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A Compliance Monitoring Program for Use and Operation of the Grasslands Bypass for Drainage Conveyance in the Western San Joaquin Valley

N.W.T. Quinn
Earth Sciences Division

November 1995

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A Compliance Monitoring Program for Use and Operation of the Grasslands Bypass for Drainage Conveyance in the western San Joaquin Valley

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1.0 SUMMARY

The Bureau of Reclamation (Reclamation) signed a Finding of No Significant Impact (FONSI) No. 92-02-MP dated October 18, 1991 and a Supplement to the FONSI No. 92-03-MP dated April 15, 1991 , for use of a 19 mile segment of the San Luis Drain, renamed the Grasslands Bypass, to convey agricultural drainage waters to the San Joaquin River. An Environmental Assessment was prepared and published in support of the FONSI. On September 7, 1995 a Supplemental Environmental Assessment was prepared to update the original document to account for changes to the original project. These changes included a change to the point of entry to the Drain and an increase in the length of the Drain utilized by the Project from 19 to 28 miles. Environmental commitments and a schedule of fees for non-compliance with monthly and annual selenium load targets were also agreed upon for the current Project. These changes have made necessary certain revisions to the existing monitoring plan which was finalized after public review in June, 1993.

Agricultural subsurface (tile) drainage water from irrigated lands currently enters the Grassland Water District (GWD or Grasslands) from the south, where it is mixed with variable quantities of surface return flows (tailwater). The commingled water flows northward through the Grasslands in ditches and canals leading to Mud and Salt Sloughs (and eventually to the San Joaquin River). The proposed Grassland Bypass project would intercept this unusable drainage water at a point between Dos Palos and Russell Avenue, south of the Grassland Water District and convey it through the existing San Luis Drain for discharge into Mud Slough (north).

The project is expected to remove contaminated agricultural drainage from approximately 90 miles of channels but will introduce more concentrated drainage waters to about 6 miles of Mud Slough (north). The FONSI includes a

number of environmental commitments to ensure potentially significant impacts are avoided. Key to the commitments is a monitoring program to provide a basis for identifying effects of the project and taking corrective actions or modifying the project as necessary. The monitoring program is subject to concurrence by involved and affected agencies through an Oversight Committee. This Oversight Committee (which may appoint a Technical Committee to provide assistance) will determine criteria for evaluation of the project impacts, whether changes are needed in the monitoring program to collect additional data, and whether monitoring data indicate a need for changes in project operation.

This document identifies and reviews monitoring activities in the project area. Monitoring activities are currently being conducted by Reclamation, U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), the California Regional Water Quality Control Board (Regional Board), California Department of Water Resources (DWR), California Department of Fish and Game (DFG), Lawrence Berkeley National Laboratory (LBNL) and the San Joaquin River Management Program (Water Quality Subcommittee). Historical biological data, including past monitoring sites and data sets, are identified and reviewed for their usefulness in describing baseline or pre-project conditions. Complementary sediment, water quality, and biological monitoring sites are proposed for the Grassland Bypass monitoring program.

This document provides a detailed monitoring plan that should enable the Oversight Committee to determine and assess potential effects of the project. The detailed monitoring plan includes data compilation, analysis, and reporting procedures demonstrating that the plan will provide necessary information consistent with environmental commitments included in Reclamation's FONSI (FONSI No. 92-02-MP) and Supplement to the FONSI No. 92-03-MP dated April 15, 1991. As one measure to ensure access to and dissemination of the data collected by this monitoring program each Agency involved in the program will be required to

analyze and report data in a timely manner. These data will be reported on the San Joaquin River Operations Bulletin Board, a listserver that has been operating for the past 12 months to disseminate relevant information on activities and operations affecting San Joaquin flows and water quality.

Existing monitoring programs are incorporated into the proposed monitoring plan and identified in one of two categories: (a) primary monitoring sites/data that will be relied upon to provide the basic, minimally required information to fulfill the needs and environmental commitments for the project; (b) secondary monitoring sites/data that will provide useful supplemental information and be included in project analysis and reporting.

This program includes provisions for sediment, water quality, and biological monitoring to be conducted at primary sampling locations within the Grasslands Bypass, in Mud Slough North (Mud Slough) from Gun Club Road (upstream of the point of discharge) to the confluence of Mud Slough with the San Joaquin River, within the San Joaquin River (both upstream and downstream of the confluence with Mud Slough), and within a seasonal backwater area adjacent to Mud Slough. Monitoring also will be conducted within Salt Slough to document environmental improvements that are anticipated to result from the proposed project. Water quality samples will also be taken with Agatha Canal, Camp 13 Canal. San Luis Canal and Santa Fe Canal to document environmental improvements within the North and South Grassland Water District channels.

The biological and water quality monitoring program has been developed, in consultation with State and Federal resource and regulatory agencies, to complement ongoing and proposed environmental monitoring activities in the area of Mud and Salt sloughs. To the extent possible, existing monitoring efforts are integrated within the monitoring program for this proposed project to avoid duplication of effort, obtain maximum, efficient utilization of scientific expertise, and develop the most cost-effective monitoring program possible. For

example, the Regional Board currently conducts a weekly water quality monitoring program for electrical conductivity, selenium and boron at sampling locations in Salt Slough, Mud Slough, and the San Joaquin River at some of the sampling locations selected as part of this proposed monitoring program. However, only four of the Regional Board sampling stations correspond to primary stations identified for monitoring the proposed project. The DFG and USFWS have initiated biological surveys of body burden concentrations of agricultural drainage water constituents in fish and crayfish inhabiting Mud Slough, Salt Slough, and the San Joaquin River. Although some of the species being analyzed are different, those findings will provide useful background information to complement the proposed program.

This document provides estimates of the effort and resources required to complete specific components of the monitoring program. Manpower estimates and resources for sample/data collection, data compilation, analysis, and reporting, and laboratory analyses costs are presented.

2.0 INTRODUCTION

The Bureau of Reclamation (Reclamation) signed a Finding of No Significant Impact (FONSI) No. 92-02-MP dated October 18, 1991 and a Supplement to the FONSI *No. 92-03-MP dated April 15, 1991* , for use of a 19 mile segment of the San Luis Drain, renamed the Grasslands Bypass, to convey agricultural drainage waters to the San Joaquin River. An Environmental Assessment was prepared and published in support of the FONSI. On September 7, 1995 a Supplemental Environmental Assessment was prepared to update the original document to account for changes to the original project. These changes included a change to the point of entry to the Drain and an increase in the length of the Drain utilized by the Project from 19 to 28 miles. Environmental commitments and a schedule of fees for non-compliance with monthly and annual selenium load targets were also agreed upon for the current Project. Environmental documents preceding the FONSI outlined a monitoring program that obtained general and informal concurrence by technical staff of the participating agencies. A revised version of the proposed monitoring program was distributed by Reclamation for review and comment by the agencies in July 1992 (USBR, 1992). A final monitoring plan document was issued in June 1993 and was subsequently approved by the Oversight Committee. This document includes substantial revisions to the existing June 1993 monitoring plan to reflect the compliance requirements of the current Project.

Agricultural subsurface (tile) drainage water from irrigated lands currently enters the Grassland Water District (GWD or Grasslands) from the south, where it is mixed with variable quantities of surface return flows (tailwater). The commingled water flows northward through the Grasslands in ditches and canals leading to Mud and Salt sloughs (and eventually to the San Joaquin River). The proposed Grassland Bypass project would intercept this unusable drainage water at a point between Dos Palos and Russell Avenue, south

of the Grassland Water District and convey it through the existing San Luis Drain for discharge into Mud Slough (north).

The project is expected to remove contaminated agricultural drainage from approximately 90 miles of channels but will introduce more concentrated drainage waters to about 6 miles of Mud Slough (north). The FONSI includes a number of environmental commitments to ensure potentially significant impacts are avoided. Key to the commitments is a monitoring program to provide a basis for identifying effects of the project and taking corrective actions.

The monitoring program will provide information relative to the loading of selenium, boron, and total dissolved solids (TDS) to the San Joaquin River (as measured from stations in Mud and Salt sloughs), the potential for adverse biological effects (based on contaminant concentrations in water, sediment, plants, and animals, as well as toxicity testing), and other aspects of assuring compliance with the environmental commitments. Loading of drainage water constituents to the river also may be regulated through adoption of a Basin Plan Amendment and subsequent implementation of Waste Discharge Requirements by the CRWQCB. A Regional Drainage Authority has been formed to centralize and coordinate drainage management decisions for the contributing agricultural water districts. The Regional Drainage Authority has hired a Drainage Co-ordinator whose job will be to work with water districts and individual farmers to control drainage flows and contaminant loads. Annual selenium load caps, monthly selenium load targets and a performance incentive fee system have been devised and were published in Appendix 4 of the Supplemental EA document (USBR, 1995). These annual targets for the first two years are based on average annual loads discharges over a 9 year historical period (1986-1994) which includes both wet and dry year data as well as full and partial water supply data. It is divided by month based on the average historical distribution of selenium loads except where the Total Maximum Monthly Load (TMML) calculation (using a 1 in 5 month

violation rate) allows for a greater monthly load. The load targets for years 3, 4 and 5 are based on an annual 5% reduction of the average historical load to a minimum 15% reduction in the fifth year. For years 3 - 5 the load reductions are applied equally across all months except where the TMML calculation (using a 1 in 5 month violation rate) allows for a greater monthly load.

As one of the environmental commitments of the FONSI, fishing and collection of wild plants and animals for human consumption will be prohibited in Mud Slough and in any other areas (e.g., mainstem of the San Joaquin River at the mouth of Mud Slough) determined through the monitoring program to present a potential public health risk. Edible portions (i.e., fillets) of the larger size fish will be collected and analyzed in the monitoring program for this assessment.

A comprehensive biological, water quality, and sediment monitoring program will be implemented by those Drainage districts contributing drainage to the Grasslands Bypass (hereafter collectively referred to as the Drainers) together with the State, Federal and local agencies that currently perform monitoring in the Grasslands Basin.

The Oversight Committee will be composed of one representative each of Reclamation, USFWS, DFG, Regional Water Quality Control Board (CRWQCB), and the U.S. Environmental Protection Agency (EPA). The role of the Oversight Committee will be to review progress and operation of the project including drainage reduction goals, monitoring data, etc., and make recommendations to the Drainers, Reclamation, and/or the Regional Board, as appropriate, regarding all aspects of the project including modifications to project operation, appropriate mitigative actions, extension of the use agreement after 2 years, and termination of the agreement if necessary. The Oversight Committee will appoint and be assisted by a Technical Committee (TC).

TABLE 1. SUMMARY OF ENVIRONMENTAL COMMITMENTS AND MONITORING NEEDS

POTENTIAL IMPACT	ENVIRONMENTAL COMMITMENT	MONITORING	ASSURANCE MECHANISM
Possible increase in selenium, boron and salt loads in San Joaquin River	Agreement to use San Luis Drain will be renewed beyond two years if: (a) The Regional Board adopts and implements basin plan amendments consistent with the consensus letter. (b) The Regional Board has issued Waste Discharge Requirements for discharges from the San Luis Drain consistent with the consensus letter. (c) The Authority agrees to selenium load targets in the consensus letter. (d) The Draining Parties have developed a long-term drainage management strategy and plan of implementation (Drainage Management Plan) consistent with the Basin Plan Amendment, and that continued use of the San Luis Drain is consistent with this Drainage Management Plan and the Basin Plan Amendment.	The Draining Parties, in coordination and cooperation with State and Federal agencies will implement a comprehensive biological, water quality, and sediment monitoring program.	

POTENTIAL IMPACT	ENVIRONMENTAL COMMITMENT	MONITORING	ASSURANCE MECHANISM
	The Draining Parties will work cooperatively with downstream entities regarding the timing of discharges from the start-up procedures and will establish procedures to cooperate with and provide advance notice to such downstream entities of any other such timed releases from the San Luis Drain. One such procedure could be posting of data and proposed timing on the DWR Electronic Bulletin Board, or mailing to an agreed listing of agencies.	Not applicable	

POTENTIAL IMPACT	ENVIRONMENTAL COMMITMENT	MONITORING	ASSURANCE MECHANISM
Possible adverse effects to fish and wildlife in affected channels	If unacceptable problems or impacts are identified, appropriate mitigative actions to address the problems will be identified by the Oversight Committee. The definition and identification of "unacceptable" problems or impacts and need for mitigative action will consider applicable laws (e.g., Migratory Bird Treaty Act, Endangered Species Act) as well as the impacts in all channels affected by implementation of the project. Appropriate mitigative actions, depending on the situation, would include, but not necessarily be limited to, for example: interruption of a specific identified contamination pathway through hazing or habitat manipulation; increased management, enhancement, and recovery activities directed at impacted species in channels cleaned up as a result of the project; and/or, establishment and attainment of more stringent contaminant load reductions. The costs of mitigation, as well as any required clean-up, shall be borne by the Draining Parties.	The Draining Parties, in coordination and cooperation with State and Federal agencies will implement a comprehensive biological, water quality, and sediment monitoring program.	
Overtopping of San Luis Drain	Modify existing structure in the drain immediately upstream of the connection point for this project to prevent drainage waters from flowing southerly in the Drain.	Not applicable	

POTENTIAL IMPACT	ENVIRONMENTAL COMMITMENT	MONITORING	ASSURANCE MECHANISM
Construction effects to threatened and endangered species	Construction areas were evaluated by CDFG and FWS biologists to ensure the absence of sensitive biological resources. None were found. Informal consultation was initiated with FWS. FWS informally stated that project would not have an effect on these species. The Draining Parties, in cooperation with Reclamation, will consult with FWS prior to engaging in any proposed O & M activities that potentially may affect threatened or endangered species.	Not applicable	
Construction effects to cultural resources	Construction areas were evaluated and cleared by Reclamation's Regional Archeologist. If, during construction, previously unidentified archeological resources are encountered, activities will stop, the Regional Archeologist will be notified and appropriate clearance obtained prior to resumption of work.	Not applicable	
Inflow of drain water to CDFG's China Island Unit	The Draining Parties coordinated with CDFG regarding the design and construction of retainer dikes or other measures to protect China Island Unit.	Not applicable	

POTENTIAL IMPACT	ENVIRONMENTAL COMMITMENT	MONITORING	ASSURANCE MECHANISM
Health risk of consuming wild plants and animals	Fishing and collection of wild plants and animals will be prohibited in Mud Slough, and any other areas determined to present a potential public health risk. The Draining Parties will provide financial or other assistance as necessary to the FWS and CDFG to ensure notification and enforcement of these prohibitions. The areas will be posted in English, Spanish, and other appropriate languages.	The Draining Parties, in coordination and cooperation with State and Federal agencies will implement a comprehensive biological, water quality, and sediment monitoring program.	Commitments are incorporated in the use agreement.

The Oversight Committee will determine criteria for evaluation of the project impacts (such as baseline years for comparisons of loading to the river, ecological significance of contaminant concentrations in biota [i.e., whether the potential effects are unacceptable], etc.). The Oversight Committee also will determine whether other types of monitoring or additional stations should be added to the ongoing program. For example, the proposed monitoring does not include biological effects assessment in nesting birds. However, if quarterly reviews of available data indicate potential toxic or reproductive effects, the Committee may determine that bird-use or reproductive-effects studies are warranted.

The monitoring program would be conducted throughout the duration of the proposed project to determine the possible effects of drainage water discharge from the San Luis Drain on the aquatic organisms (primarily fish and macroinvertebrates) inhabiting Mud Slough and on their consumers (including humans and other animals). A summary of the impacts and environmental monitoring commitments is shown in Table 1, obtained from the Supplemental EA document.

This document describes a specific and detailed monitoring plan which takes advantage of existing data and monitoring activities within the Grasslands Basin in order to develop the most cost-effective program possible. This document will be used to establish commitments from participating agencies for data collection, interpretation, and reporting responsibilities and to initiate the monitoring program.

3.0 OBJECTIVES

The objectives of this document are to complete three tasks:

- Identify and review recent and current monitoring programs in the project area
- Describe a monitoring program that will allow the Oversight Committee to determine and assess potential effects of the project
- Estimate effort and resources required to complete specific components of the monitoring program.

The objectives of the monitoring program are to:

- Provide information that will allow monthly and annual evaluation of constituent loads discharged to the San Joaquin River in order to allow comparisons to be made to the monthly and annual constituent load targets established for the project.
- Measure contaminant concentrations in water, sediment, plants, and animals within the San Luis Drain, Mud Slough, and the San Joaquin River to enable assessment of the potential adverse effects of the project (to fish, wildlife, and people).
- Measure contaminant concentrations in those same sampling media within Salt Slough to enable assessment of the beneficial effects of the project.
- Assess toxicity of drainage water discharged to Mud Slough.
- Ensure that sensitive species are not adversely affected by project-related activities.

