders, it has been extremely important to work closely with all parties to address issues. In reviewing the progress of implementation, it will be apparent that some of the more contested actions require more time for completion of the administrative steps.

Programmatic Environmental Impact Statement (PEIS)

The Act required a PEIS to assess the effects of implementing the actions specified in the CVPIA. Because the findings of the PEIS would influence many of the actions, the PEIS was among the first steps and proceeded concurrently with other early implementation actions needed to carry the CVPIA. The PEIS analyzes the direct and indirect impacts of implementing the CVPIA, was the most comprehensive document to be prepared for CVPIA implementation, and required partnering with nine agencies, extensive public involvement, and significant technical efforts. The draft, including more than 30 technical appendices, was released for public comment in November 1997. The final PEIS was released in October 1999 and the Record of Decision signed by Reclamation and the Service in January 2001.

Rules and Regulations

Interior almost immediately initiated a public involvement process to develop the necessary direction for interpreting and implementing sections of the CVPIA. However, formal rules and regulations could not be promulgated until the PEIS was completed. Consequently, to inform the public of our approach to CVPIA implementation and to provide Interior personnel with interim guidance pending formal rules and regulations, Interior developed interim guidelines and criteria for dealing with seven CVPIA issues or topic areas. We then held public scoping workshops to solicit comments on rulemaking. The topic areas covered by interim guidelines were: Interim Contract Renewals; Water Transfers; Restoration Fund Payments and Charges; Section 3406(b)(2) Water; Land Retirement; Water Conservation Proposals; and the Section 3406(b)(22) Agricultural Waterfowl Incentives Program.

Criteria were developed for evaluating water management plans and on the use of project power for fish and wildlife measures.

Administrative Proposals

In September 1995, Interior invited the public to identify any concerns they had regarding implementation of the CVPIA. To facilitate public input and discussion, representatives of Interior held a series of public meetings between September 1995 and April 1996. During these meetings, the following 11 major areas of concern were identified, and individuals volunteered to form work teams and discuss the specific issues pertaining to those areas: Trinity River; Water Conservation; Urban Water Reliability; San Joaquin River; Stanislaus River; Section 3406(b)(2)--dedicated water--combined with the Anadromous Fish Restoration Program; Water Transfers; Contracting Policies; Refuge Water Supplies; and the Restoration Fund. In April 1996, Interior committed to preparation of "Administrative Proposals" on each of the 11 areas of concern, addressing the principal issues raised by stakeholders during the public forum and work team meetings.

One of the more controversial administrative proposals, studied at length by a team of Interior personnel and stakeholders, concerned Section 3406(b)(2), management of the 800,000 acre-feet of dedicated CVP yield. Considerable debate occurred over interpretation of this section, primarily regarding how the water should be accounted and how it was to be used. Various approaches were developed and tested, all with extensive stakeholder input.

Despite the lengthy public involvement process and Interior's best efforts to move the participants toward consensus, some groups still contested Interior's proposed management of dedicated yield and took the matter to court. Pursuant to the court's direction, Interior developed a "final" *Decision on Implementation of Section 3406(b)(2) of the Central Valley Project Improvement Act* in October 1999. This decision also was litigated and the court held that parts of the decision were unlawful, arbitrary, and capricious. Consequently, Interior has revised the accounting procedures to comport with the Court's decision.

The strong feelings on this issue--some CVP users believing the formula resulted in too much water dedicated to fish, and environmental groups, too little--are indicative of the value placed on water in California. These and other issues identified during preparation of the PEIS are now part of the administrative record.

Funding Arrangements

Funding for CVPIA comes from several sources, and these have been formalized in written agreements and planning processes. Three funding mechanisms are proposed in CVPIA and have been established: the Restoration Fund, cost-share with the State of California, and funding agreements with non-Federal entities.

The Restoration Fund funds most CVPIA projects. The Restoration Fund serves as the depository in the Treasury of the United States for all revenues received by the Secretary from the following sources: pre-renewal charges, tiered water revenues, transfer revenues, Friant surcharges, Municipal and Industrial surcharges, restoration payments, and non-Federal contributions. The Restoration Fund has a public involvement component, including interaction and coordination with the Restoration Fund Roundtable (a stakeholder organization) and with the California Bay-Delta Authority.

Other CVPIA actions have been funded entirely or in part from Reclamation's Water and Related Resources Appropriation. In addition, pursuant to an agreement with the State of California signed in June 1994, State funds have been appropriated and used for various CVPIA projects and programs that call for State cost-share. Interior has also entered into numerous contracts, grants, and cooperative agreements for individual projects.

Over $629 million were obligated toward the implementation of the CVPIA's prescribed actions and programs through the first 10 years. It must be recognized, however, that many CVPIA measures were already being planned or in progress at the time the Act was passed and a large portion of these expenditures would have occurred even in the absence of the CVPIA. These include the Shasta Temperature Control Device ($84 million to implement, but saving $5 million per year in lost power generation); Glenn-Colusa Irrigation District Fish Screen Project ($41 million); rehabilitation of

Coleman National Fish Hatchery ($21 million); and fixing the fish passage problems at the Red Bluff Diversion Dam ($35 million) and the Tracy and Contra Costa Canal pumping plants ($15 million).

Of the $629 million spent during these first ten years, 54% (342 million) came from Restoration Fund appropriations. As indicated, these funds are derived from fees paid by the beneficiaries of the CVP's water and power supplies. Approximately $229 million (36%) came from Reclamation's Water and Related Resources appropriations, another $58 million (9%) from State of California cost share, and $1 million from donated funds (Figure 1).

Nearly $263 million (41.7%) of the monies obligated to implement CVPIA in these first 10 years were for structural measures, such as the Shasta Temperature Control Device and the Glenn-Colusa Irrigation District Fish Screen Project, projects that benefit water and power users as well as anadromous fish. Another $125 million (19.8%) were obligated for habitat restoration measures for anadromous fish, $132 million (20.9%) to provide water to refuge areas and on the Agricultural Waterfowl Incentives Program, and $52.5 million (8.3%) on acquisition of habitats for other fish and wildlife species, primarily those listed under the provisions of the Endangered Species Act. Administrative requirements and processes accounted for $29.3 million (4.7%) of the obligations while contracting/improved water management, studies and investigations, and monitoring accounted for the balance (Figure 2).

Figures 3-5 display the amounts obligated on each action category by each of the major fund sources - Restoration Fund, Water and Related Resources appropriations, and State cost-share. The $1 million of donated funds were used exclusively for the restoration of Clear Creek (Anadromous Fish – Habitat Restoration action category).

Fiscal data for each of the sections of the CVPIA on an annual basis is provided in the appendices and reflect the sources mentioned above, i.e., Restoration Fund, Water and Related Resources appropriations, and contributed funds (State cost-share and donated monies).