4.0 PREVIOUS STUDIES AND MONITORING PROGRAMS

4.1 Overview of studies and other monitoring programs

Monitoring programs in the project area have been conducted in the Project area by a number of agencies since 1985 to support research activities and water delivery operations. The various agencies include the CRWQCB, USGS, USBR, GWD, LBL, CDFG and Summers Engineering. The first step taken in the development of a monitoring program for the Grasslands Bypass Project was the creation of a matrix which described both past and ongoing monitoring of flow and water quality in the Grasslands Basin. This matrix (Table 2) was expanded to include sediment sampling and was included in both the 1992 and 1995 monitoring plan documents (USBR, 1992; USBR, 1995). The value of this matrix was to identify monitoring locations that were common to the various agencies, to identify any overlap of monitoring activities and to locate sites that may have been monitored in the past but where the is no ongoing data collection activity. It was agreed early in the process of developing the monitoring program for the Grasslands that the program should "piggy-back" on existing monitoring programs and research activities to the greatest extent possible, since this provided the longest data record at individual sites as well as reducing the overall cost of the program. To the extent that existing sites were not adequate or non-existant in certain monitoring locations deemed necessary by the Task Group new sites were established at these locations. These sites were designated "primary sites". *Primary sites are monitoring locations at which monitoring of one or several media takes place that are considered necessary to accomplish the goals and objectives of the monitoring program for the Grasslands Bypass Project.* These sites are designated with a "P" in Table 2. The site at which compliance monitoring for selenium loading takes place (Site B) is the most important of the primary sites.

Stations labeled secondary sites and designated with a "S" in Table 2 are stations that are not essential for accomplishing the objectives of the Grasslands Bypass Project but which will continue to have importance for the overall goals of improving resource management in the Grasslands Basin. They are listed because they also provide information that may be useful in data interpretation and for research purposes in the future. Many of the secondary sites have been maintained discontinuously and some have been eliminated.

The matrix in Table 2 includes a summary of the primary and secondary water quality monitoring sites in the proposed project area according to the agency responsible for data collection and sample station identification labels used by each agency. (Note that only the CRWQCB identification labels are used in Figure 1 to show the geographical location of the primary monitoring sites in the Grasslands Basin). Table 2 also lists both the frequency of collection and the period of record for the flow, temperature, pH, water quality and sediment data at the primary sites. The key for interpretation of the sampling frequency appears on the last page of Table 2. The last column of the matrix indicates intended use of the data whether to determine project impacts, water quality trends or for compliance purposes.

Table 3 provides a summary matrix of biological sampling programs in the proposed project area. The matrix indicates the agencies responsible for the monitoring programs and the site identification codes at each site. The matrix is divided into columns for recent, current and proposed sampling of plants, invertebrates and fish. The use of the data and the period of record is provided in the two adjacent columns on the right side of the matrix.

The existing water quality monitoring data for the Grasslands Basin, obtained from the Regional Water Quality Control Board, has been entered into the GIS-based analysis tool ARCVIEW. This tool allows the monitoring data to be linked to each of the sites in Figure 1 and allows simple statistics to be

performed on the data at each of the sites. Any computer with the ESRI ARCVIEW software installed can run this software package.

4.2 Previous studies and monitoring programs

4.2.1 Water quality monitoring

Routine water quality monitoring within the Grasslands Basin has been performed by the CRWQCB since 1985 at Crows Landing on the San Joaquin River, in Mud and Salt Sloughs, at sites within the Grassland Water District and at outflow points from the major agricultural water districts. The current monitoring program involves periodic sampling to measure temperature, pH, EC, selenium, and boron. Most sites are sampled weekly, others are sampled monthly and in the case of the Crows Landing compliance point daily samples are collected using an autosampler (Table 2).

Four Regional Board sampling stations (MER542, MER531, MER538, and STC512) are in the vicinity of the primary stations (D,F,G and H), and water quality data from these sites is included in the compliance monitoring program plan. An annual data summary report and an interpretative report are published annually by the CRWQCB for these monitoring stations.

Monitoring for the Grassland Basin Drainers is collated in an annual report by Summers Engineering. The Grasslands Basin Drainers (GBD) comprise the agricultural water districts, the State and Federal refuges and the grassland Water District all of which discharge to the San Joaquin River. The monitoring stations included in this report are numerous and are located on the San Joaquin River, along Mud and Salt Sloughs, along conveyances within the Grassland Water District and at outflow points from the major agricultural water districts. These stations are usually sampled monthly for EC, selenium, and boron; some are also monitored for flow. Four GBD stations correspond to the primary stations in the current monitoring program; two are active (GL-22a and GL-20), one has

Table 2
Summary of Recent, Current, and Proposed Water Quality and Sediment Monitoring Programs in the Proposed Project Area

	CATEGORY AND LOCATION * = Proposed Sites	AGENCY (CURRENT)	STATION ID	PHYSICAL				CHEMICAL		SEDIMENT Se		START / END OF RECORD	USE OF DATA (PURPOSE)
				Flow	Temp	pH	EC	Se	B	TSS	BOT		
	PRIMARY MONITORING SITES (essential for compliance monitoring and measuring project impacts)												
P	San Luis Drain at Hwy 152 below point of inflow *** STATION A**	CRWQCB USBR / LBNL USFWS	MER534	 D 	W Q	W Q	W Q	WW++ Q	W Q	W	 Q Q	Jul-93 Feb-92	Timing of initial filling and release Selenium loss during operation Rate of sedimentation
P	San Luis Drain above discharge point into Mud Slough (north) *** STATION B**	CRWQCB USBR / LBNL USFWS	MER535	 C 	W C Q	W Q	W C Q	D ++ Q	W Q	W	 Q Q	Oct-93 Feb-92	Compliance monitoring Timing of initial filling and release Selenium loss during operation Rate of sedimentation
P	Mud Slough at confluence of drainage from S Lake (below Skeleton Weir) *** STATION C**	CRWQCB USFWS	MER536		W Q	W Q	W Q	W Q	W Q		 Q	Aug-93 Feb-92	Project impact Project impact
P	Mud Slough at the San Luis Drain, near Gustine *** STATION D**	CRWQCB SJRMP / USGS GBD USFWS	MER542 262900 GL19a	 C 	W C Q	W Q	W C M Q	W M Q	W M Q		 Q	Oct-85 Oct-95 Feb-93 Feb-92	Compliance monitoring Real-time water management Project impact
P	Mud Slough at north end of China Island near Newman Wasteway *** STATION E**	CRWQCB	MER551		M	M	M	M	M			Oct-85	Project impact
P	Salt Slough at Lander Avenue (near Stevinson) *** STATION F**	CRWQCB SJRMP / USGS GBD DWR USFWS	MER531 261100 GL-22/22a B00470	 C C 	W C Q	W Q	W C M Q	W M Q	W M Q		 Q	Oct-85 Oct-95 Oct-85 Feb-92	Compliance monitoring Real-time water management Project impact Project impact
P	San Joaquin River at Fremont Ford *** STATION G**	CRWQCB GBD DWR USBR	MER538 GL20E B07375 SJR140		W	W	W M M	W M M M	W M A2 M			Sep 85 - Sep 85 - Mar 93 May 84 - Mar 86	Project impact
P	San Joaquin River upstream of the Merced River *** STATION H**	CRWQCB GBD	STC512 GL-21E1		W	W	W	W	W			Oct 85 - Oct 85 - Apr 92	Project impact
P	Mud Slough seasonal backwater tributary *** STATION I**	CRWQCB USFWS			B A	B A	B A	B A	B A		 A	Feb-93 May-91	Project impact
P	Camp 13 Canal north of Main Canal *** STATION J**	CRWQCB GBD USBR	MER505 GL-3/3a DSAGWD01	 B	W	W	W M	W M	W M			Nov 85 - Dec-86	Project impact
P	Agatha Canal at Mallard Road *** STATION K**	CRWQCB LBNL	MER506 ACN		W	W	W	W	W		 Q	Nov 85 - Jan 93 - Oct 95	Project impact Project impact

Table 2
Summary of Recent, Current, and Proposed Water Quality and Sediment Monitoring Programs in the Proposed Project Area

	CATEGORY AND LOCATION * = Proposed Sites	AGENCY (CURRENT)	STATION ID	PHYSICAL				CHEMICAL		SEDIMENT Se		START / END OF RECORD	USE OF DATA (PURPOSE)
				Flow	Temp	pH	EC	Se	B	TSS	BOT		
P	San Luis Canal at Henry Miller Road * STATION L	CRWQCB	MER532		W	W	W	W	W			Nov 85 -	Project impact
P	Santa Fe Canal at Henry Miller Road * STATION M	GBD CRWQCB	GL-25 MER519	W	W	W	W	W	W			Oct 85 - Oct-85	Project impact
P	San Joaquin River near Crows Landing * STATION N	GBD CRWQCB SJRMP / USGS	GL-21aE STC504	C	W C	W	M W C	M D	M W			Apr 89 - Mar 93 Jan 95 - Nov 95 -	Compliance monitoring Real-time water management
	SECONDARY MONITORING SITES (Important for data interpretation and trend analysis) E - designation indicates site eliminated in GBD monitoring program E1 - designation indicates site eliminated in GBD monitoring program												
S	Los Banos Creek at location of Highway 140	CRWQCB GBD	MER554 GL-18	W	M	M	M	M	M			Nov 85 -	Trend Trend
S	Mud Slough at location of Highway 140 downstream of San Luis Drain (Changed to Proposed Station D)	GBD	GL-19E				M	M	M			Oct 85 - Jan 93	Trend
S	Mud Slough at Newman Gun Club	CRWQCB	MER552		M	M	M	M	M				Trend
S	San Joaquin River at Lander Avenue	CRWQCB USGS DWR	MER522 260815 B07400	C	W C	W	W C C	W M	W TA				Trend Operations Operations
S	Boundary Drain at Fish and Game pumping station	CRWQCB GBD	MER521 SL-2	W	M	M	M M	M A2	M M			Jan 85 - Jan 85 -	Trend Trend
S	City Drain at location of Mud Slough	GBD	GL-23	B								Nov 85 -	Trend
S	Garzas Creek at Verdi (Worthy) weir	GBD	CCID-1a	W			M	Q	M			Nov 85 -	Trend
S	Mueller Weir	GBD	SL-17	W			M	Q	M			Jun 85 -	Trend

Table 2
Summary of Recent, Current, and Proposed Water Quality and Sediment Monitoring Programs in the Proposed Project Area

CATEGORY AND LOCATION		AGENCY (CURRENT)	STATION ID	PHYSICAL				CHEMICAL		SEDIMENT Se		START / END OF RECORD	USE OF DATA (PURPOSE)
				Flow	Temp	pH	EC	Se	B	TSS	BOT		
S	Salt Slough in the low water channel	GBD	SL-1	W			M	Q	M			Jan 85 -	Trend
S	Salt Slough at location of Hereford Road	CRWQCB	MBR528		M W	M W	M W	M W	M W			Jan 85 - Jun 91 Jun 91 - Oct 92	Trend Trend
S	San Luis Canal below San Luis/Santa Fe split (San Luis spillway)	GBD USBR	GL-24/24a SFC101	M			 M	 M	 M			Nov 85 - Jun 84 -	Trend Trend
S	San Luis Creek at location of Ingomar Grade	GBD	GL-11	W			M					Nov 85 -	Trend
S	Mud Slough (south) at Highway 152	GBD USBR	GL-9E MSL152	M			 M	 M	 M			Nov 85 - Dec 86 Mar 85 - Sep 86	Trend Trend
S	Mud Slough (south) downstream of City Drain	GBD	GL-26E				M	M	M			Sep 85 - Feb 87	Trend
S	Salt Slough at Wolfsen Road 1.0 mile east of Highway 165	GBD	GL-22E1				M	M	M			Oct 85 - July 87	Trend
S	Santa Fe Canal at Gun Club Road	GBD USBR	GL-14E SFCGCR				M M	M M	M M			Jan 85 - Oct 85 Jul 84 - Aug 86	Trend Trend
S	Santa Fe Canal at Highway 152	GBD USBR	GL-8E DASGWD09				 M	 M	 M			Nov 85 - Nov86 Jul 84 - Aug 86	Trend Trend
S	Santa Fe Canal - Mud Slough Diversion at Henry Miller Road Bypass 21 + 30	GBD	GL25s1E								A	Sep 85 -	Trend
S	Santa Fe Canal - Mud Slough Diversion at Henry Miller Road Bypass 61 + 05	GBD	GL-25s3E								A	Sep 85 -	Trend
S	Santa Fe Canal - Mud Slough Diversion at Henry Miller Road Bypass 122 + 00	GBD	GL-25s4E								A	Sep 86 -	Trend

Table 2
Summary of Recent, Current, and Proposed Water Quality and Sediment Monitoring Programs in the Proposed Project Area

	CATEGORY AND LOCATION * = Proposed Sites	AGENCY (CURRENT)	STATION ID	PHYSICAL				CHEMICAL		SEDIMENT Se		START / END OF RECORD	USE OF DATA (PURPOSE)
				Flow	Temp	pH	EC	Se	B	TSS	BOT		
S	Santa Fe Canal - Mud Slough Diversion at Henry Miller Road Bypass 140 + 00	GBD	GL-25s5E					A	A			Sep 85 -	Trend
S	San Luis Canal at location of Highway 152	CRWQCB GBD USBR	MER527 CCID-5/5a DSAGWD08	 W	W	W	W M	W A2	W M			Nov 85 - Feb 87-	Project impact
S	Westside Ditch at Santa Fe Grade 0.5 miles south of Lone Tree	GBD USBR	GL-17E1 WSDSFG	M			 M	 M	 M			Nov 85 - Jul 84 - Aug 86	Trend
S	Mud Slough at Gun Club Road upstream from the Fremont Canal	GBD USBR	GL-15E MSLGCR	M			 M	 M	 M			Nov 85 - Jan 87 May 84 - May 89	Trend Trend
S	Eagle Ditch at Gun Club Road	GBD USBR	GL-13E EDGCR	M			 M	 M	 M			Nov 85 - Jan 87 Nov 84 -Mar 86	Trend Trend
S	Fremont Canal at Gun Club Road north side of road	GBD USBR	GL-16E FRECA2	M			 M	 M	 M			Nov 85 - Jan 87 Jan 85 - Mar 86	Trend
S	Johnson Field Drain at Henry Miller Road	GBD	CCID-3E	M								Nov 85 - Jan 87	Trend
S	Los Banos Creek at Henry Miller Road	GBD	CCID-2E1	M			Q	Q				Nov 85 - July 89	Trend
S	Mexican Drain at Henry Miller Avenue	GBD	CCID-4E	M								Nov 85 - Jan 87	Trend
	ROUTINE MONITORING SITES IN GRASSLANDS BASIN (Independent of monitoring needs of project)												
	Agatha Canal inlet drain	CRWQCB GBD LBNL	MER552 AG1 ACS	 D	 W	 W	 W	 W	 	 W	 W	Nov 85 - Oct 90 Jan-93	Trend Trend
	Agatha Canal 1.0 miles north of Main Canal	GBD	GL-5	B			M	M	M			Nov 85 -	Trend
	Almond Drive Drain at location of Main Canal	CRWQCB GBD	MER555 CCID-6	 W	M	M	M M	M A2	M M			Nov 85 - Nov 84 -	Trend Trend

Table 2
Summary of Recent, Current, and Proposed Water Quality and Sediment Monitoring Programs in the Proposed Project Area

CATEGORY AND LOCATION * = Proposed Sites	AGENCY (CURRENT)	STATION ID	PHYSICAL				CHEMICAL		SEDIMENT Se		START / END OF RECORD	USE OF DATA (PURPOSE)
			Flow	Temp	pH	EC	Se	B	TSS	BOT		
Broadview Drain	GBD	BV-3	C			M	M	M			May 84 -	Trend
CCID Main Canal	CRWCB	MER510		M	M	M	M	M			7-Jun-91	Trend
Russell Avenue	CRWCB	MER510		M	M	M	M	M			Jun 91 - Oct 92	Trend
California Aqueduct at Check 13 (near Hwy 207)	GBD	GL-31E	M			Q	Q	Q			Dec 85 - May 92	Trend
Charleston Drain at location of Main Canal	CRWQCB	MER502		M	M	M	M	M			Nov 85 -	Trend
	GBD	GL-2E	M			M	M	M			Jan 87 - Dec 88	
	CRWQCB	MER502		M	M	M	M	M			Jun 91 -	
Charleston Drain at location of Gadwall Canal	GBD	CH-1	D			M	M	M			Dec 84 -	Trend
Colony Branch #2 at Swift Road	GBD	GL-6E				M	Q				Nov 85 - Jun 92	Trend
Colony Branch # 3 at weir, west of Swift Road	GBD	CCID-8E				Q	A				Nov 85 - May 92	Trend
Delta Mendota Canal at Check 13 (near Hwy 207)	GBD	GL-32E	M			Q	Q	Q			Dec 85 - May 92	Trend
Main Drain (Firebaugh) Russell Blvd.	CRWQCB	MER556		M	M	M	M	M			Mar 87 -	Trend
	GBD	FC-5	C			M	M	M			Mar 87 -	Trend
	CRWQCB	MER556		W	W	W	W	W			Jun 91 -	Trend
Pacheco Outlet on Hamburg Drain between Main and Outside Canals	CRWQCB	MER504		M	M	M	M	M			May 84 -	Trend
	GBD	PO-1	D			M	M	M			May 84 -	Trend
	CRWQCB	MER504		W	W	W	W	W			Jun 91-	Trend
Panoche Drain at O'Banion Agatha Canal	CRWQCB	MER501		M	M	M	M	M			July 84 -	Trend
	GBD	PE-14	C			C	M	M			July 84 -	Trend
		MER501		W	W	W	W	W			Jun 91-	
Rice Drain at Grassland boundary	CRWQCB	MER509		M	M	M	M	M			Apr 85 -	Trend
	GBD	PCC-1	W			M		M			Apr 85 -	Trend
	CRWQCB	MER509		W	W	W	W	W			Jun 91 -	Trend

Table 2
Summary of Recent, Current, and Proposed Water Quality and Sediment Monitoring Programs in the Proposed Project Area

CATEGORY AND LOCATION	AGENCY (CURRENT)	STATION ID	PHYSICAL				CHEMICAL		SEDIMENT Se		START / END OF RECORD	USE OF DATA (PURPOSE)
			Flow	Temp	pH	EC	Se	B	TSS	BOT		
Agatha Canal at Britto Road, north of Santa Fe Grade	GBD USBR	GL-7E DASGWD12				M	M	M			Nov 85 - Dec 86 Aug 84 - Sep 86	Trend
CCID Main Canal diversion at Ascot Ditch	GBD	GL-29E	M			M	M	M			Nov 85 - Dec 87 Dec-87	Trend
CCID Main Canal diversion at Silva Ditch	GBD	GL-30E	M			M	M	M			Nov 85 - Feb 87-	Trend
Cotton Drain at Terceira Road	GBD	GL-10E	M			M	M	M			Nov 85 - Jun-87	Trend
Firebaugh Drain at Desjardins	GBD	DJ-1E	M			M	M	M			Oct 85 - Dec 93-	Trend
Firebaugh Drain near Santa-Fe Grade	GBD	FC-1E	M			M	M	M			Nov 84 - Apr-89	Trend
Firebaugh Drain West of Crooked Drain	GBD	FC-2E				M	M	M			Nov 84 - May 85-	Trend
Firebaugh Drain West of Crooked Drain	GBD	FC-3E				M	M	M			Oct 85 - Jul 88-	Trend
Gadwall Ditch at Almond Drive Ditch	GBD USBR	GL-1E DSAGWD05	M			M	M	M			Jan 85 - Dec 86	Trend
Jensen and Brandi Drain at Almond Drive Ditch	GBD	JEN-1E1	M			M	M	M			Nov 85 - Oct 89	Trend
Main Drain at Camp 13 south side of Main Canal	GBD	FC-4E	M			M	M	M			Nov 84 - Feb 87	
Fremont Canal between Pond 6 and Gun Club Road	LBNL		NF		NF	NF	NF	NF			Apr 88 -	Trend
Mud Slough 0.9 miles north of Gun Club Road west of pond # 10	LBNL		NF		NF	NF	NF	NF			Apr 88 -	Trend

Table 2
Summary of Recent, Current, and Proposed Water Quality and Sediment Monitoring Programs in the Proposed Project Area

CATEGORY AND LOCATION * = Proposed Sites	AGENCY (CURRENT)	STATION ID	PHYSICAL				CHEMICAL		SEDIMENT Se		START / END OF RECORD	USE OF DATA (PURPOSE)
			Flow	Temp	pH	EC	Se	B	TSS	BOT		
SAN JOAQUIN RIVER AND TRIBUTARY MONITORING SITES												
Mendota Pool at location of Mobray Bridge	GBD	GL-33E	M			M	M	M			Oct 85 - Jun 92	Trend
Merced River near Stevinson	SJRMP / USGS	272500	TC	TC		TC						Real - time water management
San Joaquin River near Newman (EC and temperature measured approximately 0.5 mi. downstream)	USGS DWR	274000 B07300	C	C		C						Trend Trend
San Joaquin River at Patterson	CRWQCB DWR USGS	STC507 B07200 274570	C	W C	W	W C	W M	W A2				Trend Trend Trend
San Joaquin River at Grayson	CRWQCB DWR	STC511					M	A2				Trend Trend
San Joaquin River at Maze	CRWQCB DWR	STC510 B07040E	C	W	W	W C	W M	W A2				Trend Trend
Stansilaus River at Ripon	USGS	303000	C	C		C						Trend
Stanislaus River at Koetitz Ranch	DWR	B03115E	C			C						Trend
San Joaquin River at Vernalis	CRWQCB USGS DWR	SLC501 303500 B07020	TC C	W TC C	W	W TC C	W	W				Trend Trend
Tuolomne River at Modesto	USGS DWR	290000 B04120	C C	C C		C C						Trend Trend
Tuolomne River at Tuolomne City	DWR	B04105				C						Trend

Table 2
Summary of Recent, Current, and Proposed Water Quality and Sediment Monitoring Programs in the Proposed Project Area

CATEGORY AND LOCATION * = Proposed Sites	AGENCY (CURRENT)	STATION ID	PHYSICAL				CHEMICAL		SEDIMENT Se		START / END OF RECORD	USE OF DATA (PURPOSE)
			Flow	Temp	pH	EC	Se	B	TSS	BOT		
KESTERSON RESERVOIR MONITORING SITES												
Kesterson Reservoir ephemeral pools east border of pond # 6	LBNL		NF		NF	NF	NF	NF			Mar 87	Trend
Kesterson Reservoir ephemeral pools west border of pond # 10	LBNL		NF		NF	NF	NF	NF			Mar 87	Trend
Kesterson Reservoir ephemeral pools north - east corner of pond # 3	LBNL		NF		NF	NF	NF	NF			Dec 88	Trend
Kesterson Reservoir ephemeral pools south - west corner of pond # 3	LBNL		NF		NF	NF	NF	NF			Dec 88	Trend
Kesterson Reservoir ephemeral pools north central edge of pond # 4	LBNL		NF		NF	NF	NF	NF			Dec 88	Trend
Kesterson Reservoir ephemeral pools pond # 5 across from site at pond # 4	LBNL		NF		NF	NF	NF	NF			Dec 88	Trend

CATEGORY KEY
P - Primary sampling location for Use of Drain monitoring
S - Secondary sampling location for Use of Drain monitoring
Blank in column indicates station would not provide useful data for evaluation of effects of this project

AGENCY KEY
CCID - Central California Irrigation District
CRWQCB - California Regional Water Quality Control Board
GBD - Grassland Basin Drainers (multiple sources - compiled by Summers Engineering)
DWR - Department of Water Resources
USGS - US Geological Survey
USBR - US Bureau of Reclamation
LBNL - Lawrence Berkeley National Laboratory
SJRMP - San Joaquin River Management Program : Water Quality Subcommittee

STATION ID KEY
E - station has been eliminated

FREQUENCY KEY
C - continuous : TC - telemetered continuous
W - weekly (april - sept) : WW - weekly (all year)
M - monthly (april-sept) : MM - monthly (all year)
MO - monthly during operation : Q - quarterly
A - annual monitoring (irrigation season)
A2 - twice annually
B - biweekly
D - daily
NF - no fixed schedule for collection
.++ - Both dissolved and suspended forms of constituent analyzed

been eliminated from the current GBD monitoring program (GL-21 E1 [in 1989]), and one is a station on Mud Slough that was relocated from Highway 140 (GL-19) upstream to the vicinity of proposed Station D. In addition, GBD previously monitored Mud Slough at Gun Club Road (GL-15E, eliminated in 1987), which is upstream from proposed Station C. Except for the Gun Club Road Station (GL-15E), all the GBD stations correspond to CRWQCB stations. One of the eliminated stations (GL-21E) has been resurrected in the current monitoring program as an important source of data for environmental assessment.

The San Joaquin River at Fremont Ford (Station G) is a site that has been monitored in the past by Reclamation for EC, selenium, and boron. Reclamation has also previously collected data at nine secondary stations (Table 2) that may be used to provide background information.

4.2.2 Flow monitoring

The Department of Water Resources (DWR) measures flow at a number of stations along the San Joaquin River including Newman, which is located within the project area. The DWR also measures flow in Salt Slough at Lander Avenue. These DWR stations (B00470 and B07375) have the same location as two of the proposed primary stations (F and G), (Table 1).

The Salt Slough and Mud Slough sites (Stations D and F) were operated by the USGS until 1994, when a loss of SWRCB funding led to the USGS to abandon these sites. Operation of these sites was taken over by the SJRMP Water Quality Subcommittee with maintenance being performed jointly by the DWR and the USGS until March 1996 when the USGS was asked by Reclamation to resume operation of these sites. Dataloggers, cellular telephones and sensors for stage, EC and temperature were installed at each site during September 1995. The USGS has also

Figure 1

Monitoring Station Locations in the vicinity of the proposed use of the San Luis Drain Project

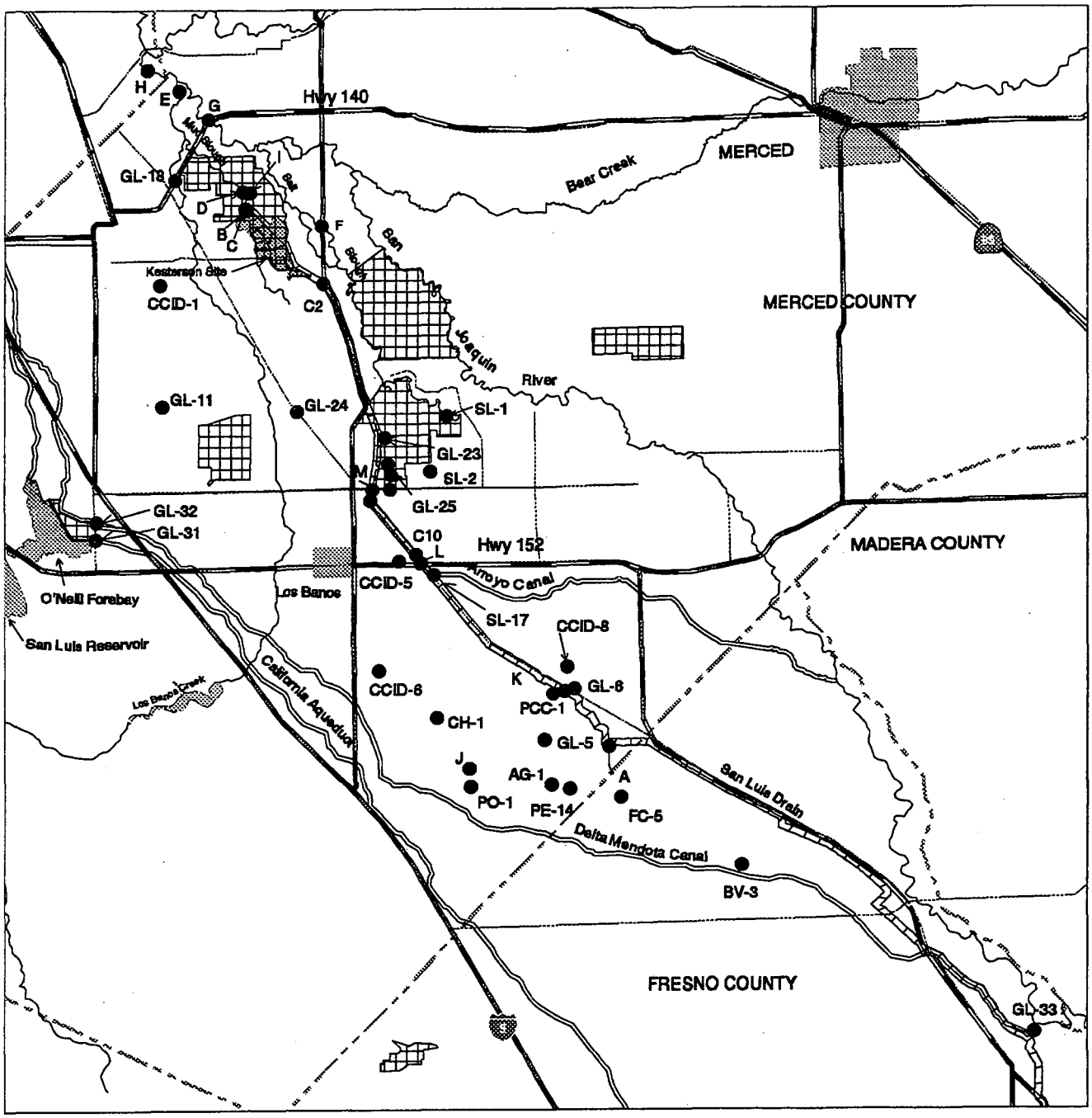
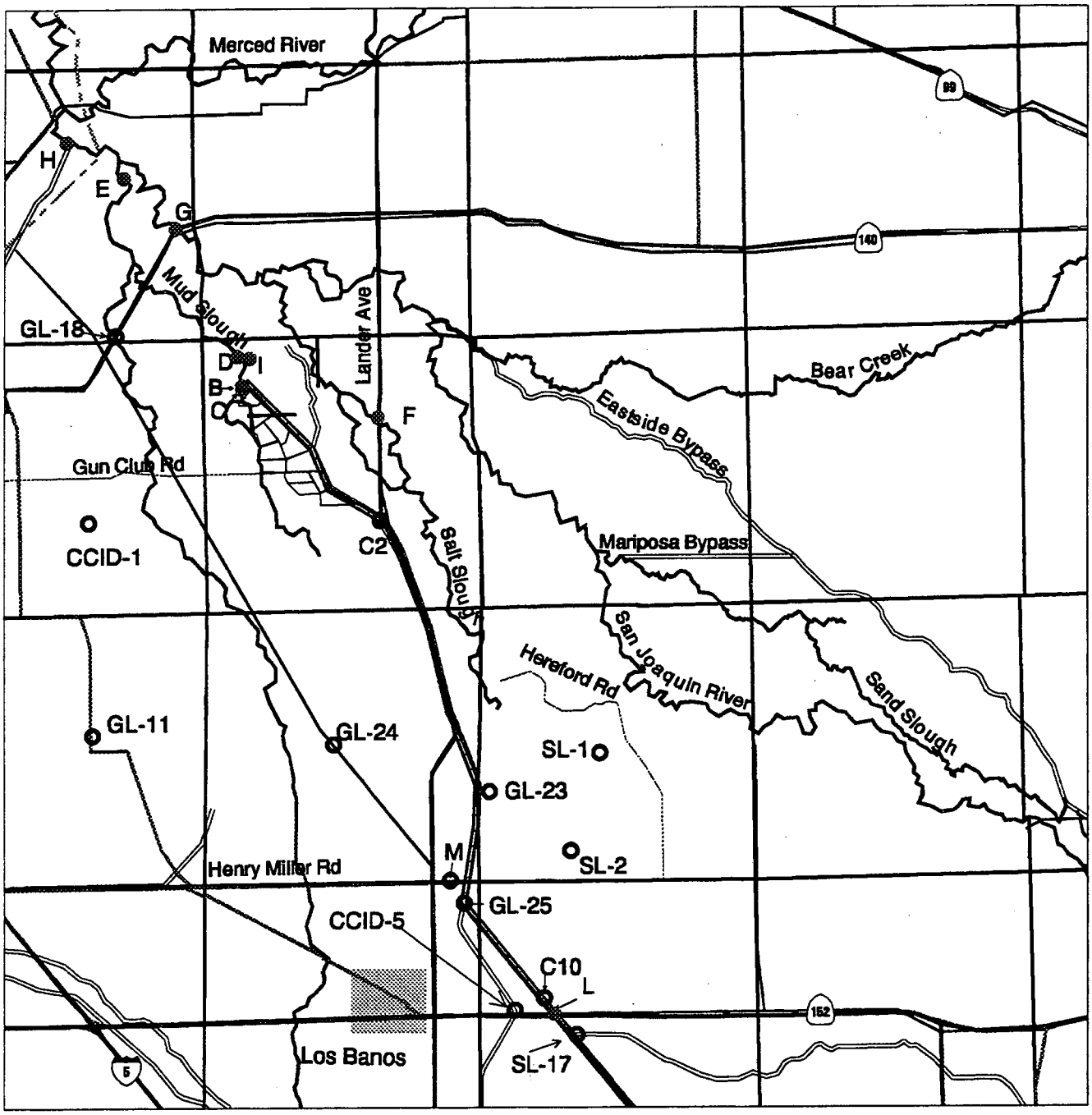


Figure 2

Proposed Primary Monitoring Stations (designated as B to I) and Secondary Monitoring Stations for use of the San Luis Drain



Road
County
Canal
Hydrology
San Luis Drain

Proposed Monitoring Site
Other Active Monitoring Sites

October 11, 1995

been charged with rehabilitating a previously abandoned gaging station at Crows Landing under a recently signed contract with Reclamation. This station will report flow (once a rating table is developed for the site) and currently reports stage, EC and temperature. The SJRMP Water Quality Subcommittee is utilizing data from the Crows Landing, Mud and Salt Slough sites to produce water quality forecasts for EC and selenium in the San Joaquin River.