Figure 1
TOTAL CVPIA OBLIGATIONS BY FUND SOURCE
Fiscal Years 1993-2002

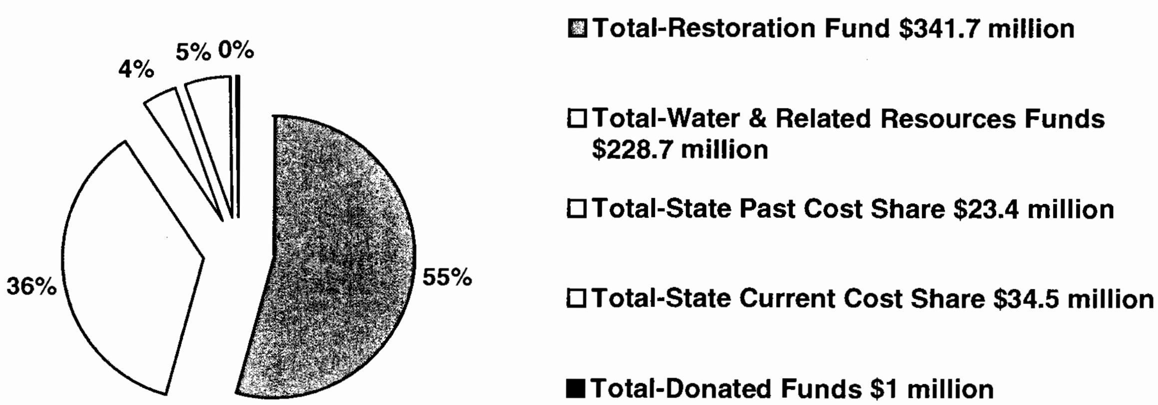


Figure 2
TOTAL CVPIA OBLIGATIONS BY ACTION CATEGORY
Fiscal Years 1993-2002

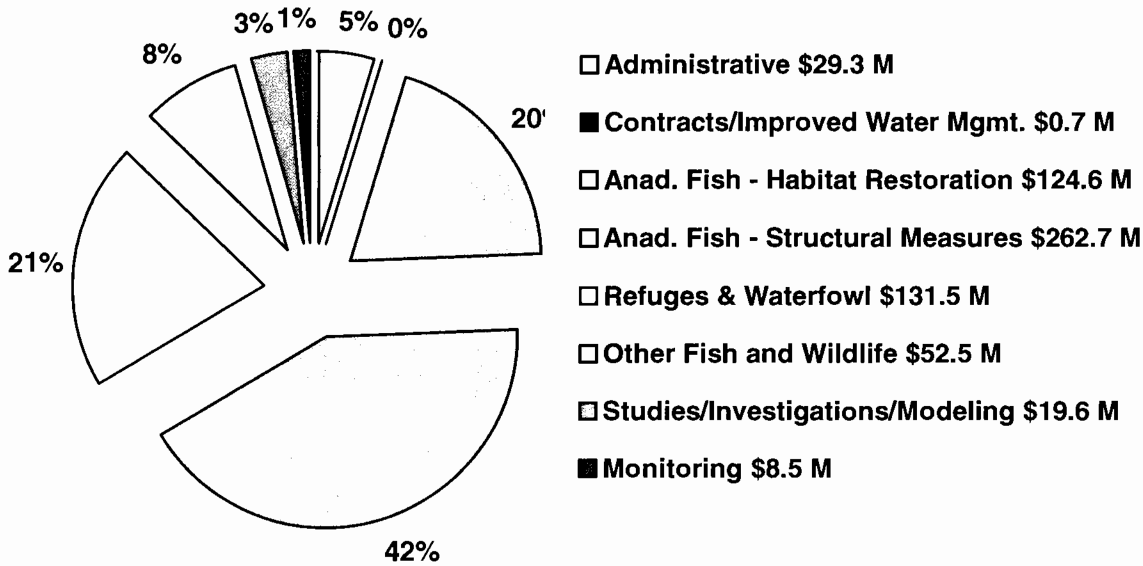


Figure 3
RESTORATION FUND OBLIGATIONS BY ACTION CATEGORY
Fiscal Years 1993-2002

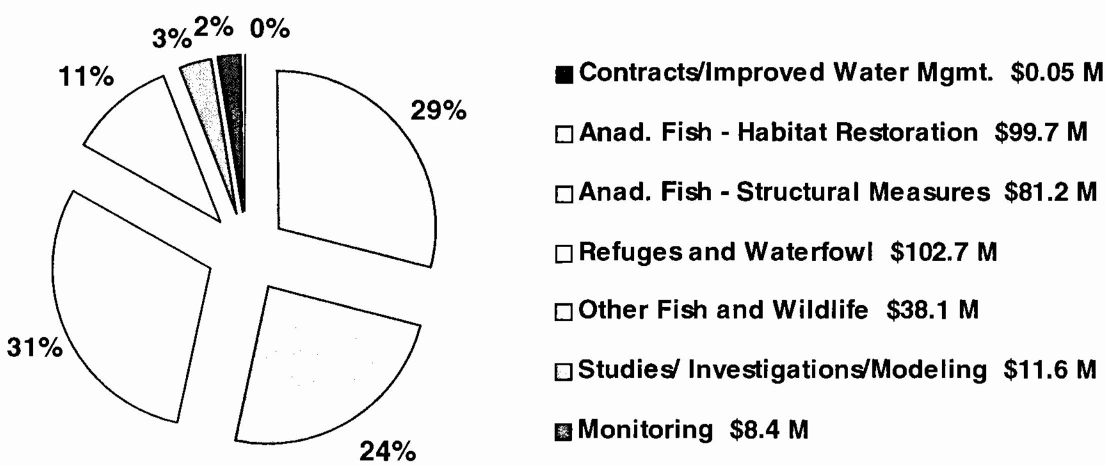


Figure 4
WATER & RELATED RESOURCE FUND OBLIGATIONS BY ACTION CATEGORY
Fiscal Years 1993-2002

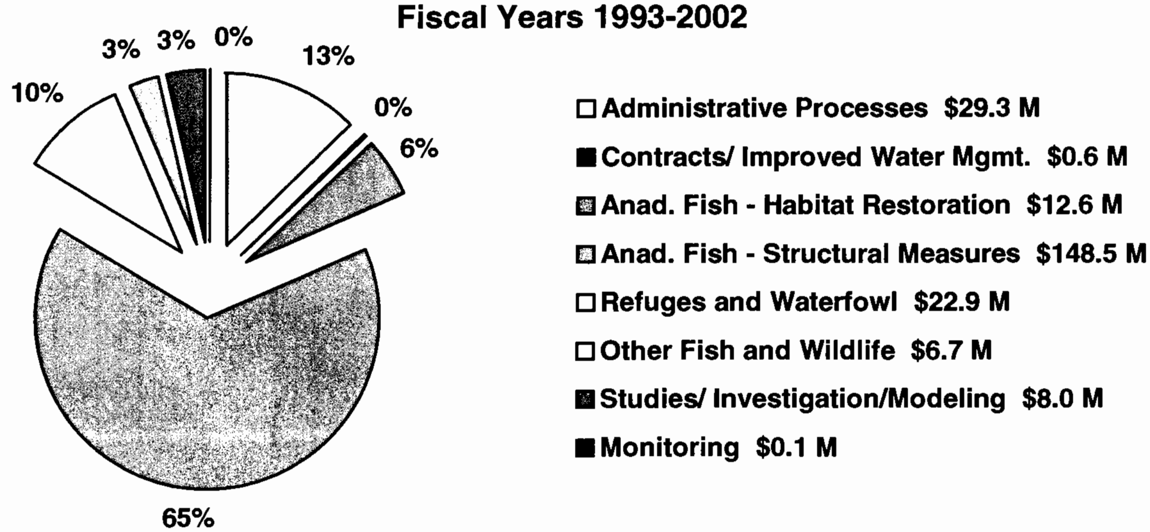
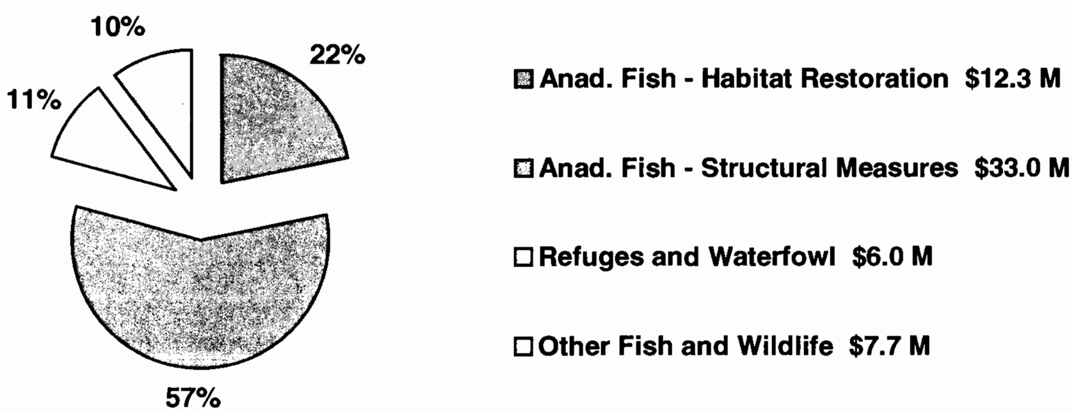


Figure 5
CONTRIBUTED FUND OBLIGATIONS BY ACTION CATEGORY
Fiscal Years 1993-2002



Contracting and Improved Water Management

This category includes provisions in the Act for renewing CVP contracts, and the management of water supplied by the CVP. Changes to be implemented by Interior included new contracting terms and conditions, and new programs for water transfers and water conservation.

Contract Renewals

The CVPIA prohibited new contracts and restricted the long-term renewal of existing contracts for water until the PEIS process was completed. It provided for interim short-term renewal of existing long-term contracts that had expired and, for those existing contracts that had not expired, provided for the execution of binding agreements requiring renewal immediately upon completion of the PEIS. Any contractor not signing a binding agreement was subject to a penalty of 1½ times the normal Restoration Fund payment. Prior to completion of the PEIS, 68 interim renewal contracts and 44 binding agreements were negotiated and signed. The PEIS was completed and the Record of Decision signed on January 9, 2001

After completion of the PEIS, 27 long-term renewal contracts were executed. Twenty-four other contracts were negotiated when efforts were suspended pending development and negotiation of a CVP-wide form of contract. That effort was still underway at the close of fiscal year 2002. In the meanwhile, Reclamation continued water deliveries pursuant to binding agreements and the interim renewal contracts.

Water Transfers

Interior developed Interim Water Transfer Guidelines to establish conditions for transfer of CVP water until final rules and regulations for the CVPIA are completed. Reclamation is currently in the process of formally revising the 1993 Interim Guidelines to conform to the sunset provisions of subsection 3405(a)(3) of the CVPIA. The process is expected to be completed, and Revised Interim Guidelines finalized, sometime after the end of 2002.

Among conditions that sunsetted according to subsection 3405(a)(3) were the right of first refusal by entities within the CVP service area before CVP water can be transferred outside the CVP service area; the condition for the Secretary to determine that the transfer will have no unreasonable impact on the water supply, operations, or financial conditions of the transferor's contracting district or agency or its water users; and the condition for the Secretary to make a determination that the transfer will have no significant long-term impact on groundwater conditions in the transferor's service area.

In April 2002, Reclamation executed a Memorandum of Understanding (MOU) with the California Department of Water Resources and the California State Water Resources Control Board regarding establishment of a water transfer information clearinghouse.

In 1996, Interior developed an Administrative Proposal to address the public's concerns regarding Interior's implementation of the CVPIA transfer provisions and the need to refine the water transfer process. In addition, a programmatic review and approval process was developed to facilitate approval of water transfers within the CVP that had historically occurred between CVP contractors inside the same service areas, to simplify the approval process, and to ensure short-term water management goals were met. In the 1998 Final CVPIA Administrative Proposal on Water Transfers, Interior committed to establish a water transfer clearinghouse to be jointly operated by Interior and the California Resources Agency to track water transfers and provide data that could be used to quantify and evaluate third-party impacts.