Other flow monitoring within the agricultural water districts and within the Grassland Water District boundary is performed jointly by Summers Engineering and the Grassland Water District. Most of these monitoring sites are listed as secondary sites in Table 2. Much of the flow monitoring performed at these sites is for water accounting purposes and for day to day water delivery scheduling purposes.

The most intensive study of flow, water quality and sediment selenium in recent years in a single conveyance within the Grassland Water District was was conducted during 1994 and 1995 by LBNL on the Agatha Canal within the Grassland Water District (Quinn, 1995). Extensive flow, water quality and sediment data were collected at two locations on the Agatha Canal in this study, the objective of which was to determine the mechanisms responsible for selenium in-transit losses within the Grasslands canal systems. The accoustic doppler flow monitoring eqipment, used in this LBNL study has been moved to Site B on the San Luis Drain.

4.2.3 Biological and toxicity monitoring

Previous research studies have shown that dissolved concentrations of trace elements such as boron and selenium occur at elevated levels in tile drainage water (Presser and Barnes, 1984, 1985; Shelton and Miller, 1988). Selenium, in particular, may accumulate to potentially toxic concentrations in fish and

Table 3

Summary of Recent, Current, and Proposed Biological Monitoring Programs in the Proposed Project Area

	CATEGORY AND LOCATION * = Proposed Sites	AGENCY	STATION ID	RECENT			CURRENT			PROPOSED			USE OF DATA (PURPOSE)	YEARS SAMPLED	REFERENCES
				plant	invert	fish	plant	invert	fish	plant	invert	fish			
	Monitoring sites not currently included in existing programs suggested for inclusion														
P	San Luis Drain at Hwy 152 below point of inflow * STATION A	USFWS	SLD-2						X	X		X	Monitoring	1993 - 1995	M. Morse, pers. comm.
P	San Luis Drain above discharge point into Mud Slough (north) * STATION B	USFWS	SLD-2				X	X	X	X		X	Monitoring	1992 - 1995	M. Morse, pers. comm.
P	Mud Slough at confluence of drainage from S Lake (below Skeleton Weir) * STATION C	USFWS	MS-5				X	X	X	X	X	X	Monitoring	1993 - 1995	M. Morse, pers. comm.
P	Mud Slough at north end of China Island near Newman Wasteway * STATION E	DFG	CHNAI			X				X	X	X	Monitoring	1991	SWRCB, in draft
P	Mud Slough seasonal backwater tributary * STATION I	USFWS	MS-3				X	X	X	X	X	X	Monitoring	1993 - 1995	M. Morse, pers. comm.
	Monitoring of the San Joaquin River and its tributaries in the vicinity of Grasslands														
P	Mud Slough	USFWS	MS-2				X	X	X	X	X	X	Monitoring	1992 -	S. Schwarzbach, pers. comm.
	at the San Luis Drain, near Gustine	USGS			X								Study	1985	Leland and Scudder, 1990
	* STATION D	DFG	MUDSL			X							Monitoring	1986	White et al., 1987
		DFG	MUDSL			X							Monitoring	1986-1987	White et al., 1988
		DFG	MUDSL			X							Monitoring	1987-1988	White et al., 1989
		DFG	MUDSL		X	X							Monitoring	1988-1990	SWRCB, 1991
		DFG	MUDSL			X							Monitoring	1991	SWRCB, in draft
		DFG	MUDSL					X	X				Monitoring	1992 -	F. Wernette, pers. comm.
P	Salt Slough	USFWS	SS-6			X							Study	1981	Saiki and May, 1988
	at Lander Avenue (near Stevinson)	DFG	SALTS			X							Monitoring	1986	White et al., 1987
	* STATION F	DFG	SALTS			X							Monitoring	1986-1987	White et al., 1988
		DFG	SALTS			X							Monitoring	1987-1988	White et al., 1989
		DFG	SALTS		X	X							Monitoring	1988-1990	SWRCB, 1991
		DFG	SALTS					X	X				Monitoring	1992 -	F. Wernette, pers. comm.
		USFWS	SS-2					X	X	X	X	X	Monitoring	1992 -	S. Schwarzbach, pers. comm.
		USGS			X		X						Study	1985	Leland and Scudder, 1990
P	San Joaquin River	USFWS	SJR-3			X							Study	1981	Saiki and May, 1988
	at Fremont Ford	USFWS	5			X							Study	1986	Saiki and Palawski, 1990
	* STATION G	USFWS	SJR-3 (7)			X							Study	1986	Saiki et al., 1992
		USGS			X								Study	1985	Leland and Scudder, 1990
		DFG								X	X	X	Monitoring		F. Wernette, pers. comm.
P	San Joaquin River upstream of the	USFWS	6			X							Study	1986	Saiki and Palawski, 1990
	Merced River	USFWS	SJR-3 (8)			X							Study	1986	Saiki et al., 1992
	* STATION H	USFWS	SJR-2	X	X	X							Study	1987	Saiki et al., 1993
		DFG	SJRAM			X							Monitoring	1991	SWRCB, in draft
		DFG	SJRAM					X	X	X	X	X	Monitoring	1992 -	F. Wernette, pers. comm.

Table 3

Summary of Recent, Current, and Proposed Biological Monitoring Programs in the Proposed Project Area

CATEGORY AND LOCATION		AGENCY	STATION ID	RECENT			CURRENT			PROPOSED			USE OF DATA (PURPOSE)	YEARS SAMPLED	REFERENCES
* = Proposed Sites				plant	invert	fish	plant	invert	fish	plant	invert	fish			
S	San Joaquin River at Lander Avenue	USFWS	4			X							Study	1986	Saiki and Palawski, 1990
		USFWS	SJR-2 (6)			X							Study	1986	Saiki et al., 1992
		USFWS	SJR-1	X	X	X							Study	1987	Saiki et al., 1993
		DFG	SJRLN			X							Monitoring	1987-1988	White et al., 1989
		DFG	SJRLN			X							Monitoring	1986-1987	White et al., 1988
		DFG	SJRLN		X	X							Monitoring	1988-1990	SWRCB, 1991
		DFG	SJRLN					X	X				Monitoring	1992 -	F. Wernette, pers. comm.
	San Joaquin River near Crows Landing	USFWS	SJR-4			X							Study	1981	Saiki and May, 1988
		USFWS	7			X							Study	1986	Saiki and Palawski, 1990
		USFWS	SJR-4 (9)			X							Study	1986	Saiki et al., 1992
	San Joaquin River at Maze	USFWS	9			X							Study	1986	Saiki and Palawski, 1990
		USFWS	SJR-4 (11)			X							Study	1986	Saiki et al., 1992
		DFG	MAZEB			X							Monitoring	1987-1988	White et al., 1989
		DFG	MAZEB			X							Monitoring	1988-1990	SWRCB, 1991
	San Joaquin River at Vernalis	DFG	VRNLS			X							Monitoring	1986-1987	White et al., 1988
	Routine Grassland monitoring sites as listed in SWRCB (1987)														
S	Salt Slough at Wolfsen Road Bridge	USFWS	16			X							Study	1986	Saiki and Palawski, 1990
		USFWS	TRIB2 (21)			X							Study	1986	Saiki et al., 1992
		USFWS	SS-1					X	X				Monitoring	1992	S. Schwarzbach, pers. comm.
		USGS			X								Study	1985	Leland and Scudder, 1990
	Additional Grasslands sites monitored by Grasslands Water District prior to 1987														
S	Mud Slough at Gun Club Road upstream from the Fremont Canal	USFWS	TRIB2 (23)			X							Study	1986	Saiki et al., 1992
		USFWS	MS-1				X	X	X	X	X	X	Monitoring	1992 -	S. Schwarzbach, pers. comm.

CATEGORY KEY

P - Primary sampling location for Use of Drain monitoring
S - Secondary sampling location for Use of Drain monitoring
Blank in column indicates station would not provide useful data for evaluation of effects of this project

AGENCY KEY

DFG - California Department of Fish and Game
USFWS - U.S. Fish and Wildlife Service
USGS - U.S. Geological Survey
SWRCB - State Water Resources Control Board

aquatic birds primarily through bioaccumulation associated with contaminated prey (Ohlendorf et al., 1986; Saiki and Lowe, 1987; Ohlendorf, 1989; Saiki, 1989). Baseline contaminant information on selenium, boron, and other chemical constituents is available for Mud Slough, Salt Slough, and the San Joaquin River from previous investigations (Saiki, 1985a, 1985b; 1986a, 1986b; Ohlendorf et al., 1987; White et al., 1987, 1988, 1989; Ardans et al., 1988; Saiki and May, 1988; Leland and Scudder, 1990; Saiki and Palawski, 1990; SWRCB, 1991; Saiki et al., 1992, 1993) as well as from ongoing investigations being conducted under the direction of the Regional Board (routine water quality monitoring) and biological body burden contaminant studies by the USFWS and DFG. Water, sediment, detritus, aquatic plants and invertebrates, and fish have been sampled and analyzed for selenium and/or boron (Saiki, 1985a, 1985b, 1986b; Saiki and Lowe, 1987; Ohlendorf et al., 1987; Saiki and May, 1988; Hothem and Ohlendorf, 1989; Saiki and Palawski, 1990; Schuler et al., 1990; Saiki et al., 1992, 1993).

Biological monitoring programs have been carried out by the USFWS and DFG since 1993 to ascertain environmental impacts of elevated selenium levels in water. The USFWS has five active biota sampling stations along or near Mud and Salt Sloughs. Each site has been sampled monthly from March through September 1992. Types of samples taken include crayfish, non-game fish, immature game fish and water boatmen. These samples, together with water and sediment samples taken at the same sites, were analyzed for selenium and boron. The three USFWS sampling stations along Mud Slough and Salt Slough are located in the vicinity of Stations C, D, and F (USFWS monitoring was conducted on Mud Slough at Gun Club Road, but this station was moved downstream to Station C at the outflow from S Lake. The other two USFWS stations on Salt Slough [at Wolfsen Road Bridge] and on Kesterson National Wildlife Refuge [at East Big Lake] provide comparative data to the Grasslands Bypass project.) Five USFWS sites previously

sampled for water, sediment and biota correspond to primary stations or they are located nearby (Stations C, D, F, G, and H).

CDFG conducted quarterly sampling by electrofishing and hoop-netting at five stations along the San Joaquin River and Mud and Salt sloughs from April, 1992 to spring 1993 as part of the Selenium Monitoring and Evaluation Program (F. Wernette, DFG, pers. comm.). The goal of the study was to measure selenium and other trace elements in biota from suspected problem areas and determine if these elements occurred at levels harmful to fish and wildlife. The fish species collected included channel catfish, white catfish, green sunfish, bluegill and crayfish. Two stations sampled by CDFG in the pastin Mud and Salt sloughs are sufficiently close to provide background data for proposed Stations D and F. In addition, CDFG has sampled fish from proposed Station E during 1991. CDFG also has sampled fish and invertebrates from the San Joaquin River upstream of the Merced River confluence and downstream of the Newman Wasteway.

The USGS sampled freshwater clams (*Corbicula flumina*) at a number of sites within the project area during 1985 (Leland and Scudder, 1990). Several of the USGS sites (listed in Table 3) provide background toxicity information for comparative purposes.

Reclamation has monitored sites in the Kesterson Refuge in the vicinity of Mud Slough and the San Luis Drain as part of the Kesterson Reservoir Biological Monitoring Program. Samples have been collected each year since 1986 from various sites in the Reservoir and analyzed for selenium. These samples include bird eggs, small mammals, vegetation, invertebrates, and soil.

4.2.4 Sediment Monitoring

Sediment samples have been collected quarterly by Reclamation since August 1993 for selenium and boron analysis from each of the two monitoring locations

TABLE 4

Summary of the Sediment, Water Quality, and Biological Samples to be Collected Annually from for Chemical Analysis in North Grasslands [a]

Parameter	Sampling Frequency	Number of Samples									
		San Luis Drain		Mud Slough			Salt Slough at Hwy. 165 (F)	San Joaquin River		Seasonally Isolated Backwater to Mud Slough[b] (I)	Total
		(A)	(B)	Upstream of Discharge (C)	Downstream of Discharge (D)	Confluence with San Joaquin River (E)		Upstream of Mud Slough (G)	Downstream of Mud Slough (H)		
Sediment	Quarterly	4	4	4	4	4	4	--	--	1	25
Water Quality											
Routine	Various	52	365	52	52	12	52	52	52	5	694
Expanded	Quarterly	4	4	4	4	4	4	4	4	1	33
Body Burden Analysis											
Aquatic Vegetation	Annual (Spring)	3	3	3	3	3	3	3	3	3	27
Aquatic Insects	Annual (Spring)	--	--	--	--	--	--	--	--	3	3
Other Invertebrates (Crayfish)	Quarterly	--	--	12	12	12	12	12	12	3	75
Fish											
Mosquitofish	Quarterly	12	12	12	12	12	12	(12)[c]	(12)[c]	3	99
"Game fish"[d]	Quarterly	--	--	12	12	12	12	12	12	--	72

[a]Assuming that sufficient samples are collected during routine sampling to provide adequate tissue biomass for three replicate samples of each target species at each station during all surveys. Single sediment samples and single water quality samples will be collected at each station on each designated date. In addition, quality control samples will be added to the total samples shown here in accordance with the QA/QC plan.
[b]Sampling of isolated backwater during a 3-month period in spring, if present.
[c]If mosquitofish are not sufficiently abundant for sampling, another small species will be substituted.
[d]Species will vary among stations and time periods, but the most common species will be selected for analysis of fillets.

within the San Luis Drain (Check 2 and Check 10); from each of the primary stations in Mud Slough (Stations C, D, and E); from Salt Slough (Station F), and annually from the backwater site (Station I). Separate samples of the top and bottom sediments were taken at three locations across the channel. The samples taken on the channel transect were composited. After September 1994 separate sediment samples were taken at each of three depth ranges (0 - 30mm, 30mm - 80mm and > 80mm) to help answer questions about selenium transport through the sediments and selenium bioavailability, with the invention of a precise bottom sediment core sampler. Samples were composited for each of the three channel sampling points on the transects as before.

In September 1994, and again in March 1996, a Sediment Task Group comprising Monitoring Committee members, conducted a sediment survey at the upper, middle and lower end of five channel reaches along the San Luis Drain. In both surveys the sampling protocol remained the same although in the 1996 survey the deepest sample was taken from 80mm to the contact with the Drain lining in order to obtain a total sediment depth and minimize sampling error. In the September 1994 survey the channel reaches chosen were considered representative of the range of conditions observed along the Drain. The reaches chosen for this survey were between : Checks 1 and 2; Checks 10 and 11; Checks 15 and 16; and betweeen Checks 27 and 28. Soon after this survey was completed the Project was revised to move the inlet to the San Luis Drain from Check 30 to a point between Check 18 and 19. The second survey in March 1996 therefore eliminated the reach between Checks 27 and 28 and added sampling points between Checks 17 and 18, upstream of Check 18 and at Site B, the compliance point on the Grasslands Bypass.

Sediment surveys have been conducted in the San Luis Drain in 1985, 1987, 1995 and most recently in 1996. These surveys, together with sediment depth measurements at these and three other stations within the Drain and monitoring

of TSS in water at Stations A and B, may allow estimation of selenium and boron movement within the sediments and provide information on sediment deposition and movement. This data will assist in the evaluation of the sediment as an exposure medium for aquatic organisms.

The only experiment that has been conducted on selenium mass transfer rates and potential mobilization of selenium from San Luis Drain sediments was conducted by Oleh Weres in a laboratory setting, which showed that selenium and molybdenum were immobilized within the sediment by geochemical processes, and that soluble species accounted for a small fraction of the selenium and molybdenum in the San Luis Drain (Weres, 1993). Weres hypothesized that a large fraction of boron would quickly be extracted by clean water added to the San Luis Drain during the initial start-up of the Grasslands Bypass, but much less molybdenum and very little selenium. The initial inventory of soluble selenium, boron and molybdenum and boron would be flushed from the Drain in the first full volume discharged, equal to approximately 900 acre-ft, which would require 36 hours at a flow rate of 300 cfs. Beyond 900 acre-ft of discharge, selenium, molybdenum and boron added to the water flowing at 300 cfs would rapidly drop below the limit of analytic detection. Weres considered that for a much smaller flow rate, the amount of selenium, molybdenum and boron transferred to water might be detectable in an analytical sense, but probably would not be of regulatory concern.

The anticipated flow rate in the San Luis Drain after the initial flushing will not exceed 150 cfs - about one half the design flow of the San Luis Drain. The Weres experiments used fresh water rather than agricultural drainage water and hence did not measure selenium flux from the water column into the sediments. Loss of selenium to the sediments would reduce selenium load in the drainage water but increase the inventory in the Drain sediments.

Selenium and boron concentrations in organic detritus were much higher than those in sediments from stations in or near the project area in an experiment conducted by Saiki (Saiki et al., 1993). Research conducted by LBNL (Quinn et al., 1995) has shown that the organic detritus which appears to accumulate in the stagnant San Luis Drain does not build up in a flowing system like the Agatha Canal. Quarterly sediment samples taken from the Agatha Canal showed no visible organic detrital layer. Sediment size analyses conducted on these sediments show them to be predominantly silty-clay in composition. A similar sediment size analysis conducted by the USBR Laboratory in Denver on San Luis Drain sediments was inconclusive owing to the high organic fraction which prevented the laboratory from using standard methods. The Laboratory classified the San Luis Drain sediment samples as a "muck".

5.0 PROPOSED MONITORING PROGRAM

The monitoring program provides a framework to assess possible significant impacts of drainage water on key components of the Mud Slough aquatic community and its consumers as a result of the proposed project. At the completion of the first year's operation of the San Luis Drain, and after each subsequent year of monitoring, results of the water quality and biological monitoring program will be reviewed by the Oversight Committee to determine whether modifications to the program, such as an increase or decrease in the frequency of sampling, the locations at which these samples are taken, or the organisms or constituents being monitored, are appropriate.

5.1 Contaminant Monitoring

The proposed biological monitoring program was developed on the basis of the preliminary proposal by the Panoche Drainage District et al. (1990) and the previously published monitoring program document (June, 1993). Modifications to the previous proposal have been made in the current proposed program, which includes water quality monitoring, sediment analysis, and biological monitoring. For biological sampling, the analyses of aquatic vegetation, invertebrates (insects and crayfish), and fish are considered essential for monitoring the effects of the project.

5.1.1 Sampling Locations

Proposed sampling stations for water quality, sediment, and biological monitoring will be located within the San Luis Drain, Mud Slough, Salt Slough, and the San Joaquin River. The location of specific sampling sites has been determined from field reconnaissance surveys, performed in cooperation with Reclamation, USFWS, USGS, DFG, and the CRWQCB The general survey locations

(shown in Figure 2) are consistent with monitoring stations sampled in previous and ongoing studies conducted by those agencies and include the following:

- The San Luis Drain between Russell Avenue and Dos Palos downstream of the inflow to the Drain (Station A) and near the northern end of the Drain adjacent to former Pond 12 of Kesterson Reservoir (Station B). No monitoring is currently done at either of these stations.
- Mud Slough upstream from the point of discharge of the San Luis Drain that will serve as a reference location (Station C, at the confluence of drainage from S Lake below the Skeleton Weir). No monitoring has been conducted previously at this station, but both Reclamation (Station MSLGCR) and GWD (Station GL-15E) have collected water quality samples upstream at Gun Club Road. USFWS is currently sampling water quality, sediment chemistry, and biota contaminant levels near this station. . Although Mud Slough may be dry farther upstream during some portions of the year, this upstream station should be sampled when it is feasible to do so because it represents the "dilution water" for the discharge.
- Mud Slough at the USGS gaging station, immediately downstream of the discharge from the San Luis Drain (Station D). This location is sampled weekly by the CRWQCB (MER542) and less frequently by the USGS (262900) and GWD (Station GL-19 being relocated from Highway 140 bridge but not yet renumbered) for flow and water quality. The USGS, USFWS, and DFG have sampled biota at or near this station. . Although the USGS is no longer being funded by the SWRCB to perform monitoring at Mud Slough, the SJRMP Water Quality Subcommittee has contracted with the USGS to install telemetry, flow and electrical conductivity sensors at this site and to assist DWR staff maintain this site through FY 1997.
- Mud Slough upstream of the confluence with the San Joaquin River (Station E, at the north end of China Island, near Newman Wasteway). .

The CRWQCB collects water quality samples upstream of this site at the Newman Gun Club. The DFG ceased sampling at this site in June 1993 having had limited success in collecting fish from the site during 1991.

- Salt Slough at Highway 165 (Lander Avenue, Station F) to document environmental improvements resulting from the proposed project. GWD (GL-22a), Regional Board (MER531), USGS (261100), and DWR (B00470) currently monitor this station for flow and water quality. Although the USGS is no longer being funded by the SWRCB to perform monitoring at Salt Slough, the SJRMP Water Quality Subcommittee has contracted with the USGS to install telemetry, flow and electrical conductivity sensors at this site and to assist DWR staff maintain this site through FY 1997. Biological samples for the selenium verification studies have been collected by DFG at a site near proposed Station F. Sediments, invertebrates, and fish also have been collected by USFWS or USGS near Station F, and the data will provide further background information. The USFWS plans to continue biota sampling at this station.
- Four monitoring sites inside Grassland Water District will be monitored weekly by the CRWQCB to document improvements in water quality in the Grassland Water District channels. These sites are the Agatha Canal at Mallard Road (MER506); Camp 13 Canal, north of the Main Canal (MER505); the San Luis Canal at Highway 152 (MER527); and the Santa Fe Canal at Henry Miller Road (GL-25). These sites have been monitored since 1985. Water quality sampling of the Agatha Canal at mallard Road has been intensively monitored by LBNL for the past two years.
- The San Joaquin River at Fremont Ford (Station G), upstream of the confluence with Mud Slough but downstream of the confluence with Salt Slough. GWD (GL-20), Reclamation (SJR140), the CRWQCB (MER538), and DWR (B07375) monitor this station for water quality only. USFWS and USGS have

collected biological samples at Fremont Ford but there is no ongoing biological monitoring at this station.

- The San Joaquin River downstream from the mouth of Mud Slough and upstream of the confluence with the Merced River (Station H). The Regional Board currently monitors water quality at this station (STC 512). GWD (GL-21E1) discontinued water quality sampling at this station in 1989. The USFWS and DFG have collected water, sediment, plants, invertebrates and fish from this location (or nearby) in previous studies.
- An isolated seasonal backwater area adjacent to Mud Slough that receives periodic inundation by drain water, if present at the time of sampling, downstream of the point of discharge from the San Luis Drain (Station I, east-northeast of the foot bridge). This station has not been monitored previously.
- The San Joaquin River at Crows Landing is the compliance point on the river for the CRWQCB. A 24 bottle automatic sampler has been deployed on a floating platform downstream from the bridge which is taking daily water quality samples. A new station is currently being installed by the USGS and LBNL to continuously monitor flow, EC and temperature as part of the SJRMP Water Quality Subcommittee Real-Time Water Quality Management Demonstration Project. This site will be maintained by DWR with help from the USGS through FY 1997.

These sampling stations will provide information on the effects of the discharge of unusable agricultural drainage water into Mud Slough, the beneficial effects of the removal of these drainage waters from Salt Slough, and the effects of the proposed project on loading and water quality characteristics within the San Joaquin River.

5.2 Flow Monitoring

Flow is an important parameter in the measurement of selenium, boron and salt loads in the Grasslands Basin. Loads are typically calculated by multiplying the concentration of the contaminant of concern (typically expressed in ppb or ppm) by the flow (typically in cubic feet/second) and then multiplying by an appropriate constant to convert the mass flux into lbs or tons, depending on the constituent. In previous monitoring programs flow has been the most inconsistently monitored parameter. Flows within the Basin can fluctuate quite widely and are especially susceptible to rainfall runoff events.

5.2.1 Station locations and rationale

The site description of the flow monitoring stations are listed in Table 2. Figures 1 and 2 show the geographic locations of the primary sites including flow monitoring sites in north Grassland Water District and along the San Joaquin River. Many of the flow monitoring stations suggested in the monitoring plan have been established for more than a decade and provide data that can be compared to the present flow conditions. These sites were chosen for a variety of purposes including water delivery accounting by Grassland Water District, water quality assessment of returns into the San Joaquin River by the CRWQCB and for Basin water resource inventory purposes by the USGS.

Site A is the upstream flow monitoring site on the Grasslands Bypass section of the San Luis Drain. Site A is located at Check 17 on the San Luis Drain. This site was chosen because it is an existing station, a Stevens recorder, stilling well and access bridge exist at this site. The existing broad crested weir is fouled and in poor condition. This control structure will be replaced with twin broad crested weirs attached to the flash boards with panels added to the approach to improve inlet hydraulics. Ventilation tubes will

be placed below the nappe on the downstream side of the weir to minimize flow turbulence at the weir crest.

Site B was chosen on account of its proximity to the terminus of the San Luis Drain and the availability of single phase power for the site. The Fish and Wildlife service wanted to minimize traffic along the Drain service road adjacent to the newly established wetland to the north-east of Kesterson Reservoir and suggested locating the site as close to Gun Club Road as practicable. The existence of cattails and sediment accumulation immediately downstream from the Gun Club Road culvert also had to be considered in site location. Only one site met all these restrictions. A footbridge and a cantilevered bridge have been constructed at Site B on which to attach the acoustic sensors, the stage and the water quality sensors. These sensors are connected to a datalogger, which in turn is connected to a cellular phone and modem which will allow the data to be telemetered to each of the participating agencies upon dial-up.

Sites D and F are USGS flow and water quality monitoring sites which have been operated more more than 10 years. These sites were chosen on account of the road bridges at each location which facilitates the deployment of sensors and minimizes the potential for change to channel cross section owing to bank stabilization below the bridges. Flow gaging is performed directly from the bridge at Mud Slough (Site D) and from a cable way at Salt Slough (site F).

Site N, at the Crows Landing Bridge on the San Joaquin River is a former flow gaging station that has been reinstated. Although the site is far from ideal, being close to a bend in the River and having poor access to sensors from the bridge (the roadway allows insufficient walkway to be safe for USGS personnel) site retrofit, which will add a gage house on the north bank of the river will improve monitoring conditions. The current pressure sensor will be replaced with a nitogen bubbler sensor when the gage house is completed which

will greatly improve the accuracy and reliability of the stage measurement. Development of a rating curve for the site will take some time.

Site E was chosen as a downstream flow monitoring site to allow the computation of selenium load losses in Mud Slough between the Drain discharge point and the San Joaquin River. Flow monitoring will be performed bi-monthly to coincide with flow rating quality assurance monitoring at Site D. Selenium samples taken at both sites during the synoptic study will allow the estimation of in-transit selenium losses.

Sites J and M (Camp 13 Canal and Santa Fe Canal respectively) are listed as flow sites in the monitoring plan, though the primary purpose of these sites and sites K (Agatha Canal) and L (San Luis Canal) are to ensure that no agricultural drainage water enters either north or south Grasslands. Flow monitoring will allow computation of selenium and salt loads at each site though neither of these load computations is critical to the monitoring program. Flow at these sites will be continue to be measured daily by Grassland Water District staff using stage over the flash boards to compute discharge.

5.2.2 Frequency of sampling and rationale

The frequency at which flow is measured at flow sites depends on the nature of the site, whether a control structure is present at the site, the equipment available to measure and record flow measurements and the budget allocated to flow measurement at each monitoring location. Where measurements are taken by manual observation, daily or weekly measurements of flow using a staff gage are most common. If a Stevens stage recorder is available at the site hourly measurements are possible. However, the chart from the Stevens recorder must be removed and read to determine stage. Most Stevens recorders are checked weekly or monthly - hence the data from these monitoring stations is unlikely to be useful for operations. Electronic sensors, such as pressure

transducers which measure stage directly or indirectly, and shaft encoders, which convert analog Stevens stage recorder output to a digital signal lend themselves to telemetry. With electronic sensors, readings are typically taken evry 15 minutes or hourly. A high frequency of sampling is of little consequence if the flow monitoring site is not regularly rated and the relationship between stage and discharge checked at regular intervals. The frequency at which this re-calibration and site maintenance is performed depends on the characteristics of the site and the flow conditions. More frequent calibration is required for stream sites in unlined earthern channels that are susceptible to backwater effects and where sedimentation or streambed erosion is possible.

5.2.3 Field sampling techniques

Control structures such as V-notch weirs and broad crested weirs are commonly used in irrigation canals to measure flow. The stage, measured a short distance upstream of the control structure is functionally related to discharge - though each weir needs to be calibrated to account for conditions that can affect this relationship such as weed growth, obstructions and algae growth on the control structure. The stage at these flow measuring structures if measured with electronic pressure transducers or shaft encoders and relayed as digital signals to a datalogger, can be telemetered. In the case of the Grasslands sites all telemetry is performed using cellular phones and Campbell CR10 dataloggers. The discharge measured at these stations should have an accuracy of better than +/- 5%.

Flow is measured at canal check structures by Grassland Water District by measuring the height of the flow above the boards. Although not a textbook recommended technique this method of flow gaging has been of sufficient accuracy for Grassland Water District accounting purposes. Flow is typically measured

once per day using a graduated rule placed upon the top flash board of the control structure. Accuracy of flow measurement has not been determined at all sites, although monitoring by both Grassland Water District and LBNL along the Agatha Canal during 1994 and 1995 suggests that flows are within 15% of those measured with the accoustic doppler and pressure transducer technologies.

In large streams such as Mud and Salt Slough and the San Joaquin River where control structures are not available, flow measurements are made using direct stage measurements and a stream rating curve. The rating curve for a gaging station is a graphical depiction of the relation between stage and discharge. Each station rating curve represents the individual characteristics of each site which, in the case of a stream, may change from time to time after flood events, seasonally or as a result of sedimentation or streambed erosion. These changes result in a correction or "shift" in the fixed relationship between stage and discharge. Occasionally downstream conditions may control the discharge creating a "backwater" condition during which time the rating curve is no longer valid. During these episodes flow measurements need to be made directly. Regular site visits are necessary with this type of flow monitoring station to develop an accurate rating curve and to check the check the current stream rating. This subject is discussed at length in the USGS Quality Assurance Plan for the Grasslands Bypass project, to be found in Appendix D of the Quality Assurance Project Plan (USBR, 1996). Both Mud and Salt Slough stations are rated "good" by the USGS and should produce flow measurements that are accurate to within +/- 5%.

Another measurement system, deployed at Site B, on the San Luis Drain is an acoustic doppler sensor, which measures flow velocity directly within the canal. The flow sensors are mounted on adjacent bridge piers at depths of 0.8 and 0.2 of the average flow depth in the Drain and aligned to face each other across the canal. The sensors make measurements every minute and report a mean

velocity every 15 minutes. The velocity measurements are combined with stage measurements, also taken every 15 minutes, to produce a discharge measurement. This measurement system is expensive and very accurate and is anticipated to produce flow measurements with an accuracy of +/- 1%.

5.2.4 Analytical techniques

Analytical techniques are employed to convert stage measurements in channels or over control structures to discharge and to make corrections to estimated discharge based on current shifts in the flow rating curve for the monitoring site. These techniques can be found in any hydraulics textbook or the USGS Water Supply paper 2175 (USGS, 1982).