The 2002 MOU establishes the framework of agency roles and responsibilities for managing and implementing a water transfer information clearinghouse to improve access to information about water transfers through the development of an on-line water transfer information website. The website is a collaborative effort by the agencies to clarify the agencies' water transfer policies and procedures and to provide up-to-date information about ongoing water transfer activities.

This increased market information will provide a unique opportunity for the water-user community to monitor the availability and use of transferred CVP water. It will also promote public disclosure of water transfer activities and assist third parties (including local communities) to track water transfers that may affect them and to identify related outcomes from those transfers.

Water Conservation

Reclamation has completed the implementation of the water conservation program specified in the Act. A Water Conservation Advisory Center was established in Sacramento in 1993, and has since been relocated to Folsom. Other centers are being planned or implemented throughout the State, including a Virtual Water Conservation Center on the Internet (www.watershare.mp.usbr.gov).

Reclamation's Water Conservation Office has prepared Criteria for Evaluating Water Conservation Plans (1993 and revised in 1996 and 1999) for the guidance of water and irrigation districts. Reclamation has reviewed the water management plans submitted, and has approved 85 as adequate under CVPIA. To support water conservation efforts, Reclamation developed a database that provides each water district with specific information to enable the district to prepare its annual plan update. The database also provides examples of successful programs and capabilities for sharing information and research.

Reclamation's Water Conservation Office also developed guidelines and criteria for a cost-share program for water conservation projects, and issued four proposal solicitations. This program elicited little interest from CVP contractors and was ended in late 1997.

Anadromous Fish Restoration

The Anadromous Fish Restoration Program (AFRP), the most complicated of the directed programs under CVPIA, influences or is influenced by most of the other programs created by the Act. Interior's efforts to restore anadromous fish populations in the Central Valley are divided into two "Action Categories": Anadromous Fish-Habitat Restoration and Anadromous Fish-Structural Measures. Most of the efforts in these action categories fall within the various provisions of Section 3406(b) of the CVPIA, but many other CVPIA provisions also provide some level of benefit for anadromous fish.

The CVPIA provides both specific direction and general guidance for anadromous fish restoration. Specific, directed actions include projects such as the construction of fish screens at Glenn-Colusa Irrigation District's Hamilton City Pumping Plant and at the Contra Costa Canal Pumping Plant. More general guidance comes in the form of directed programs, such as the Clear Creek Fishery Restoration Program and the Gravel Replenishment and Riparian Habitat Protection Program. Because it was necessary to better define these program level efforts, Interior developed large-scale planning processes that included other agencies, the public, and stakeholder groups.

The Final Restoration Plan for the Anadromous Fish Restoration Program (AFRP Restoration Plan) was developed by the Service and Reclamation to guide Interior in making all reasonable efforts to at least double the natural production of anadromous fish in Central Valley rivers and streams. The AFRP was formulated, and its program plan created, by a coalition of senior fish experts from the Service, Reclamation, Environmental Protection Agency, National Marine Fisheries Service, and California's Departments of Fish and Game and Water Resources, with extensive public involvement.

The AFRP Restoration Plan has become the cornerstone of many actions aimed at restoring natural production of anadromous fish in the Central Valley, and includes partnerships, local involvement and public support. The plan, which describes Interior's overall goals, objectives and strategies for anadromous fish restoration in the Central Valley, identifies nearly 300 prioritized restoration actions and evaluations, all partitioned by watershed. It includes anadromous fish restoration actions found in other sections of the CVPIA as well as actions not specifically prescribed in the CVPIA but considered necessary by the experts to accomplish the goal of doubling the natural production of anadromous fish (doubling is expressed as twice the average production for the period 1967-91).

Restoration actions for anadromous fish have been focused in four geographic areas:

Sacramento-San Joaquin Delta - Emphasis in the Delta has been on offsetting effects of CVP and SWP export facilities (entrainment, impingement, diversion, and increased predation) on all species of anadromous fish. This is particularly important because all anadromous fishes of the Central Valley watershed use the Delta as a migration corridor and/or as habitat for some part of their life cycle.

Sacramento River Tributaries - Actions have focused on riparian and shaded riverine aquatic habitat restoration; improved access to available upstream habitat; improvement of flows; and reduction of losses at diversions, especially for spring-run Chinook salmon and steelhead.

Sacramento River - Actions have focused on flow and temperature control, restoration of spawning habitat, reduction of losses at diversions, and acquisition of riparian lands to improve rearing habitat, especially for winter-run Chinook salmon.

San Joaquin River and Tributaries - Actions have focused on improvement of flows, restoration of river channels, spawning gravels, and riparian cover, and on the elimination of predator habitat. Most of the actions undertaken have been on tributaries to the mainstem San Joaquin River.

The ultimate success of Interior's anadromous fish restoration effort depends on the successful linkage of all CVPIA programs and actions, and those related efforts underway in other processes and by other entities. Increasing and sustaining the natural production of anadromous fish in the Central Valley is an ecosystem-level effort. It will require the provision of adequate instream habitat including appropriate management of available water supplies, improving adult access to spawning areas, and protection of juveniles from mortality due to diversion and other man-induced causes.

Monitoring and additional studies will also be essential to assess the relative success of CVPIA actions and to enable Interior to adaptively manage actions in the future.

Anadromous Fish in the Central Valley

Anadromous fishes are those that begin their lives in freshwater streams, and then migrate to the ocean to mature, returning to their natal streams to spawn and die. California's stocks of anadromous fish (salmon, steelhead, striped bass, American shad, sturgeon) have greatly declined from their historic numbers. A century of land uses such as mining, logging, farming and urban development--and water development to serve them--has greatly reduced the habitat available to fish. While fish losses can result from natural weather conditions (floods, droughts, ocean warming), habitat deterioration is known to be a major cause of declines in the Central Valley.

Chinook salmon and steelhead, two of the anadromous species covered by the provisions of the CVPIA, are present in the Sacramento-San Joaquin River system year-round and rely on adequate habitat conditions within the system to survive. Four separate runs of Chinook salmon occur in the Central Valley and are distinguished by the time of year they begin their upstream migrations (spring, fall, late fall and winter).

In the Sacramento River system, winter-run Chinook salmon has been designated endangered, and the spring-run Chinook salmon and steelhead have been designated threatened species.

In the San Joaquin River system, while remaining anadromous fish populations have been dramatically reduced from historic levels and at least one race of salmon has been extirpated (the spring-run Chinook salmon), the steelhead is currently listed as a threatened species.

At times when anadromous fish are dependent on freshwater, they require a variety of habitat components that include spawning gravel, adequate flows and temperatures for all life stages, protection from predators, and relief from diversion intakes, pumps and obstructions such as dams. The AFRP has had to address all these habitat needs for their restoration efforts to work. It was also important to coordinate with other programs, because actions to improve conditions for one run or one species could be harmful for another.

Anadromous Fish - Habitat Restoration

Habitat restoration actions that have been completed include the acquisition and dedication of water for instream flows, channel restoration and enhancement, removal of dams and blockages that interfere with fish migration, gravel replenishment, acquisition and restoration of riparian habitat, and erosion control to decrease the deposition of fine sediments in spawning gravels.

Interior has used the 800,000 acre-feet of dedicated CVP yield annually since 1993 to help meet AFRP targeted needs. This water was applied to improve adult migration, spawning, egg incubation, and fry and juvenile rearing and migration, especially in the Delta. Interior has also acquired over 913,000 acre-feet of supplemental water from willing sellers to meet anadromous fish needs in both the Sacramento and San Joaquin basins. In addition, up to 95 cubic feet per second of additional water was made available at appropriate times of the year for anadromous fish on Butte and Clear Creeks as a result of removing diversions.

Other anadromous fish habitat restoration efforts have occurred along nearly 40 miles of river and stream corridors, valley-wide. These actions included the improvement of instream habitats through erosion control, channel improvement, replenishment of over 242,788 tons of spawning gravel, and the restoration of terrestrial habitats adjacent-to-stream channels including acquisition of over 7,900 acres of riparian and floodplain habitat and the restoration of an additional 883 acres. With the participation and assistance of DFG, the program to replenish gravel and protect riparian habitat on CVP streams has developed, and is implementing, long-term plans for the restoration and protection of spawning gravels on the Sacramento, American and Stanislaus rivers.

The Clear Creek Fishery Restoration Program is an example of a program focusing many of these habitat actions in a single watershed to restore anadromous fish habitat. Efforts on Clear Creek include the removal of McCormick-Saeltzer Dam (an impediment to upstream salmon and steelhead migration) and a related 55 cubic foot per second diversion, improvements in instream flows, replenishment of spawning gravels, restoration of portions of the stream channel that were degraded, and acquisition and restoration of floodplain and riparian habitats. Additionally, projects have been implemented to control erosion in the watershed that has been adversely affecting the stream.

The Tuolumne River is another area where extensive habitat restoration actions are being implemented. Large-scale stream channel re-construction actions have been implemented in concert with floodplain restoration and re-vegetation and gravel replenishment in a reach of the Tuolumne where gravel mining had essentially captured portions of the river channel in a series of aggregate pits, upsetting the natural geomorphologic and hydrologic processes and degrading the value of the active channel for salmonids. Over 7 miles of the river channel have been or are in the process of being re-constructed and a 500-foot wide floodplain restored. In addition, over 50,000 tons of spawning gravels have been placed below LaGrange Dam.