Quality assurance measures applied to flow measurement are concerned with verification of the stage-discharge relationship at the monitoring site and checking and recalibration of the sensors deployed at each site. At each of the USGS and USBR sites (sites A,B,D,E and N), quality assurance protocols will be carried out in accordance with the USGS Quality Assurance Plan for the Grasslands Bypass project (Appendix D in the USBR Quality Assurance Project Plan). This Plan describes the tasks performed during routine site maintenance which include cleaning and recalibration of sensors, flow gaging using conventional current meter measurements from bridges, by wading and by boat and computation of shifts in the stage-discharge rating.

5.2.5 Data uses

The importance of flow data in the Grasslands Bypass monitoring program is for selenium load computation. Accounting for selenium load losses within the San Luis Drain, Mud Slough, Salt Slough, and the San Joaquin River will be performed using data from both the existing hydrologic gaging stations and new stations to be installed in the San Luis Drain (at Stations A and B). These

data will allow also determination of seasonal flow patterns within Salt and Mud Sloughs, the influence of discharge from the San Luis Drain on the hydrology of Mud Slough, and changes in the loading of other drainwater constituents to the San Joaquin River resulting from implementation of the project.

5.3 Water Quality Monitoring

Collection of samples for analyses of water quality variables (to be measured in grab samples that are not filtered but preserved (on ice) in the field and kept cold until they are acidified in the laboratory) are summarized in Table 3. Water samples from the San Luis Drain (Stations A and B) also will be analyzed for total suspended solids (TSS) to monitor transport through the Drain using a USGS depth integrating sampler. The CRWQCB will place a 24 bottle automatic sampler at site B which will take daily water samples for constituents analysis. A bridge will be constructed at site B below which the flow sensors will be mounted and upon which the water quality sampler will be chained to allow samples to be taken from mid-channel.

Samples from sites A and B will also be analyzed for both dissolved and total selenium concentrations in order to calculate the selenium associated with the suspended sediments and other suspended material. Field measurement of water temperature and electrical conductivity (EC) will be recorded for each water sample collected during weekly grab sampling. Table 2 lists the various constituents and water quality parameters measured and the frequency of sample collection.

These baseline water quality monitoring data will allow determination of variations in water quality parameters influenced by seasonal fluctuations in hydrologic conditions and fluctuations in agricultural drainage operations. They also will measure differences among geographic areas, including Mud Slough and San Luis Drain where unusable drainage water will be discharged and Salt

Slough from which unusable drainage flows will be eliminated. Routine water quality monitoring will be complemented on a quarterly basis by additional chemical analyses for an expanded list of chemical constituents present in agricultural drainage water which, in addition to selenium and boron, will include major ions (calcium, potassium, magnesium, sodium, chloride, bicarbonate, sulfate), total alkalinity, total hardness, total dissolved solids and pH. Those constituents are considered significant indicators of water quality and could affect toxicity of other elements or cause direct toxicity.

Sample collection, handling, and analytical procedures will be standardized with protocols established for use in the routine water quality monitoring currently being conducted in Mud Slough, Salt Slough, and the San Joaquin River under the direction of the Regional Board (CRWQCB, 1991), or by Reclamation (USBR, undated). Standard procedures will be used to measure routine water quality variables such as temperature and EC during each field collection. Analytical chemistry will be performed using samples that are unfiltered, but chilled in the field and acidified in the laboratory following established protocol, by certified chemical laboratories.

5.4 Sediment Characteristics

Patterns of sediment deposition and erosion within the San Luis Drain will be monitored at five designated survey locations from Russell Avenue (Station A) northward on an annual basis. Monitoring will include measurement of the depth of accumulated sediment along the centerline and each side of the San Luis Drain channel. On a quarterly basis, sediment samples will be collected from each of the two monitoring locations within the San Luis Drain (Stations A and B) for analysis of selenium and boron following Reclamation procedures (USBR, undated). These samples will utilize the sediment sampler developed at LBNL by Quinn, Clyde and Tokunaga (LBNL Patent application IB 1046) to separate three depth

ranges in the sediment sample (0 - 3 cm ; 3 - 8 cm and > 8 cm). These depth fractions will be composited with the similar depth fractions at three evenly spaced sample locations across the Drain.

These samples, along with sediment depth measurements at these and three other stations within the Drain and monitoring of TSS in water at Stations A and B will allow assessment of sediment movement and contaminant movement within the sediments. In addition, sediment samples will be collected quarterly from each of the primary stations in Mud Slough (Stations C, D, and E) and Salt Slough (Station F), and annually from the backwater site (Station I), to be analyzed for selenium and boron, using the same protocol described above. These analyses will also enable evaluation of sediment as an exposure medium for aquatic organisms.

Selenium and boron concentrations in organic detritus were much higher than those in sediments from stations in or near the project area (Saiki et al., 1993). Because this particulate organic matter and the upper fine sediments are important in assessing the effects of the project, sediment samples will be collected with care to assure that those materials are not lost.

Research conducted by LBNL (Quinn et al., 1995) has shown that the organic detritus observed in the stagnant San Luis Drain do not build up in a flowing system like the Agatha Canal. Quarterly sediment samples taken from the Agatha Canal show no visible organic detrital layer.Sediment size analyses conducted on these sediments show them to be predominantly silty-clay in composition. A similar sediment size analysis conducted by the USBR Laboratory in Denver was inconclusive owing to the high organic fraction which prevented the laboratory from using standard methods. The Laboratory classified the sediment samples as a "muck".

Any organic detritus with the top sediment layer will be accounted for in analysis by expressing concentrations of selenium or boron as µg/gram of total

organic carbon in the sample [i.e., to normalize the data on the basis of organic carbon] as well as normal dry-weight basis.)

5.5 Contaminant Body Burdens

There are two primary purposes for contaminant monitoring in biological specimens: some aquatic food-chain plants and animals will be analyzed for evaluation of potential effects on fish or wildlife resources, whereas edible portions (fillets) of game fish will be analyzed to allow assessment of risks to people who may eat fish from the sloughs or river in the vicinity of the proposed project area. The fish and wildlife food-chain sampling will include representative plants, invertebrates and fish. The level of sampling effort will be greatest during the spring and summer months because the reproductive season (i.e., eggs and young animals) is the period when fish and wildlife species are most sensitive to the adverse effects of selenium and boron.

Fishing and collection of wild plants and animals for human consumption will be prohibited in Mud Slough, and in any other areas (i.e., mainstem San Joaquin River at the mouth of Mud Slough) determined through the monitoring program to present a potential public health risk (FONSI No. 92-02-MP). The plan outlined in this section should allow the Oversight Committee to evaluate the potential biological effects (adverse and beneficial) of the project. Some organisms (e.g., plants and insects) are to be sampled only in the spring or at selected stations (e.g., the backwater Station I). If the Oversight Committee determines that sampling should be intensified, the additional collections could be added to the program in subsequent years. Selenium and boron analyses of fish fillets also will allow the Oversight Committee to determine whether a survey should be conducted of the human fishing and foraging activities in the affected areas.

Biological specimens collected from the San Luis Drain, Mud and Salt sloughs, and the San Joaquin River will be analyzed for body burden concentrations of selenium and boron. Concentrations of these elements will be reported on dry-weight basis in all samples, and they also will be reported on wet-weight basis in game fish. Other elements associated with tile drainwater in the project area are not likely to bioaccumulate to significant levels. The food-chain analyses will be based on composite samples of several to many individuals of the same species, as necessary to achieve an appropriate sample volume (25 grams except insects [5 grams]) for chemical analysis (the sampling design may need to be modified if the numbers of organisms available at various locations is not adequate for chemical analysis). Because fish and waterfowl foraging on insects, other macroinvertebrates, and fish would consume the entire organism, chemical analyses will be performed on whole-body composite food-chain samples for fish and wildlife effects assessment. However, for public health risk assessment purposes, fillets from the more common game fish species will be analyzed.

The initial experimental design for the sampling program is based on the assumption that adequate tissue samples of each individual target species can be collected for chemical analyses at all sampling stations during each survey to permit statistical analyses for significant differences between locations. However, prior sampling experience in Mud and Salt sloughs has shown that the collection of adequate samples of each individual target species at each sampling station during all surveys may be impractical. It is anticipated that insufficient numbers of selected species may be collected at some times or stations to perform chemical analyses or to provide replicate samples. For this reason, tissue samples from various alternative fish and macroinvertebrate taxa collected during each of the surveys at each of the sampling locations will be retained and preserved (frozen) for subsequent chemical analyses if necessary.

Procedures and protocol for sampling vegetation, macroinvertebrates, and fish for chemical body burden analyses will be standardized to complement recent or current studies of contaminant body burdens in fish and invertebrates being conducted by USFWS and DFG at some of these sites (Saiki, 1986a, 1986b; Saiki and Lowe, 1987; White et al., 1987, 1988, 1989; Saiki and May, 1988; Saiki and Palawski, 1990; Saiki et al., 1992, 1993; SWRCB, 1991; S. Schwarzbach, pers. comm.).

5.5.1 Vegetation.

Vegetation sampling will include portions of submerged aquatic plants (such as widgeongrass, *Ruppia maritima*) or algae that are used most extensively as a food resource by waterfowl during the spring breeding period, insofar as these plants are available. However, at each station the most appropriate species will be selected on the basis of its potential for consumption by birds, its abundance, and its expected long-term occurrence there. Interpretation of monitoring data will depend more heavily upon temporal trends than on spatial differences among stations. Therefore, it is not necessary (although desirable) to monitor the same plant species at each location, but the same species should be sampled consistently at each individual station once the species is selected for that station. Vegetation sampling for chemical analysis will be conducted at each of the designated sampling locations, provided sufficient vegetation exists for chemical analysis. If available, three composite vegetation samples will be collected at each sampling location during the spring survey for chemical analysis. Each sample will be labeled, frozen, and transported to the certified chemical laboratory for analysis of selenium and boron concentrations.

5.5.2 Invertebrates.

Body burden analyses will be performed on aquatic lifestages of insects collected from the one designated seasonal backwater area (Station I). Composite samples of aquatic insects (such as chironomid larvae) will be collected once per year, during the spring waterfowl breeding period, for these analyses. The collection of a sufficient number of target insects to provide adequate sample sizes for chemical analyses on three replicate samples will be attempted but may prove to be impractical depending on the relative abundance of the target species in the isolated backwater habitat. Selenium is the element of greatest concern, so it will receive highest priority for analysis if sample sizes are not adequate for analysis of boron, which does not bioaccumulate in invertebrates as readily as it does in plants.

Collections of other aquatic macroinvertebrates at the remaining sampling locations will focus on species such as crayfish (*Procambarus* sp.), which represent an omnivorous epibenthic foraging species. If available, sufficient tissue samples will be collected for three composite whole-body samples for chemical analysis from each designated sampling station during each quarterly survey (Table 3). Crayfish will be collected by using electrofishing, seines, and/or traps.

An alternative to the analyses of crayfish may be to use resident freshwater clams (*Corbicula fluminea*) if crayfish are not sufficiently abundant at all stations in Mud Slough, Salt Slough, and the San Joaquin River. (It is not considered likely that crayfish or clams will be found in the San Luis Drain.) Resident clams would be collected with kick dipper seine nets. Caged clams also could be deployed at each of the sampling stations and left in place long enough for them to reach equilibrium for exposure at that location. However, the caged clams may be stolen or vandalized, so this procedure is not recommended as an

initial component of the monitoring program. If later considered useful by the Oversight Committee, caged clams might be deployed at selected stations or resident clams could be collected for trend monitoring. Only the soft tissues would be analyzed for selenium and boron. Although clams from the San Joaquin River and its tributaries accumulated elevated concentrations of selenium in areas receiving subsurface drainage water, they did not accumulate boron in a corresponding manner (Leland and Scudder, 1990). Thus, clams could be indicator organisms for selenium exposure, but probably not for boron.

Use of these relatively non-mobile invertebrates (either crayfish or clams) alleviates some of the problems associated with monitoring contaminants in fish, which could move readily from one monitoring site to another, especially in Mud Slough.

5.5.3 Fish

Fish specimens will be collected for chemical analyses quarterly from each designated sampling location by seining or electrofishing. The goal of the program is to collect sufficient numbers of fish to provide three replicates, composited by species, at each location. Fish samples analyzed for evaluation of potential effects on fish and wildlife resources will include composited whole-body tissue samples from enough specimens to obtain a representative sample of at least 25 grams per replicate sample. For the "gamefish" analysis, three samples will be collected at each station in Mud Slough, Salt Slough, and the San Joaquin River (i.e., Stations C through H). Samples will be analyzed as composited fillets from five fish per replicate (unless it is not practical to collect that many per station where larger fish are scarce).

The monitoring program outlined earlier by Panoche Drainage District et al. (1990) suggested that body burden analyses for fish species would focus on fathead minnows (*Pimephales promelas*) and red shiners (Cyprinella lutrensis).

Both of these species are important as forage for piscivorous fish and birds inhabiting the areas adjacent to both Mud and Salt sloughs. However, more background data are available for mosquitofish (*Gambusia affinis*) than for fathead minnows and red shiners, and the mosquitofish also are important food-chain items for other fish and for birds. Mosquitofish may be the only fish available for monitoring in the San Luis Drain, and using this species will simplify the monitoring of contaminants in fish inhabiting the Drain and sloughs. Mosquitofish may not be sufficiently abundant for sampling at the San Joaquin River stations. If this occurs, another small species (such as fathead minnows or red shiners) will be selected for sampling.

The game fish species will vary among stations and time periods, but the most common species of larger fish will be selected for analysis (at each collection location and time). The most likely species are expected to be channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), or common carp (*Cyprinus carpio*). Selenium and boron concentrations in game fish will be reported on both wet-weight and dry-weight basis. (Boron is of less concern, and analyses after the first year may be limited to selenium.)

Changes in fish species could be made in the monitoring program if it is ascertained that other species are found more consistently at certain stations. Although invertebrates would provide a better indicator of site-specific bioaccumulation of selenium and boron, some fish monitoring is essential for the program because of their importance in wildlife food chains and because they would indicate any potential health risk for humans.

Comparisons between the river and the sloughs would be desirable, but using fish for that purpose is not necessary. For comparisons among all the slough and river stations, analysis of crayfish (or freshwater clams) should be

superior to analysis of fish, and this determination should be possible after one year of monitoring when the program may be refined.

Additional specimens of both target and alternative fish species will be archived (frozen) for subsequent chemical body burden analyses at the completion of each year's third-quarter sampling, if necessary, based on the collection of insufficient numbers of any target fish species at all designated sampling stations during each survey.

A semi-quantitative assessment of the aquatic community will be conducted quarterly in conjunction with the collection of fish and invertebrates at the various sampling stations. The purpose of this assessment will be to determine whether impairment of the community is occurring as a result of the project. Procedures will be generally comparable to the Rapid Bioassessment Protocol for use in streams and rivers (Plafkin et al., 1989). The assessment will describe species abundance and diversity, catch-per-unit-effort, and general condition of collected organisms (such as presence of lesions or abnormalities). Under conditions of long-term field exposure, selenium can affect health and reproduction of sensitive species such as bluegill (see Hermanutz et al., 1992).

5.6 Toxicity Testing

The purpose of toxicity testing is to determine whether direct exposure of test organisms to water at selected locations causes toxicity. The toxicity testing will include a combination of laboratory and field methods. Short-term chronic toxicity testing will be performed quarterly on water samples from the sampling site located immediately downstream of the discharge from the San Luis Drain into Mud Slough (Station D). If those toxicity tests indicate significant toxicity, additional short-term chronic toxicity tests will be conducted with water from the Mud Slough reference site (Station C). Toxicity testing also will be performed quarterly with water collected in Salt Slough at Station F.

Toxicity testing will follow USEPA protocols (U.S. EPA, 1991), and will consist of the species listed in the table below. For each toxicity test, 24-hour composite samples of water will be collected from the sampling location and refrigerated in polyethylene containers. Because volatile compounds are not of great concern, water samples will be collected once for use throughout each of the toxicity tests.

Common Name (Species Name)	**Test Duration**	**Test Endpoints**
• Fathead minnow (*Pimephales promelas*)	7 days	Larval growth, survival, and observable effects such as edema, lordosis, and hemorrhaging (if present)
• Cladoceran (*Ceriodaphnia dubia*)	Approx. 7 days (until 60 percent of control have 3 broods)	Survival, reproduction
• Freshwater algae (*Selenastrum capricornutum*)	96 hours	Growth

The initial tests will be conducted using full-strength field-collected water. If the water is not significantly more toxic than control waters, no further testing will be performed on that sample. However, if toxicity occurs further testing will be conducted as full definitive tests, using 5 dilutions of Mud Slough or of Salt Slough waters plus two types of control water. One control water used for toxicity tests will consist of reformulated EPA "very hard" water having major ionic composition similar to that observed within Mud Slough downstream of the effluent discharge from the San Luis Drain without the addition of trace elements present in agricultural drainage water. The other control water will be fresh water collected from the Delta-Mendota Canal, which also would be used as the dilution water if dilution series testing of Mud

Slough or Salt Slough water is conducted. Test organisms will be fed daily throughout the duration of each toxicity test.

In addition to the laboratory toxicity testing described above, *in situ* toxicity testing with larval fathead minnows will be conducted quarterly at Stations D and F. The fish will be placed in plastic pipes that are screened at both ends and these "test chambers" will be suspended in flowing water at those two stations for 7 days. A similar exposure of "control" fish will occur at the outflow from East Big Lake (on Kesterson National Wildlife Refuge) as a reference location for comparison to those at Stations D and F.

Data collected during the first year of this survey on chemical constituent body burdens for fish inhabiting Mud Slough and results of the toxicity testing will be evaluated to determine the need for modification to the toxicity testing program including alterations in the frequency of testing, or the use of alternative test species, such as juvenile bluegill, chinook salmon, or striped bass. The relative sensitivity of those species to constituents in the San Luis Drain water may be greater than that of standard test species, but their expected occurrence at the discharge point under future conditions is unknown.

5.7 Quality Assurance

A Quality Assurance Project Plan (QAPP) has been developed by the US Bureau of Reclamation (USBR,1995) which follows EPA's 16 element protocol for the development of Quality Assurance (QA) project plans. Quality control is defined as processes internal to the analytical process and thus would include the laboratory incorporation of replicates, spiked samples, laboratory control samples, split or duplicate samples, control charts, blanks, internal standards, surrogate compounds, calibration standards, and reagent checks. Quality assurance is defined as processes external to the analytical process and could

include blind replicates, blind spiked samples, blind splits or duplicates, blind reference materials, and blind blanks.

Each laboratory involved with data generation will submit a Quality Assurance Manual to the agency Quality Assurance Officer (QAO) and will verify that the documented quality control procedures are acceptable for the purposes of this program. The Quality Assurance Project Plan, developed by the US Bureau of Reclamation (USBR,1995) includes the detailed quality assurance procedures and protocols for both field and laboratory procedures used by Reclamation, the Fish and Wildlife Service and the Department of Fish and Game (Saiki, 1985a, 1985b, 1986b; Saiki and Lowe, 1987; USBR, undated; White et al., 1987, 1988, 1989; SWRCB, 1991). Also included in the QAPP (USBR, 1995) is a description of the field and laboratory procedures used by the CRWQCB (CRWQCB, 1991; SWRCB, 1991). The CRWQCB conducts sample collections as outlined in their internal document: *Procedures Manual for the Agricultural Investigations and Planning Unit* (April 1991). A tabular summary of the quality assurance objectives for each matrix, described in the USBR (1995) plan is shown in Table 5. Table 6 summarizes analysis parameters, matrix, sample preservation, analysis methods and holding times. The QAPP also provides detailed descriptions of the analytical procedures to be used, calibration procedures and reporting requirements, preventative maintenance and methodologies to assess data precision, accuracy and completeness. The reader is referred to the QAPP (USBR, 1995) for further information on each of the elements of the EPA 16-point Quality Assurance Project Plan protocol as they relate to the Grasslands Bypass Project.

5.7.1 Laboratory analyses

Chemical analyses will be performed by certified analytical laboratories using established and approved procedures. If the same sample matrices are

being analyzed at two or more laboratories, split samples will be analyzed at the different laboratories to determine comparability of results. However, this plan provides for all water analyses to be performed by the CRWQCB and all sediment analyses to be performed by Reclamation. Biological samples collected by USFWS and DFG are expected to be analyzed by the same laboratory, and it is

Table 5

Sampling Plan for Sediment, Water Quality, And Biological Samples

Site Location	Sample Matrices	Sampling Stations Per Site	No. of Samples per Station	Sample Type	Sample Parameters	Frequency of Sampling
San Luis Drain	Sediment	2	4	Composite	Se,B,TOC	Quarterly
	Water-routine		52/365	Grab	Se,B,TSS,Temp,EC	Weekly
	Water-expanded		4	Grab	Se,B,Ca,K,Mg,Na,Cl,TDS,pH,HCO3 & total alkalinity, hardness, sulfate	Quarterly
	Suspended sediment		52/365	Grab	Se,B, TOC	
	Aquatic		3	Composite	Se,B	Annual(spring)
	Vegetation		12	Composite	Se,B	Quarterly
	Mosquitofish					
Mud Slough	Sediment	3	4	Composite	Se,B,TOC	Quarterly
	Water-routine		52	Grab	Se,B,Temp,EC	Weekly
	Water-expanded		4	Grab	Se,B,Ca,K,Mg,Na,Cl,TDS,pH,HCO3 & total alkalinity,hardness,sulfate	Quarterly
	Aquatic		3	Composite	Se,B	Annual(spring)
	Vegetation		12	Composite	Se,B	Quarterly
	Other		12	Composite	Se,B	Quarterly
	Invertebrates		12	Composite	Se,B	Quarterly
	Mosquitofish					
	Game Fish					
Salt Slough	Sediment	1	4	Composite	Se,B,TOC	Quarterly
	Water-routine		52	Grab	Se,B,Temp,EC	Weekly
	Water-expanded		4	Grab	Se,B,Ca,K,Mg,Na,Cl,TDS,pH,HCO3 & total alkalinity,hardness,sulfate	Quarterly
	Aquatic		3	Composite	Se,B	Annual(spring)
	Vegetation		12	Composite	Se,B	Quarterly
	Other		12	Composite	Se,B	Quarterly
	Invertebrates		12	Composite	Se,B	Quarterly
	Mosquitofish					
	Game Fish					
San Joaquin River	Water-routine	2	22	Grab	Se,B,Temp,EC	Biweekly
	Water-expanded		4	Grab	Se,B,Ca,,K,Mg,Na,Cl,TDS,pH,HCO3 & total alkalinity,hardness,sulfate	Quarterly
	Aquatic		3	Composite	Se,B	Annual(spring)
	Vegetation		12	Composite	Se,B	Quarterly
	Other		12	Composite	Se,B	Quarterly
	Invertebrates		12	Composite	Se,B	Quarterly
	Mosquitofish					
	Game Fish					
Seasonally Isolated Backwater to Mud Slough	Sediment	1	1	Composite	Se,B,TOC	Quarterly
	Water-routine		22	Grab	Se,B,Temp,EC	Bi-weekly
	Water-expanded		1	Grab	Se,B,Ca,K,Mg,Na,Cl,TDS,pH,NH3, HCO3 & total alkalinity,hardness,sulfate	Quarterly
	Aquatic		3	Composite		Annual(spring)
	Vegetation		3	Composite	Se,B	Annual(spring)
	Aquatic Insects		3	Composite	Se,B	Quarterly
	Other		3	Composite	Se,B	Quarterly
	Invertebrates				Se,B	
	Mosquitofish					

Table 6

Laboratory Protocols for Water Quality Samples

Parameter	Matrix	Sample Preservation	Holding Time	Method
Selenium	Water	Chill to 4°F Acidify in Lab	6 Months	South Dakota State University Method (see Appendix D)
Boron	Water	"	"	EPA 3020/6010
Calcium	Water	"	"	EPA 3020/6010
Potassium	Water	"	"	EPA 3020/7610
Magnesium	Water	"	"	EPA 3020/6010
Sodium	Water	"	"	EPA 3020/7610
Chloride	Water	Chill to 4°F	28 Days	EPA 300
Sulfate	Water	"	"	EPA 300
Total Alkalinity	Water	"	14 Days	STD 2320-B
Bicarbonate Alkalinity	Water	"	"	STD 2320-B
Total Hardness	Water	"	***	STD 2340-B
Total Dissolved Solids	Water	"	7 Days	STD 2540-C
Total Suspended Solids	Water	"	7 Days	STD 2540-D
**pH	Water	Analyze Immediately	——	pH meter used in the field
**Conductivity	Water	"	3 Days for Lab Value	Conductivity meter in the lab
**Temperature	Water	"	N/A	Thermometer

* Measured bi-weekly at 2 stations in the San Luis Drain
** Field Measurements
*** Based on Ca and Mg Analysis

Table 6 (Continued)

Parameter	Matrix	Sample Preservation	Holding Time	Method
Selenium	Sediment	Maintain in Dry State	Indefinite	USGS (see Appendix D)
Boron	Sediment	"	"	USGS (see Appendix D)
Total Organic Carbon	Sediment	"	"	USGS (see Appendix D)
Selenium	Aquatic Vegetation	Freeze or none required	"	<To be supplied by USFWS>
Boron	"	Freeze if necessary	"	"
Selenium	Aquatic Insects	"	"	"
Boron	"	"	"	"
Selenium	Other Inverte-brates	"	"	"
Boron	"	"	"	"
Selenium	Mosquito Fish	Freeze	"	"
Boron	"	"	"	"
Selenium	Game Fish	"	"	"
Boron	Game Fish	"	"	"

Table 7

Quality Assurance Objectives for Water Quality Data

Analytical Measurement	Precision (RPD)	Accuracy (% recovery)	Completeness (%)	Detection Limit	Quality Assurance (External) Per Batch	Quality Control (Internal) Per Batch
Selenium (sediment)	>5x DL = ≤35% ≤5x DL difference within ±2 x DL	65%-135%	90	0.1 mg/kg	batch=20 samples Reference &/or 2 Duplicates	batch=20 samples Blank, Reference, Duplicate
Boron (sediment)		65%-135%	90	0.4 mg/kg	batch=20 samples Reference &/or 2 Duplicates	batch=20 samples Blank, Reference, Duplicate
Selenium (water)	1-20x DL = ±5 ug/l	90%-110%	95	0.1 ug/l	<To be supplied by RWQCB>	<To be supplied by RWQCB>
Boron (water)	<to be supplied by RWQCB>	85%-115%	95	0.05 mg/l	"	"
Calcium (water)	"	85%-115%	95	5 mg/l	"	"
Potassium (water)	"	85%-115%	95	1 mg/l	"	"
Magnesium (water)	"	85%-115%	95	5 mg/l	"	"
Sodium (water)	"	85%-115%	95	5 mg/l	"	"
Chloride (water)	"	85%-115%	95	5 mg/l	"	"
Sulfate (water)	"	85%-115%	95	5 mg/l	"	"
Bicarbonate (water)	"	80%-120%	95	1 mg/l	"	"
Total Alkalinity (water)	"	85%-115%	95	1 mg/l	"	"
Total Hardness (water)	"	85%-115%	95	–	"	"
Total Dissolved Solids (water)	"	85%-115%	95	–	"	"
Total Suspended Solids (water)	"	85%-115%	95	–	"	"
Selenium (biota)	<To be provided by USFWS>	<To be provided by USFWS>	<To be provided by USFWS>	<To be provided by USFWS>	<To be provided by USFWS>	<To be provided by USFWS>
Boron (biota)	"	"	"	"	"	"

recommended that biological samples collected from the San Luis Drain by the drainers be analyzed at the same laboratory. Thus, inter-laboratory comparability of results should not be an issue.

The precision and accuracy criteria listed in Table 7 will be used to determine data quality. The criteria will be applied to external QA samples and data will be accepted or rejected based upon where it falls in relation to the established ranges. Internal QC criteria are determined within each laboratory and specified in the Quality Assurance Program Manuals which are also maintained by agency/organization QAO's. As internal control ranges are often updated in laboratories based upon instrumentation, personnel, or other influences, it is the responsibility of each organization/ agency involved in this project, to verify that these limits are well documented and appropriately updated during a system audit.

Completeness as specified in Table 7, refers to the percentage of project data that must be successfully collected, validated and reported in order to proceed with its intended use in decision making and compliance assessment. Table 5 contains a current summary of expected data collections against which completeness is assessed.

5.7.2 Chain of custody

Chain of custody (COC) documentation will be initiated during sample collection for all matrices and maintained throughout analytical and storage processes. Sample collectors, individuals transferring samples, and those receiving samples will sign the COC. Each agency will follow their established COC procedures to include utilization of forms routinely used for this purpose. The exception is the analytical work performed on biota through Environmental Trace Substances Research. Chain of Custody forms are not submitted with the

samples to this laboratory due to the per sample charge for COC samples. In these cases an order form will be submitted with samples in place of the COC.

Laboratory COC procedures are described in each laboratory's Quality Assurance Program Manual which are kept on file with the contracting organizations Quality Assurance Officer. At a minimum, laboratory documentation must be in place to track a sample from arrival at the laboratory through sample storage/ disposal. Laboratories must receive the COC documentation submitted with each batch of samples and sign all appropriate paperwork noting any sample discrepancies (ie labeling, breakage, etc.). This documentation must be maintained a minimum of eight years. Samples in all laboratories must be maintained in a secured area.

5.7.3 Calibration procedures and frequency

Sensors deployed at Mud Slough, Salt Slough and Site B at the terminus of the San Luis Drain will cleaned and recalibrated monthly to ensure accuracy. EC data from sensors at these sites will be recalibrated against standard solutions in the field and results compared to laboratory EC for each reporting period. The USGS, with assistance from DWR personnel, will be responsible for resurveying the channels on a quarterly basis at Mud Slough, Salt Slough and the San Joaquin River at Crows Landing to update the stage - discharge relationship, used to calculating river discharge from river stage. A propeller meter will be used by LBNL to check the flow velocity in the Drain and check it against the acoustic doppler sensor reading each month.

Calibration procedures and frequency of calibration have been established and documented for each laboratory conducting analysis for this project. As three different matrices are involved in this study with a minimum of three different laboratories performing analyses, specific calibration information can be obtained by referring to the laboratory Quality Assurance Program Manuals

which are kept with each representative agencies QAO. Copies of Quality Assurance Manuals for laboratories which are added to this program after the publication of this document will be kept on file with the quality assurance officer for the associated agency and with the QAO for Reclamation.

5.7.4 Quality assurance reporting procedures

A summary of quality control analyses should be provided by each agency or contractor responsible for generation of data for the Project. In addition, each participating agency will provide a narrative report describing any occurrence of corrective action and followup information, quality assurance data, along with quality control reports with their quarterly reports provided to the Oversight Committee.

5.8 Reports

Agencies collecting data would be responsible for assembling, summarizing, and distributing quarterly reports to the designated Technical Committee. The designated entity will be responsible for disseminating the data once consensus has been reached on data interpretation and analysis.

Quarterly tabulations of water quality and biological monitoring information will be developed throughout this project and distributed to participating and interested agencies or groups. The tabulations will include data by station and sample matrix with comparisons to previous comparable data. A summary data report will be posted to the SJRMP Water Quality Bulletin Board "sjrwqop@sacto.mp.usbr.gov" and to Reclamation's Home Page on the Internet, each quarter, from which it can be accessed by anyone with an Internet account. Hard copy of the Quarterly Report will be available to individuals who request to be placed on a mailing list if they do not have access to the Internet.

The focus of the monitoring data will be to assess trends that are attributable to effects of the proposed project. Because the monitoring program will be initiated at least 3 months before operation of the project (in accordance with the FONSI), it will be possible to collect pre-project data from almost all stations to complement background data available from other sources for the primary and secondary stations. Among the primary stations (A-I), the following trends will be described:

- **San Luis Drain** (Grasslands Bypass) - temporal trends in flow, contaminant concentrations and contaminant loads measured at the two primary stations (A and B) and in sediment depths at five stations. Using time of travel estimates, comparison of selenium concentrations and loads at inlet and outlet of the Grasslands Bypass.
- **Mud Slough** - comparisons among the three stations (C, D, and E) within the slough channel; temporal trends in flow, contaminant concentrations and contaminant loads individually at each of those stations and at the seasonal backwater area (Station I); comparisons to available background data; and results of toxicity testing.
- **Salt Slough** - temporal trends in flow, contaminant concentrations and contaminant loads, including comparisons to available background data; results of toxicity testing.
- **San Joaquin River** - comparisons between upstream (Station G) and downstream (H) stations; temporal trends in flow, contaminant concentrations and contaminant loads at each of the stations individually.

For the secondary stations trends in water quality data will be summarized using data provided by participating agencies. The data will be reviewed and discussed quarterly by a Technical Committee to the Oversight Committee. As appropriate, any issues will be brought to the attention of the Oversight Committee for resolution pursuant to the commitments outlined in the FONSI.

6.0 COSTS AND ALLOCATION OF RESPONSIBILITIES

A summary of estimated costs (for sample collection, handling, and preparation and for analysis) for the proposed monitoring program is shown in Table 8. The proposed program relies on continuation of ongoing monitoring programs (including operation of the SJRMP / USGS gaging stations in Mud and Salt Sloughs) and the availability of data from those programs for use in assessing the effects of the proposed Use of the San Luis Drain project (Figure 3).