Anadromous Fish - Structural Measures

Anadromous fish structural measures include construction or modification of devices to improve instream habitat, such as the Temperature Control Device on Shasta Dam; to improve access or reduce mortality during fish migrations, such as fish ladders on dams and screens at diversions; and to supplement fish populations, such as the improvements to the Coleman National Fish Hatchery and construction of the Livingston Stone National Fish Hatchery. A great many structural projects have been completed, and others are in progress. Some of these efforts have been able to proceed rapidly because planning was already in progress prior to passage of the CVPIA and/or support funding was available through partners.

The most impressive structural project completed under CVPIA is the Shasta Temperature Control Device (TCD). This innovative structure permits the selective release of water from Shasta Dam to provide cooler water for fish without bypassing the powerplant and has prevented the loss of power supplies and millions of dollars in revenues from hydroelectric power since its completion in 1997.

Since 1993, 57 major structural improvement actions aimed at correcting anadromous fish problems have been completed, resulting in improved adult passage to spawning areas and reduced mortality of juvenile fish as they migrate to the sea. The installation of 29 fish screens, the laddering or removal of 29 dams, weirs, diversions, or other obstacles to migration, construction of 2 bypass facilities, and changes in operation at several CVP facilities have provided improved access and survival of anadromous fish in approximately 190 miles of Central Valley rivers and streams.

The Anadromous Fish Screen Program has provided grants for 27 screening projects in the Central Valley. As of the end of fiscal year 2002, 15 had been completed and construction was underway on 3: the rest were in feasibility or design stages. Over 3,500 cubic feet per second of diversion capability had been made fish safe through this one program alone. The installation and/or improvement of fish screens at diversions have not only increased the survival of juvenile anadromous fish as they migrate to the sea. They also benefit CVP contractors by improving the reliability of their water supplies.

In addition to Anadromous Fish Screen Program projects, other important structural projects to improve fish passage and survival that have been completed include improvements at the Red Bluff Diversion Dam to reduce fish entrainment and improve the fish ladder, and a major project to mitigate serious fishery impacts at the Glenn-Colusa Irrigation District's 3,000 cubic foot per second Hamilton City Pumping Plant. Both of these projects are on the Sacramento River

An excellent example of a comprehensive effort utilizing both structural and habitat restoration techniques to enhance fish passage is the large-scale effort undertaken on Butte Creek, an important spring-run Chinook salmon stream. Focusing on improvement of access for upstream migrating adults and survival of downstream migrating juveniles, four dams have been removed and three have been laddered. Twelve diversions have been removed, four have been screened, and two others modified to preclude fish from becoming entrained. Instream flows have been significantly enhanced. Work will continue on screens and ladders at the remaining dams and diversions until all impediments to fish migration and survival in the lower 85 miles of the stream have been addressed.

The Delta is one of Interior's highest priority focus areas because all species and races of anadromous fish migrate through the Delta--moving as adults to upstream spawning areas and as juveniles to San Francisco Bay and the ocean. Important programs in the Delta have focused on efforts to minimize the effects of CVP and SWP export facilities on anadromous fish. Structural efforts in the Delta have included improvements at the Tracy Pumping Plant, fish screen design at the Contra Costa Canal Pumping Plant, modification of operations at the Delta Cross Channel to reduce mortality of anadromous fish, and installation of an acoustic barrier on Georgiana Slough to redirect fish movement.

Other structural project accomplishments include modifications to the Keswick Dam fish trap, modifications to the Anderson-Cottonwood Irrigation District Diversion Dam to allow removal of its boards at higher flows, construction of a fish bypass and relocation of diversion facilities on Big Chico Creek, installation of an ozone water treatment facility at the Coleman National Fish Hatchery, and construction of a new hatchery facility on the Sacramento River below Keswick Dam (Livingston Stone National Fish Hatchery).

Refuges and Waterfowl

The CVPIA identifies wetland restoration as a key component of wildlife protection and enhancement in the Central Valley. The Act directs Interior to provide a firm, reliable water supply to Central Valley waterfowl refuges. The Act also authorized an incentives program to encourage farmers to seasonally flood their fields to create additional waterfowl habitat while still maintaining the farmland for crop production. Rice growers can flood fields to decompose rice straw, creating seasonal wetlands without interfering with farming operations.

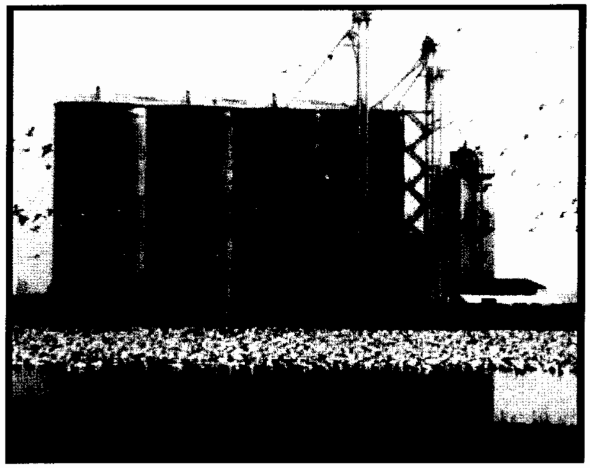
There are several programs charged with meeting these mandates: the Water Acquisition Program (Refuge Focus), the Refuge Conveyance Program (Wheeling), the Refuge Construction Program (Facilities Construction and San Joaquin Basin Action Plan Lands), and the Agricultural Waterfowl Incentives Program. The refuge programs are managed by Reclamation and are a joint effort with the Service. The Service manages the Waterfowl Incentives Program.

Significant progress has been made on these programs. A major goal of the Water Acquisition

Program is to acquire water to upgrade refuge water supplies from Level 2 to Level 4 (Level 4 is the full water allocation for optimum management of wetlands in Reclamation's 1989 Refuge Water Supply Report and for remaining water needs in the San Joaquin Basin Action Plan.). The total increase, approximately 159,000 acre-feet over Level 2 supplies, is to be achieved in increments of 10 percent per year. Interior has acquired temporary water supplies each year to meet the annual requirement since the program was established in 1993. At the end of fiscal year 2002, a total of 484,114 acre-feet of annual water supplies had been acquired. In addition, in 1998 Interior acquired the first 6,300 acre-feet of permanent water supply to help meet Level 4 requirements.

Since 1993, Reclamation has increased the reliability of existing supplies to managed wetlands that have conveyance systems. Under the Refuge Conveyance Program, Interior executed eight water-wheeling agreements that provide for the delivery of up to 556,000 acre-feet of Level 2 and Level 4 water to wetlands. Under the Refuge Construction Program, critical conveyance facilities to three refuges in the west Sacramento Valley have been constructed. This was the result of a cooperative agreement reached with the Glenn-Colusa Irrigation District, which resulted in the expansion of water delivery systems enabling water deliveries to the refuges. Three additional projects to deliver water to San Joaquin valley refuge areas have also been completed and others are under consideration.

The Agricultural Waterfowl Incentives Program has been extremely and increasingly successful since its initial start in the winter of 1997-98. In that first year, 41 farmers participated in the program and created 22,314 acres of habitat for wintering migratory waterfowl. Monitoring that year showed



Central Valley Wetlands

The Central Valley is 400 miles long and contains about 10 million acres of land, of which at least 4 million acres were once wetlands, both permanent and seasonal. Historically, valley waterways regularly overflowed their banks in the winter, and much of the valley floor functioned as seasonal wetlands. Just prior to CVPIA, a little more than 300,000 acres of wetlands remained, and the bulk of those had to be intensively managed to support waterfowl, other migratory birds, and resident wildlife in the Central Valley.

The valley is on the Pacific Flyway, a major route for millions of North America's ducks, geese, and other migratory birds. Despite the greatly reduced habitat, Central Valley wetlands are host to large annual migrations and support 20 percent of North America's continental waterfowl populations. As a result of inadequate or unreliable water supplies, most of the Federal, State, and private refuges that host these birds have had to operate on what is, in ecosystem term, a critical edge to provide the food and habitat necessary to support these millions of wintering visitors. Thus, any wisely applied addition to their water supply helps immensely to overcome the reduction in the historical habitat base.

as many as 40,000 ducks and geese at one time using a single 80-acre newly flooded field. Herons, egrets, cranes, ibis and several species of shore birds also used these new seasonal wetlands, adding to the species diversity of the areas. Program participation has grown since then, with 84 farmers participating in the winter of 2000-01 and enrolling over 58,000 acres. Tens of millions of bird use-days have been recorded on enrolled fields in the 5 years since the program was initiated. Unfortunately, even though interest remains high, enrolled acreage was down slightly in 2002 as a result of reduced budgets.

Participation and enrolled acreage would have continued at a high level if funding were not an issue. In accordance with the language of CVPIA, funding for this program was terminated at the end of fiscal year2002.

Other Fish and Wildlife

This category includes actions to mitigate for other impacts of the CVP that are not specifically provided for elsewhere in the Act. Programs in this category include the Habitat Restoration Program, the San Joaquin River Riparian Habitat Restoration Program, and, because of its benefits to other fish and wildlife, the Land Retirement Program.

Since 1996, the Habitat Restoration Program has focused its efforts on the protection and enhancement of habitats and species most dramatically affected over the last 60 years. To date, this program has collaborated with numerous partners in the acquisition and/or restoration of crucial terrestrial habitats on 89,375 acres of land valley-wide.