Sediment and water quality monitoring would be performed most efficiently by Reclamation and the CRWQCB , because of their established programs and responsibilities. The CRWQCB currently collects water samples at weekly intervals for routine analyses from all of the proposed primary stations except A,B,C and I. The proposed monitoring program would increase the numbers of analyses being performed. The USGS and DWR will be operating continuous monitoring stations at two of those locations (proposed Stations D and F). Reclamation would monitor sediments in the San Luis Drain, Mud Slough, and Salt Slough.

The costs of the biological monitoring and the toxicity testing program will be borne by the Drainers or by cooperating agencies. The USFWS will cover biota sampling on Mud and Salt sloughs at Stations C, D, and F, as well as the backwater site (Station I) if agency funding continues to be available (S. Schwarzbach, pers. comm.). Similarly, the DFG would conduct the biota sampling on lower Mud Slough (Station E) and on the San Joaquin River (Stations G and H)

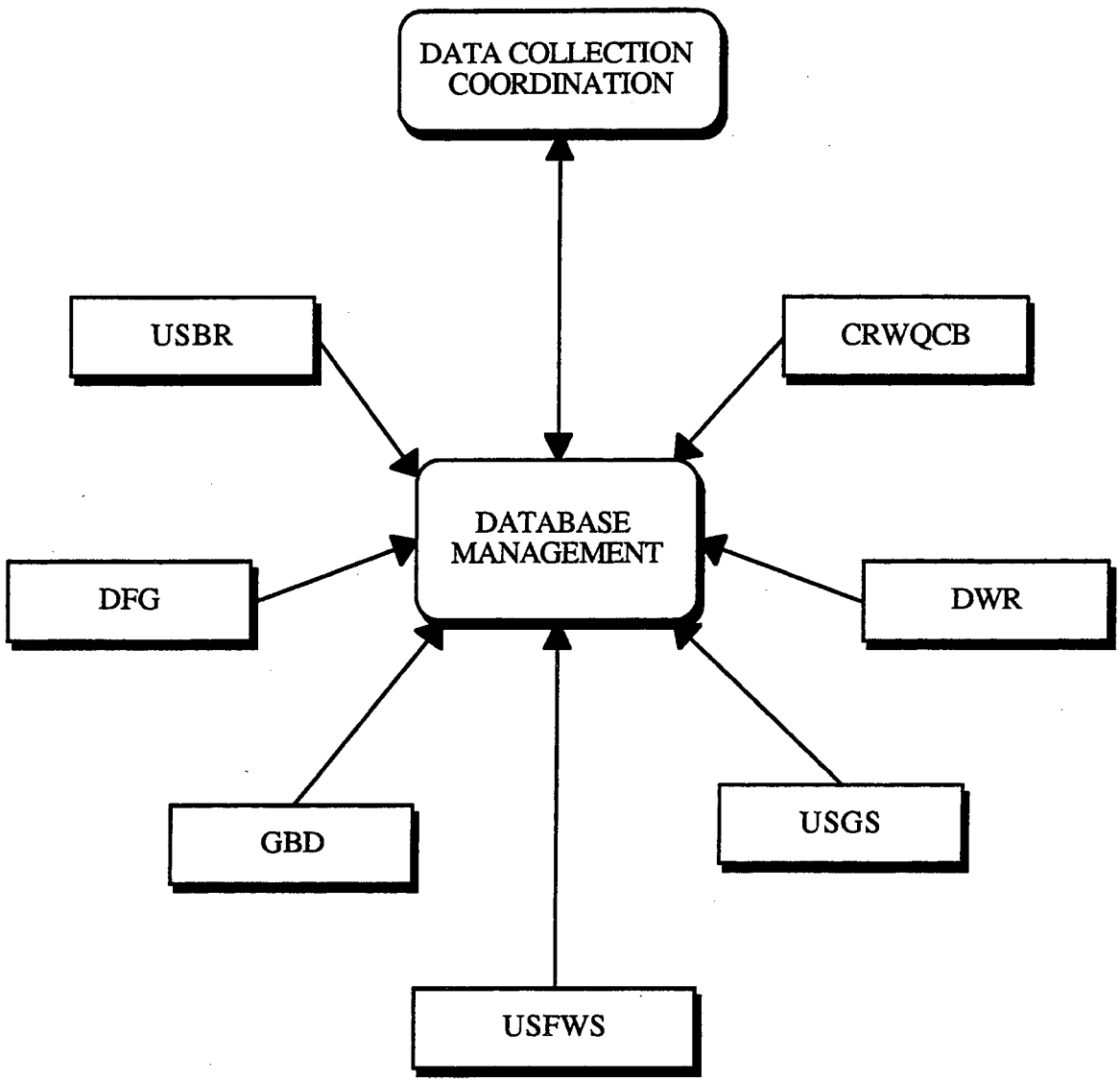


Figure 3. Proposed data collection and coordination process

TABLE 8

Estimated Annual Costs[a] and Proposed Responsible Agencies for the Grasslands Bypass Monitoring Program

Task	Sampling Frequency (No.)	Responsible Agencies[b]										Total No. of Samples[c]	Total Annual Cost[a]
		USBR		CRWQCB		USFWS		DFG		Drainers			
		Stations and No. of Samples	Cost	Stations and No. of Samples	Cost	Stations and No. of Samples	Cost	Stations and No. of Samples	Cost	Stations and No. of Samples	Cost		
Sediment Monitoring													11.8
Bottom	Quarterly (4)	A,B,D,F	9.9									20	
Suspended	Weekly (48)			A,B	1.9							96	
Water Quality Monitoring					66.0							1500	66.0
Routine	Monthly (12)			All									
Routine	Biweekly (22)			60									
Routine	Weekly (52)			22									
Expanded	Quarterly (4)			676									
Routine	Daily (365)			64									
				730									
Flow monitoring													50.5
	Daily (365)	A	5.5										
	Continuous	B, D, F g	45.0										
Bological Monitoring						C, D, F, I	50.0	E, G, H	20.5	A, B	7.5		78.0
Aquatic vegetation	Annual (1)					12		9		6		27	
Aquatic insects	Annual (1)					3		--		--		3	
Crayfish	Quarterly (4)					39		36		--		75	
Fish	Quarterly (4)					75		72		24		171	
Aquatic Communities[e]	Quarterly (4)					d		d		--		N/A	
Toxicity Testing										C, D, F			
Laboratory	Quarterly (4)										5.0		5.0
Screening Level[f]										12	22.2	12	22.2
Dilution Series[g]										12	36.0	12	36.0
Field	Quarterly (4)									12	14.8	12	14.8
Reporting	Quarterly (4)		5.0		5.0		5.0		5.0		5.0		25.0
TOTALS			**65.4**		**72.9**		**55.0**		**25.5**		**90.5**		**309.3**

[a]All costs are given as thousands ($1,000). Labor costs are estimated at $500/day for those instances where labor was not included in the agency estimate.
[b]Funding for each agency contingent upon annual budgets.
[c]Not including an additional 25 percent for quality assurance.
[d]Aquatic community assessment to be completed at each station in Mud Slough, Salt Slough, and San Joaquin River each quarter (but not in San Luis Drain).
[e]Number of tests depends on whether water at Station D is toxic; it could be only 4 samples per year if not toxic.
[f] Dilution series run if water from Station D is toxic.
g San Joaquin River Stations currently maintained by USGS and DWR under funding under a USBR Challenge Grant awarded to the SJRMP Water Quality Subcommittee

with funding provided through its agency budget. The DFG also has proposed conducting the biota sampling in the San Luis Drain (Stations A and B), but those costs should be the responsibility of the Drainers (not agency budgets). The Drainers will be responsible for costs of the toxicity testing program.

The costs associated with data management and data reduction will be shared by Reclamation and the cooperating agencies.

6.1 Research Activities

Although this document focuses on the compliance monitoring plan required for use and operation of the Grasslands Bypass it is anticipated that the massive data collection effort, which has an approximated annual cost of $307,000 (Table 8), will afford opportunities for further research. After almost a decade of research by the University of California, the USGS and the FWS there are still unanswered questions related to selenium mobilization, fate and transport. The comprehensive data collection effort outlined may allow more in-depth, interagency research projects to be performed than might have been otherwise possible. The data collection, reporting and dissemination process will be implemented to foster close cooperation and coordination, not only with the agencies and organizations involved in the monitoring program but also with the research community. Figures 4 and 5 show the sequence of steps that will be followed in carrying out the compliance monitoring program and the possible avenues of interaction with the research community. As with every new endeavor, it is likely that the process will evolve and become more automated and efficient with time. Since many of the agencies and organizations responsible for the compliance monitoring program have research scientists on their staff it is likely that the lines between research needs and compliance needs may become blurred. The assistance of the Oversight Committee might be called upon

periodically to review any future proposed changes to the monitoring plan outlined in this document.

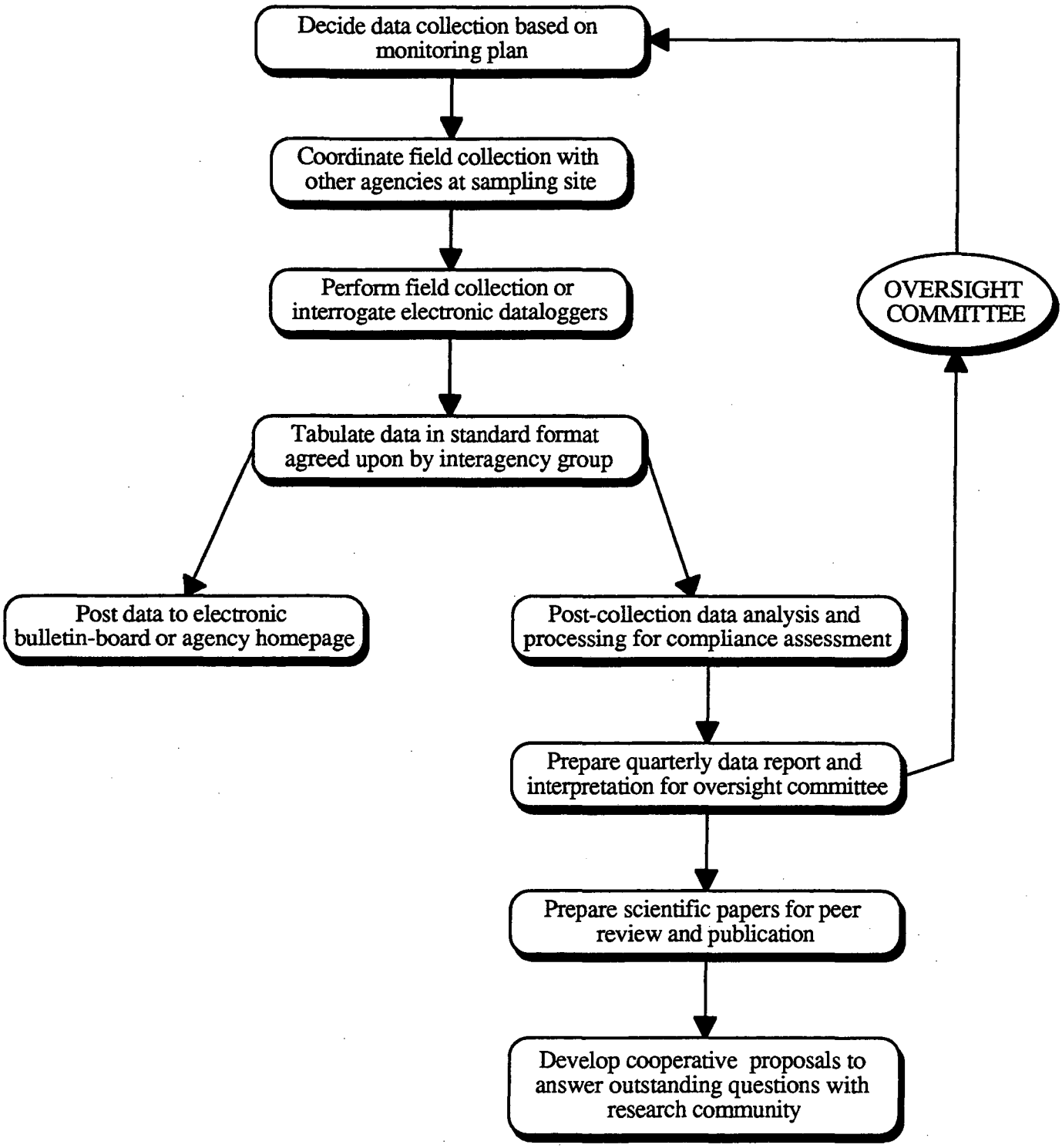


Figure 4. Flowchart of steps involved in implementation of monitoring plan

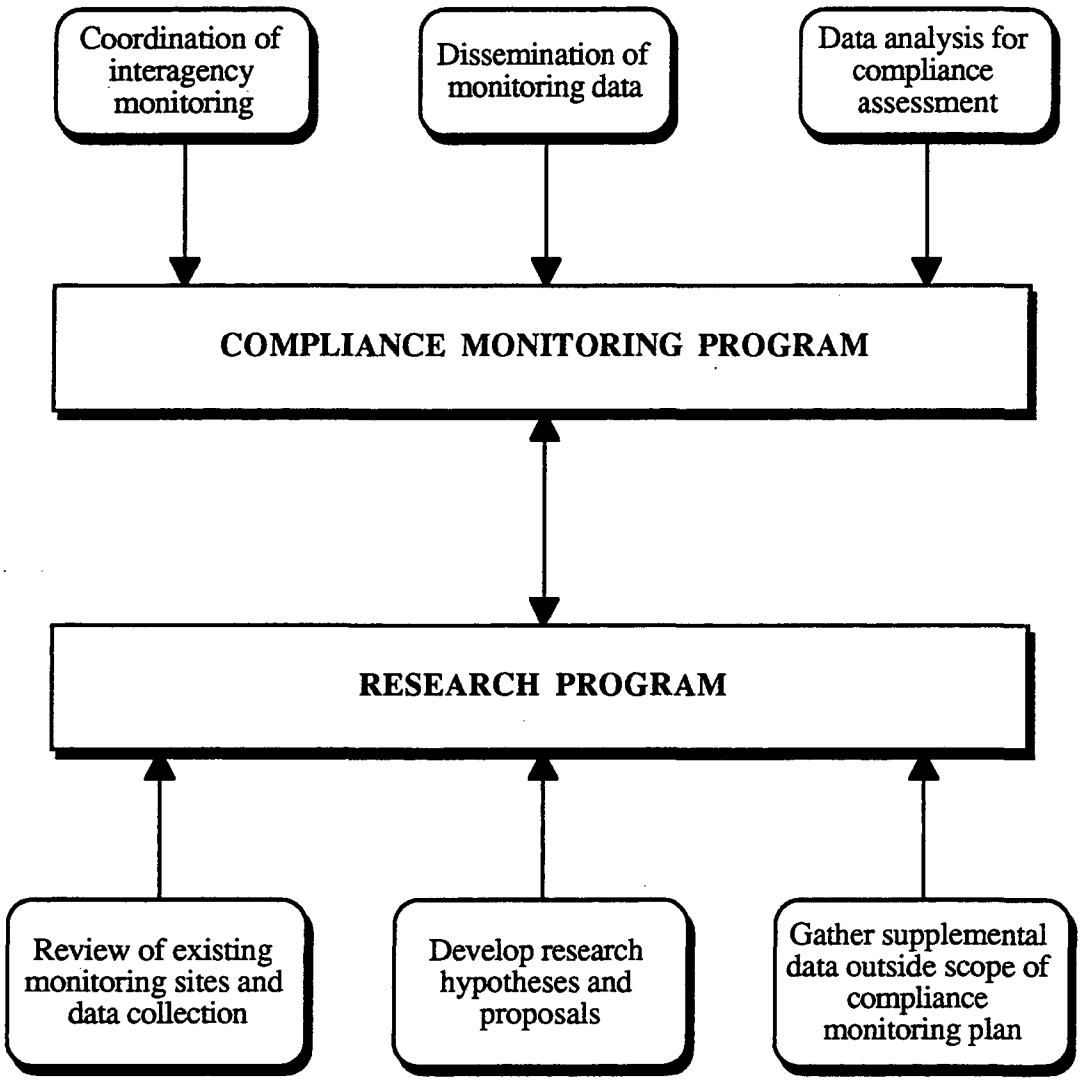


Figure 5. Potential linkage between compliance monitoring and research activities related to Grasslands Bypass project

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