Projects have been distributed throughout the Central Valley from as far north as Shasta County along the Sacramento River south to Kern County. The program has obtained contributions of nearly $48 million from various partners, approximately 50 percent of program costs to date. Fee title acquisitions and conservation easements totaling 88,364 acres through FY02 have ensured the protection and allow for the restoration and enhancement of a diversity of native habitats, habitats that have significantly declined since construction of the CVP began. Habitats have been restored or enhanced on an additional 1,111 acres. A variety of Federal and State-listed species are expected to benefit directly from these actions. In addition, the development and implementation of management plans for these areas should further improve conditions for these species and contribute towards their recovery. Efforts are underway to track the benefits of these efforts.

A San Joaquin River Riparian Habitat Restoration Program has been developed and implemented to improve desirable plant and animal habitat along the river from Friant Dam to the San Joaquin's confluence with the Merced River. This program has been able to identify from studies, field investigations, Geographic Information System (GIS) mapping, and modeling efforts, numerous issues and data needs associated with San Joaquin River riparian habitat improvement and long-term restoration. From the issues and data needs identified, a prioritization system will be defined, methods for filling data gaps developed, and restoration techniques refined.

For example, through field investigations and GIS vegetative mapping, the Program has prioritized the development and implementation of an invasive plant removal and re-vegetation management plan for the San Joaquin River. It also funded the development of a new model for calculating river channel roughness that is more accurate than other methods historically used and will have widespread application.

Through stakeholder partnerships, the San Joaquin River Riparian Habitat Restoration Program has also initiated several site-specific restoration actions and programs and supported river education activities and workshops for the surrounding community.

The Land Retirement Program was developed in concert with habitat restoration and other CVPIA purposes and provides one means to manage drainage-related problems within the central and western side of the San Joaquin Valley. The program's principal objectives are to decrease drainage problems; rehabilitate upland habitat; contribute to the recovery of wildlife species, including listed species; and acquire water for other CVPIA purposes.

Implementation of the CVPIA Land Retirement Program is provided through an interagency effort of Reclamation, Bureau of Land Management, and the Service. An interagency team including these three agencies developed interim guidelines to purchase from willing sellers land poorly suited for agricultural uses. Adaptive management of the program stresses minimizing, to the greatest extent possible, any harmful effects on fish and wildlife.

The program acquired Prospect Island in the Sacramento-San Joaquin Delta in 1995. This island contains 1,228 acres of existing and potential wildlife and fisheries habitats. Beginning in 1997, the program began soliciting offers from willing sellers within eligible areas in the San Joaquin Valley and Tulare basin. A total of 70 applications were received, amounting to approximately 45,000 acres. By the end of fiscal year 2002, a total of 8,694 acres had been acquired by the Land Retirement Program and another 485 acres was added to the program through acquisitions under the Habitat Restoration Program. Upland habitat on over 1,800 acres of these retired lands was treated and managed to enhance wildlife values. A Demonstration Project was initiated in 1998 on 1,891 acres in the Westlands Water District in Fresno County to study land retirement effects upon ground-water levels, groundwater and surface-water quality, soil chemistry, wildlife and plants. The Demonstration Project has been expanded and will cover up to 15,000 acres, both in Westlands and in the Tulare Basin. The Demonstration Project is expected to take 5 years and will provide the necessary information to assess the ecological risks that might be associated with land retirement. Demonstration Project results will also provide information necessary for establishing future long-term land retirement goals and the data needed for completion of an environmental (National Environmental Policy Act) document for the larger Land Retirement Program.

As the Land Retirement Program is implemented, and the drainage problem reduced through various treatments and land restoration measures, both the aquatic and terrestrial environments in the San Joaquin Valley and downstream in the estuary will benefit.

Monitoring

An adequate monitoring program is essential if we are to assess the long-term results of implementing CVPIA actions and programs, make needed adjustments to improve our effectiveness, and achieve the purposes of the Act. A three-tiered monitoring process has been established that consists of:

(1) CVPIA action-specific monitoring to assess an individual measure's results and effectiveness. The responsibility for developing this tier of information is at the project level. CAMP serves as the repository for the information once it has been collected;

(2) ecosystem-level monitoring provided to assess the overall effectiveness of programs and groups of actions carried out under Section 3406(b) of the CVPIA. CAMP develops this tier of information with input from the various CVPIA programs. An example of this type of information would be an assessment of the effectiveness of a suite of actions undertaken on a specific stream, such as on Clear Creek or Butte Creek, or the overall and relative effectiveness of a single program, such as the Anadromous Fish Screen Program, towards achieving the CVPIA doubling goal; and

(3) the analysis of monitoring data from many other related efforts to ascertain "landscape level" results. Good examples of this tier of the CAMP program would be the use of Pacific Fisheries Management Council salmon data and funding the Department of Fish and Game to conduct angler surveys. The combined collected data would then be analyzed to determine progress towards achieving the doubling goal valley-wide.

Interior began in 1994 by evaluating existing monitoring programs to determine their suitability for meeting CVPIA needs. This also provided a baseline for development of a CVPIA program to evaluate the biological results and effectiveness of CVPIA actions. Following that assessment, an ecosystem-level monitoring effort, the Comprehensive Assessment and Monitoring Program (CAMP), was developed to monitor various target fish species including Chinook salmon, steelhead, striped bass, and American shad. This program includes an Implementation Plan that describes in detail how field monitoring is to be accomplished and how data is to be processed and evaluated, and a Conceptual Plan for evaluating the overall success of various actions. The program will provide information on long-term changes at the population or landscape level that accrue as a result of programs or suites of actions.

Data under the CAMP program began to be gathered in 1995 and has been collected insofar as funding has allowed every year since. Data generated by CAMP is provided to the Interagency Ecological Program for management and to be shared with others working on related activities. (The IEP was established to provide information on factors that affect ecological resources associated with the Sacramento-San Joaquin Delta) CAMP has supported several monitoring efforts, including surveys of shad and striped bass populations in the estuary, emigration monitoring of juvenile salmonids in the Yuba, Merced, and Tuolumne rivers, and a creel survey to gauge the numbers of Central Valley salmon and steelhead being caught in the inland recreational fisheries. To date, however, the ability to undertake a truly comprehensive assessment has been constrained somewhat by the availability of funds to implement needed assessment measures and meet established sampling protocols.

Annual reports of the findings of the CAMP-funded and other monitoring activities are prepared and disseminated. CAMP also undertook and completed a riparian mapping program for the Sacramento River and its tributaries in 1994.

Studies, Investigations and Modeling

Extensive studies, investigations and modeling efforts are required to help develop some of the actions needed to implement the CVPIA. They have been, and will continue to be, important sources of information to help make CVPIA implementation decisions and to evaluate the probable results of proposed changes. These are a necessary first step in planning for many CVPIA actions. Many studies, investigations and models have been prepared jointly with, or contracted to, other agencies.

Numerous studies have been completed, and others are ongoing, in connection with efforts to restore anadromous fish. These include analyses of flow fluctuations due to CVP operations, release patterns on the American and Stanislaus rivers, and carryover storage requirements; evaluations of temperature control and tributary enhancement opportunities; and an assessment of the major impacts of CVP facilities and operations on anadromous fish.

With regard to the Refuges and Waterfowl thrust, the Central Valley Wetlands Water Supply Investigations has developed a geographic information system (GIS) database to identify private wetlands and additional water needs, as well as to identify potential water supplies for supplemental wetlands.

Ecological and hydrologic models are being prepared to evaluate effects of various operations of water facilities and systems in the Sacramento, San Joaquin and Trinity River watersheds. This is a cooperative effort with the California Department of Water Resources, U.S. Geological Survey (USGS) and others to evaluate potential impacts of various CVP actions.

A study has also been completed to develop a least-cost plan to increase the yield of the CVP by the amount dedicated to fish and wildlife purposes in the CVPIA. This plan was submitted to Congress in 1996. To date, there has been no congressional action on the plan. A copy of the plan is available through the Mid-Pacific Regional Office, Bureau of Reclamation, and Public Affairs Office, at 2800 Cottage Way in Sacramento.

Table 1 - Summary of Activities and Accomplishments – 1993-2002

CVPIA SECTION	PROGRAM OR PROJECT	STATUS
	Appendix A: Administrative Processes	
3406(h)	Cost-Share Agreement with State of California	Agreement signed 6/27/94. Twelve Task Orders processed. Additional State funding required. **Continuing.**
3407	Restoration Fund	Established Fund. Collected $354,998,786 (1993-2002). **Continuing**.
3408(a)	Rules and Regulations	Interim guidelines & criteria developed for 10 CVPIA sections. Administrative Proposal process concluded. Final rules will follow now that PEIS Record of Decision has been signed. **Continuing**.
3409	Programmatic EIS	Draft PEIS released November 1997. Final released November 1999. Record of Decision signed January 2001. **Completed.**
	Appendix B: Contracting and Improved Water Management	
3404	Contracting	Negotiated and executed 68 interim renewal contracts and executed 44 of 45 binding agreements for early renewal of long-term contracts. Since completion of PEIS, executed 27 long-term contracts and negotiated 24 others. Negotiations with remaining CVP contractors suspended pending development of a CVP-wide form of contract. **Continuing.**
3405(a)	Water Transfers	Developed & streamlined transfer approval process within CVP. Approved transfers of more than 4.3 million acre-feet for agricultural and municipal uses and more than 396,000 acre-feet for Level 4 refuge needs. No transfers yet approved outside CVP service area. Most of the 4.3 million acre-feet of CVP water approved for transfer were approved for a period of up to 5 years with annual reviews. Approved transfer of 5,000 acre-feet to CALFED Environmental Water Account. **Continuing.**
3405(b) and (e)	Water Conservation	Established Water Conservation and Advisory Center. Developed criteria and database to track plan implementation. Approved 85 water management plans. Provided cost-share and technical help. **Continuing.**
3408(i)	Water Conservation Projects	Program established, but no serious interest from CVP contractors before 1999 sunset date. **Completed.**
	Appendix C: Anadromous Fish - Habitat Restoration	
3406(b) (1)	Anadromous Fish Restoration Program	Established AFRP and developed Restoration Plan to guide implementation of efforts. Partnered with local watershed groups in acquisition of nearly 8,000 acres and restoration of 883 acres of riparian habitat. Restored over 15 miles of stream channel and placed 71,388 tons of spawning gravels. Eliminated predator habitat in San Joaquin River tributaries. Provided for fish protective devices at seven diversion structures on Butte Creek. **Continuing.**
3406(b)(2)	Dedicated CVP Yield	Implemented management of 800,000 acre-feet of water dedicated to CVPIA purposes. **Continuing.**
3406(b) (3)	Water Acquisition Program (Anadromous Fish Focus)	Acquired 913,452 acre-feet of water for anadromous fish from 1993-2002. **Continuing.**
3406(b)(12)	Clear Creek Fishery Restoration	Removed Saeltzer Dam and diversion. Increased flows, restored 2.0 miles of stream channel and 68 acres of floodplain, and added 54,000 tons of spawning gravel to stream. 152 acres of shaded fuelbreak have been constructed and 12 miles of roadway treated to control erosion. **Continuing.**

Table 1 - Summary of Accomplishments

CVPIA SECTION	PROGRAM OR PROJECT	STATUS
3406(b)(13)	Gravel Replenishment and Riparian Habitat Protection	Developed long-term plans for CVP streams and placed 126,488 tons of gravel in Sacramento, American and Stanislaus rivers. **Continuing.**
3406(b)(23)	Trinity River Fishery Flow Evaluation Program	Completed flow evaluation studies and EIR/EIS to analyze range of alternatives for restoring and maintaining fish populations downstream from Lewiston Dam. Record of Decision signed December 2000. Construction underway on improvements to infrastructure to accommodate increased streamflows. **Continuing.**
Appendix D: Anadromous Fish – Structural Measures		
3406(b)(4)	Tracy Pumping Plant Mitigation	Improved predator removal and increased biological oversight of pumping. Developed better research program, new lab and aquaculture facilities and improved/modified existing facilities. **Continuing.**
3406(b)(5)	Contra Costa Canal Pumping Plant Mitigation	Established cooperative program for fish screen project for Rock Slough intake of Contra Costa Canal. 90% designs and environmental evaluation completed. New short-term, low-cost mitigation measures are being developed to allow for an extension of the construction completion date. Final design and construction pending results of CALFED Stage 1 and other studies. **Continuing.**
3406(b)(6)	Shasta Temperature Control Device	Construction finished 2/28/97. Dam now operated to reduce river temperatures without interruption to power generation operations. **Completed.**
3406(b)(10)	Red Bluff Dam Fish Passage Program	Completed interim actions and modification of Red Bluff Diversion Dam to meet needs of fish and water users. Studies of fish passage alternatives are ongoing. **Continuing.**
3406(b)(11)	Coleman National Fish Hatchery Restoration and Keswick Fish Trap Modification	Installed ozone water treatment system, improved raceways and barrier weir and ladders, and installed interim screens at CNFH intakes. Installed fish trap improvements at Keswick dam. Established Livingston Stone National Fish Hatchery. **Continuing.**
3406(b)(17)	Anderson-Cottonwood I.D. Fish Passage	Modified dam and operations to improve fish passage. Designed new fish ladders and screens for project completed with ERP funding. **Completed.**
3406(b)(20)	Glenn-Colusa I.D. Pumping Plant	Constructed fish screen for 3,000 cfs diversion. Completed water control structure and access bridge and improvements on side channel. **Construction completed, testing underway.**
3406(b)(21)	Anadromous Fish Screen Program	Established program. Installed 18 screens and 3 fish ladders at diversions totaling about 2,500 cfs capacity; removed 4 dams and 14 diversions totaling 750 cfs. Three screens under construction: others in design. **Continuing.**
Appendix E: Refuges and Waterfowl		
3406(b)(3) & (d)(2)	Water Acquisition Program (Refuge Focus)	Acquired 484,114 acre-feet of interim and 6,300 acre-feet of long-term water for refuge Level 4 supplies. **Continuing.**
3406(b)(22)	Agricultural Waterfowl Incentives Program	Created nearly 238,000 acres of new seasonal waterfowl habitat during the six winters the program has been in existence. **Program expired.**
3406(d)(1,3-5)	Refuge Water Conveyance (Wheeling) and Construction	Assisted in the acquisition of 484,114 acre-feet of Level 4 water supplies. Executed 8 interim "wheeling" agreements. Completed construction on 4 conveyance facilities. **Continuing.**

Table 1 - Summary of Accomplishments

CVPIA SECTION	PROGRAM OR PROJECT	STATUS
	Appendix F: Other Fish and Wildlife	
3406(b)(1)	Habitat Restoration Program	Established Habitat Restoration Program and San Joaquin River Riparian Habitat Restoration Program. Participated in acquisition of 88,364 acres of native habitat and restore 1,111 acres. **Continuing.**
3408(h)	Land Retirement Program	Established land retirement program to decrease drainage problems in San Joaquin Valley and enhance wildlife habitat and recovery of endangered species. Acquired 8,694 acres from willing sellers and added 485 from Habitat Restoration Program. Demonstration project underway with various land treatments applied on over 1,800 acres of retired lands to date. **Continuing.**
	Appendix G: Monitoring	
3406(b)(16)	Comprehensive Assessment and Monitoring Program	Established program to evaluate success of restoration efforts. **Continuing.**
	Appendix H: Studies, Investigations and Modeling	
3406(b)(9)	Flow Fluctuation	Coordinated management of CVP facilities and developed standards to minimize fishery impacts from flow fluctuation. Conducting studies on American and Stanislaus rivers. **Continuing.**
3406(b)(19)	Shasta and Trinity Reservoir Carryover Storage Studies	Studies underway. [related studies funded under 3406(b)(9)]. **Continuing.**
3406(c)(1)	San Joaquin River Comprehensive Plan	Initiated evaluation to reestablish anadromous fish from Friant Dam to Bay-Delta Estuary. **Continuing.**
3406(c)(2)	Stanislaus River Basin Water Needs	Prepared Stanislaus and Calaveras River water use program and ESA report. Additional studies ongoing concurrent with development of Stanislaus River long-term management plans. **Continuing.**
3406(d)(6)	Central Valley Wetlands Water Supply Investigations	Report completed identifying private wetlands and water needs, alternative supplies and potential water supplies for supplemental wetlands. Developed GIS database to identify potential water supply sources. **Completed.**
3406(e)(1)	Investigation on Maintaining Temperatures for Anadromous Fish	Completed field investigations and report on interaction between riparian forests and river water temperatures and on the general effects on water temperature of vegetation, irrigation return flow and sewage effluent discharge. **Completed.**
3406(e)(3, 6)	Investigations on Tributary Enhancement	Prepared report in 1998 on investigations to eliminate fish barriers and improve habitat on all Central Valley tributary streams. **Completed.**
3406(f)	Report on Fishery Impacts	Prepared report in 1995 describing major impacts of CVP reservoir facilities and operations on anadromous fish. **Completed.**
3406(g)	Ecological and Hydrologic Models	Developing models and data to evaluate effects of various operations of water facilities and systems in Sacramento, San Joaquin and Trinity River watersheds (to evaluate potential impacts of various CVP actions). Cooperative effort with DWR, USGS, others. **Continuing.**
3408(j)	Project Yield Increase (Water Augmentation Program)	Developed least-cost plan considering supply increase and demand reduction opportunities and submitted to Congress. **Completed.**

PART IV - ASSESSING THE RESULTS

The Ecosystem Response

From all indications, the CVPIA has had very positive results from its efforts to protect, restore and enhance fish and wildlife and their habitats in the Central Valley. The numbers of anadromous fish returning to Central Valley rivers and streams have increased, and salmon have returned to spawn in areas where they have not been seen for many years. Hundreds of thousands of ducks and geese and other migrating birds and waterfowl have used new wetlands areas the CVPIA programs have created, and avian diseases have declined.

While the ecosystem and fish and wildlife populations are undoubtedly influenced by other factors, it is certain that many of the beneficial effects being observed throughout the Central Valley are due to CVPIA actions. However, it will be difficult to separate the effects of CVPIA actions from other influences. Factors such as weather, ocean conditions, pollution, and the introduction of non-native species, also affect fish and wildlife and their ecosystems. It will take many years of study and monitoring before the results of CVPIA actions, individually and collectively, can be teased apart from other causes of ecosystem change and assessed with confidence.

Interior has developed and is implementing programs to assess the results and effectiveness of CVPIA actions in terms of ecosystem response. The largest of these programs is the Comprehensive Assessment and Monitoring Program. This program will provide information on long-term changes at the population or landscape level that accrue as a result of programs or suites of actions.

Separating CVPIA implementation effects from other influences also requires a thorough understanding of the ecosystem of the Central Valley and its many inter-relationships. The Ecosystem and Water System Operations Models have furnished improved scientific understanding of the Central Valley ecosystem and hydrology, and the interactions of various factors in surface water and ground water, watersheds, reservoirs, and fish and wildlife habitats. The knowledge gained on ecosystem functions, together with the data gathered by the Comprehensive Assessment and Monitoring Program, will help Interior to develop model improvements to more accurately assess the results of CVPIA actions over time.

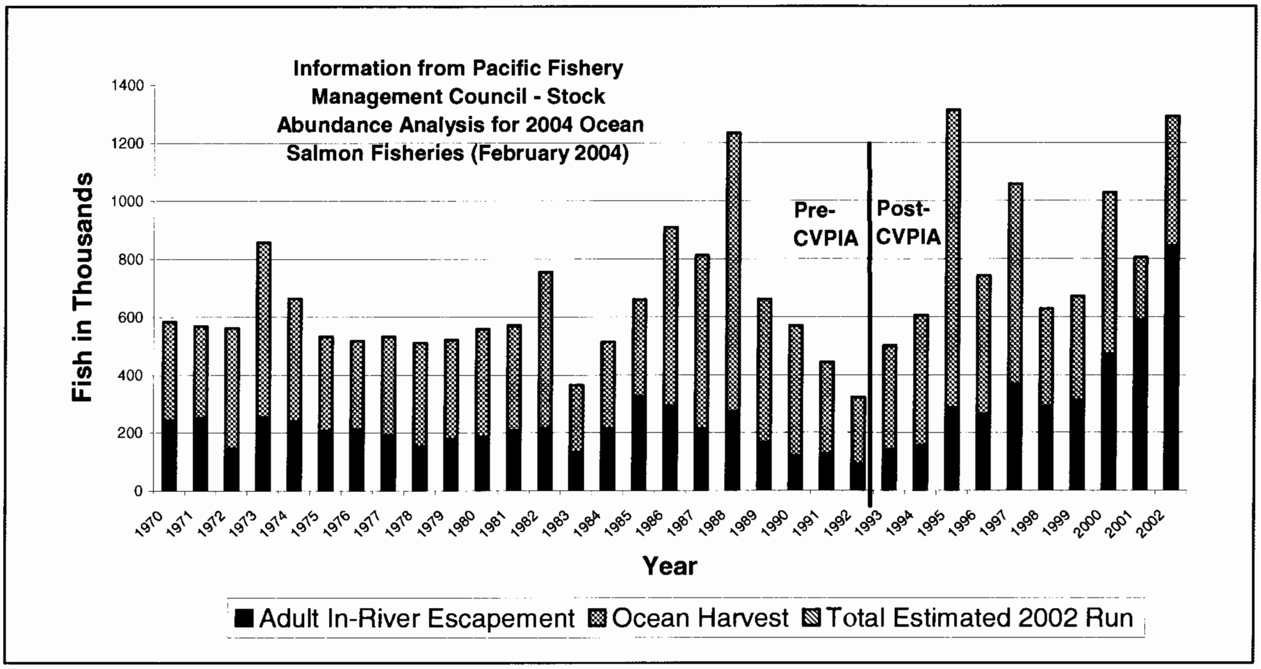
CVPIA actions and monitoring programs have been in effect for a relatively few years. While we have been able to ascertain the effectiveness of many of the individual actions over this short time span and within a limited geographic area, assessing the overall effectiveness of CVPIA programs in meeting valley-wide goals will take many more years. At this time it is possible only to identify trends in fish and wildlife populations that align with Interior's CVPIA efforts and which suggest a likely response. When monitoring and modeling programs have been in effect longer, there will be a more scientific basis to show a cause and affect relationship between CVPIA actions and ecosystem response.

Extensive research by Federal, State and local agencies has followed the changing Central Valley environment for many years. Data from this research have been used to discern environmental trends during the 1993 through 2002 period for this report. Though it does not conclusively identify the extent to which changes can be attributed to CVPIA, the trends aligned with CVPIA actions are a good indication that the ecosystem is responding positively to CVPIA implementation.

Anadromous Fish Species

Chinook salmon have been a high priority for CVPIA restoration efforts. While their numbers along the entire west coast have generally declined during this period, returns to the Central Valley and the catch off the California coast, as identified by the Pacific Fishery Management Council (Figure 10), have increased significantly since CVPIA measures began to be implemented in 1993. Factors such as hydrology, ocean conditions, and fishing regulations have undoubtedly had some effect, however, other west coast fisheries have been subject to the same factors and, in many cases, similar conditions. To a large extent, factors within and unique to the Central Valley are responsible for the increasing salmon population trends valley-wide.

Figure 10
Central Valley Chinook Salmon Abundance Indicies



Some CVPIA actions, such as placement of gravel for spawning in the Sacramento, American, Mokelumne, Stanislaus, and Tuolumne rivers and Clear Creek, have resulted in almost immediate benefits to anadromous fish species such as Chinook salmon and steelhead. In several instances, fish successfully spawned where none had spawned for many years and juvenile production seems to have increased substantially as a result. Whether such immediate results will translate into long-term population increases will take more time to ascertain. The long-term benefits of measures to improve conditions for juvenile fishes generally do not become apparent until the resultant adult fishes return years later. However, there is strong evidence of the success of CVPIA actions in the Clear Creek and Butte Creek watersheds. After years of diversion and other human uses, anadromous fish populations were very low in these streams. Interior has focused CVPIA efforts in these watersheds since 1993, and adult salmon returns have increased dramatically in both streams (Figures 11 and 12).

Implementation of actions under the CVPIA is certainly providing momentum for these increases in Chinook salmon in the valley. Even if CVPIA actions are only partly responsible, the increased abundance is certain evidence that the ecosystem is resilient and can support greater fish populations. This is encouraging for the probable success of CVPIA efforts, and reinforces the importance of continuing the restoration efforts.

Figure 11
Clear Creek Fall-Run Chinook Salmon
Escapement and CVPIA Implementation

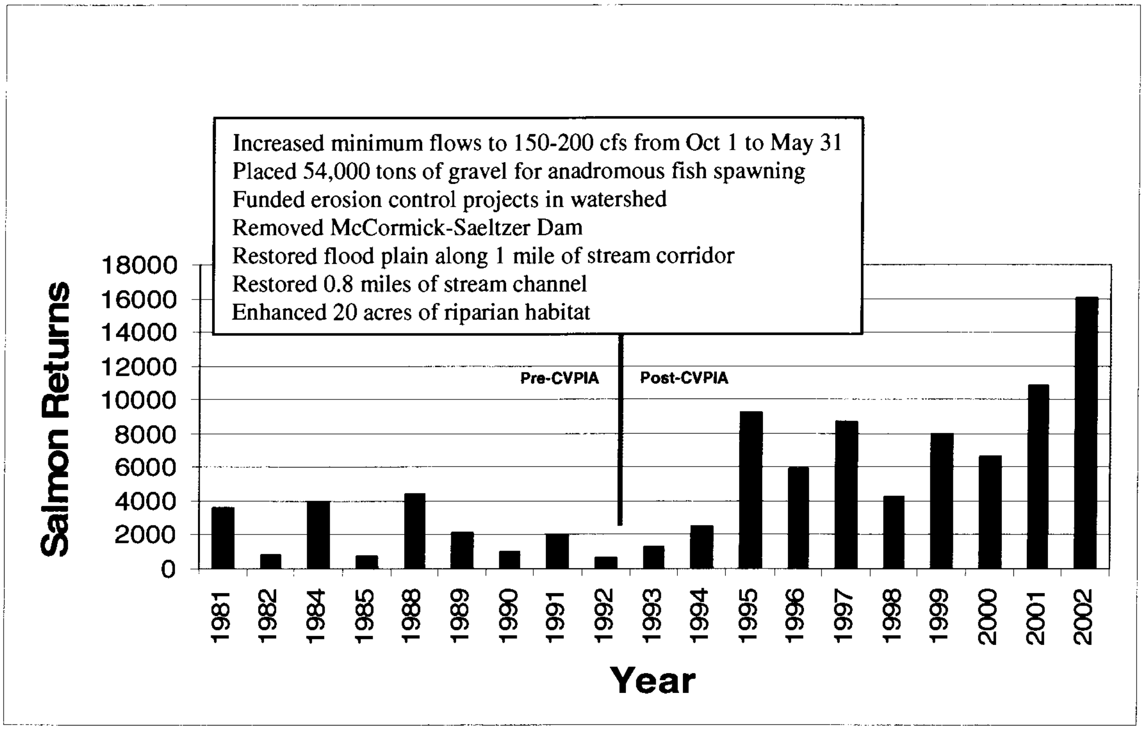
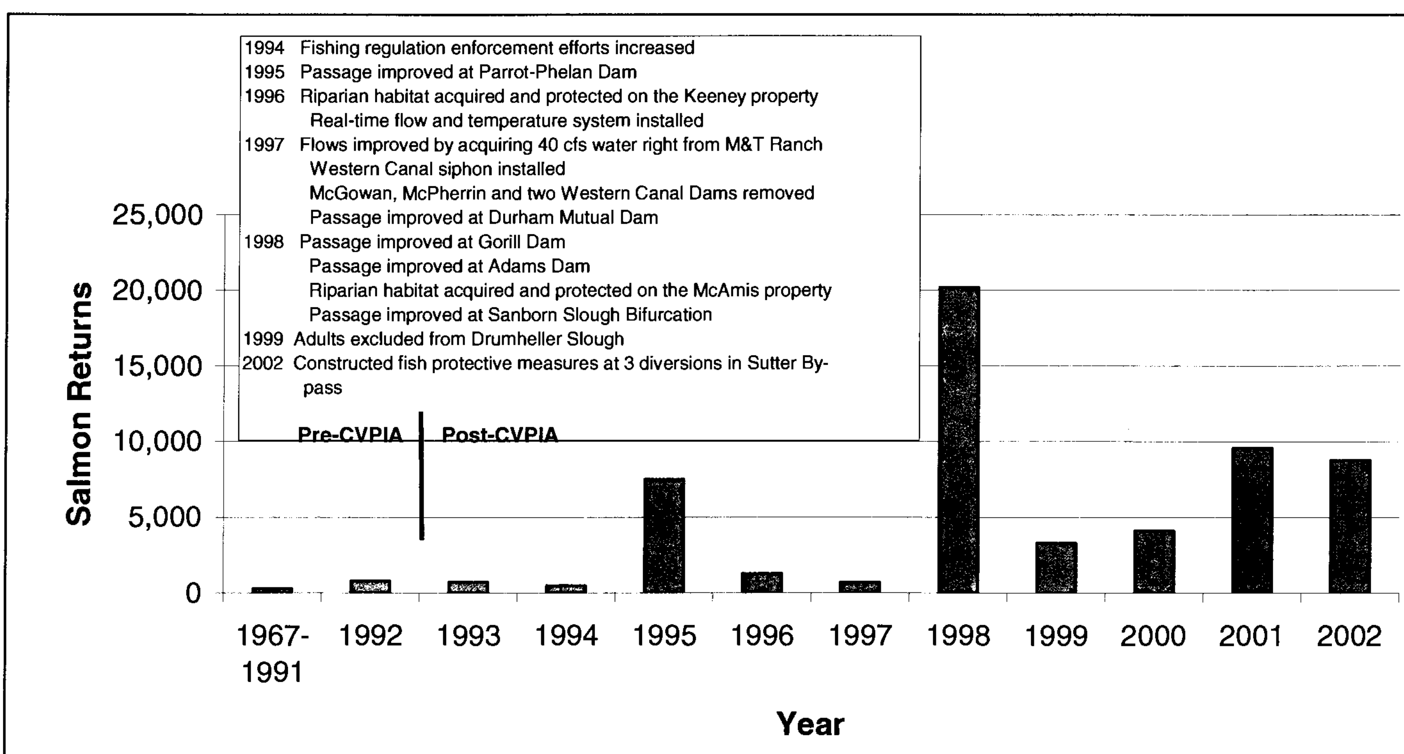


Figure 12
Butte Creek Spring-Run Chinook Salmon
Escapement and CVPIA Implementation



Refuges and Waterfowl

Most of the historic wetland areas in the Central Valley have been converted to other uses. Less than 5 percent of the more than 4 million acres of seasonal and permanent wetlands that existed 150 years ago remain and the bulk of these must be intensively managed to continue to support the 20 percent of North America's waterfowl populations that depend on the Central Valley for wintering habitat. Federal, State, and private refuges have had to operate on what is, in ecosystem terms, a critical edge. Thus, any wisely applied addition to the water supply, or increase in the acreage of wetlands under management, generates a reduction in the habitat deficit. As a result, the benefits of CVPIA efforts have made a dramatic difference.

Central Valley wetlands receiving CVP water supplies have increased by more than 20,000 acres since passage of the CVPIA. The average annual increase was above 13,000 acres, a 35 percent increase. This increase in overall wetland acreage helps explain the 75 percent decrease in waterfowl disease-related mortality in some wetland areas as the birds spread out over a greater area. At least as important as the increase in acreage, however, is the improvement in the quality of previously existing wetlands that has resulted from having a firm and adequate supply of water available over more of the year, enabling managers to implement improved management techniques.

Increased acreage and improved conditions have resulted in more waterfowl use and lower mortality rates. Sacramento Valley areas receiving CVP water have seen a 20-percent increase in waterfowl use, according to California Waterfowl Association data.

On Grassland Resource Conservation District lands only limited moist-soil summer irrigation or soil salinity treatments were possible before the CVPIA. With the improved water supply, the area managed for production of waterfowl food plants such as swamp timothy and watergrass was increased from 4,000 acres in 1991-92 to 26,000 acres by 2002. The yield per acre in these areas has doubled as well as a result of their improved water supply. The result was a net 300 percent increase in waterfowl use in some areas as early as 1995. Waterfowl numbers and the health of these birds have responded commensurately.

Other areas of the valley also experienced increases in waterfowl use. An increase of 18 million waterfowl-use days occurred at the Gray Lodge Wildlife Area in 1995. In other areas, waterfowl and shore bird food production increased by more than 300 percent, with a corresponding increase in use.

As a result of new wetlands and enhancement of previously existing wetlands made possible by improved water supplies, populations of Federal and State listed threatened species at Sacramento and San Joaquin Valley refuge areas have increased. The species benefited include the peregrine falcon, southern bald eagle, tri-colored blackbird and white-faced ibis. White-faced ibis have been particularly remarkable in their response to late-spring and summer water. This water provides nesting habitat and increases the numbers of frogs, snails, insects, and small fish on which they feed. At Sutter National Wildlife Refuge, the population of ibis increased for 100 birds in 1991 to over 15,000 in 2002. Kern National Wildlife Refuge experienced a similar increase, with the number of white-faced ibis increasing from 50 birds to 5,600 birds from 1993 to 2001.

In addition to enhanced conditions on established refuges, the incentive program for farmers to flood harvested fields has created seasonal habitat for a host of wildlife species, including waterfowl and shore birds. This program has resulted in an average of nearly 40,000 acres of additional habitat being available each year for migratory water birds in the 6 years the program has been in existence. These have supported tens of millions of bird use-days annually over the same period. This increase in available habitat area off-refuge during peak waterfowl use periods, in combination with increases on refuge areas provided by the delivery of Level 2 and Level 4 water supplies, seems to have contributed to the significant decrease in overall waterfowl disease-related mortality that we have observed. The additional food supply also helps to ensure that birds are in peak condition when they begin their migrations back to their breeding grounds in spring.

The improvement of conditions at refuges also increases the support they provide for a very long list of species other than waterfowl, including many special-status species. Protecting these plants and animals, many of which are interdependent, makes the overall ecosystem more stable and increases its ability to function despite adverse changes.

Increasing water supplies to wetlands also has the effect of improving water quality, both on and off refuges. The increased seepage has had the benefit of bio-filtration, thus entering the ground water as a much more valuable contribution to the overall water supply. Providing firm, quality water supplies has also reduced the exposure of waterfowl and shore birds spending the winter in the Grasslands area of the valley to contaminants. In a report on selenium in aquatic birds from the Central Valley, 1986-1994, Fish and Wildlife Service scientists noted that application of freshwater resulted in the decline of selenium contamination in mallard and northern pintail ducks, American coots and black necked stilts.

Other Fish and Wildlife

Since 1996, the CVPIA Habitat Restoration Program has implemented actions to mitigate for impacts of the CVP to habitats and species not specifically provided for elsewhere in the Act. Primary emphasis has been on the protection, acquisition, and enhancement of habitats most dramatically affected since construction of the CVP began and on improving conditions for a variety of Federal and State listed species. As described earlier, the Habitat Restoration Program has participated in the acquisition of 88,364 acres of crucial terrestrial habitats throughout the valley and in the restoration of more than 1,111 acres to benefit listed plants and animals. (See figures 8 and 9 and Appendix F for a complete list of actions)

These efforts have resulted in the preservation, in perpetuity, of many native habitats including riparian, wetland, grassland, hardwood woodland, and vernal pool habitats, and have directly improved conditions for numerous fish and wildlife species, including several listed species. In some instances, immediate improvement of habitat conditions for listed species like the giant garter snake, vernal pool plant and invertebrate species, and gabbro soil plant species in the foothills of the Sierra Nevada has been realized.

For example, restoration activities for giant garter snake habitat at the 450-acre Zumwalt tract of the Colusa National Wildlife Refuge were initially funded in 1997. Construction of wetlands on this parcel was completed in 1999 and a 3-year monitoring program was initiated in 2000 to assess the benefits of the restored wetland habitat for giant garter snakes. Results to date indicate a healthy population of giant garter snakes with successful recruitment of the young in the vicinity of the restoration project. Data from this effort will also provide valuable information for use in developing a giant garter snake habitat management plan for the refuge and contribute towards species recovery.

In addition to the efforts of the Habitat Restoration Program, the Land Retirement Program also provides benefits to fish and wildlife. To date, this program has acquired and retired from irrigated agriculture 10,000 acres of land in the valley. The acquisition of Prospect Island provided for the preservation and restoration of 1,228 acres of wetland habitat in the Delta, benefiting both fish and wildlife species. The retirement of an additional 7,951 acres of drainage impacted agricultural land in the San Joaquin Valley began an evaluation process that will shape the program in the future. The various treatments and restoration measures on these retired lands have demonstrated that they can safely provide much needed habitat for many valley floor species while simultaneously lowering the levels of the highly saline perched groundwater tables and reducing the volume of contaminated drainwater they generate. Almost immediately following restoration efforts, treated lands in the Westlands Water District were supporting 17 special status bird species. In addition, populations of small mammals increased significantly, including 3 special status mammalian species found on retired lands in the Atwell Island Irrigation District. Monitoring of vegetation, invertebrates, and small mammals for bio-accumulated selenium in these areas has shown no significant increases of this sometimes-toxic element. All levels measured have been well below concentrations of concern to the Service and the Environmental Protection Agency.