SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT, PHASE I 2002 WILDLIFE MONITORING REPORT

Prepared by

H. T. HARVEY & ASSOCIATES

Scott B. Terrill, Ph.D., Division Head, Senior Ornithologist
Brian B. Boroski, Ph.D., Project Manager, Senior Wildlife Ecologist
Jeffrey Seay, B.A., Wildlife Biologist

Prepared for

Panoche Drainage District
52027 W. Althea Avenue
Firebaugh, CA 93622

January 29, 2003 File No. 1960-02

TABLE OF CONTENTS

TABLES:

FIGURES:

EXECUTIVE SUMMARY

This report presents the biological monitoring results for the second year of Phase I of the San Joaquin River Water Quality Improvement Project. This project is designed to reduce the amount of salt and selenium delivered to the San Luis Drain and Mud Slough through the Grassland Bypass. Thus far, approximately 1,800 acres of the 4,000-acre project site have been planted with salt tolerant crops and irrigated with agricultural drainwater.

An ornithologist monitored bird use on 2,500 acres of the project site on six occasions from April 10 to June 13, 2002. Avian species diversity and numbers were relatively low for a 2,500-acre site and comprised primarily species common in disturbed and ruderal habitats.

H. T. Harvey & Associates collected five Killdeer eggs, three American Avocet eggs, and two Black-necked Stilt eggs from within the project site. These eggs were analyzed for selenium and boron concentrations. Additionally, five Killdeer eggs were collected from the vicinity of the project to provide background selenium and boron information.

All of the eggs analyzed contained at least partially elevated egg-selenium concentrations. The combined recurvirostrid eggs (Black-necked Stilt and American Avocet) from the project site contained one egg within the range (3 to 7.9 ppm) that has been associated with an increased probability of effects on avian reproduction, three eggs within the range (8-18 ppm dry wt) associated with an increased probability of reduced hatchability, and one egg was in the range (>18 ppm) that has been associated with a high probability of reproductive effects, including reduced hatchability and increased occurrence of embryo deformities (teratogenesis).

The Killdeer eggs from the project site contained selenium concentrations within the range (8-18 ppm dry wt) associated with an increased probability of reduced hatchability. Mean egg-selenium levels in reference eggs for Killdeer collected within the vicinity of the project were significantly lower than those from the project site (t =2.91, df = 8, P <0.02). All of the Killdeer nests from which eggs were collected both on and off the project site were adjacent to or in close proximity to open drainwater ditches. These drainwater ditches were likely the source of the elevated selenium found in the sampled eggs.

The results of the boron analysis of the five Killdeer eggs collected from the project site (mean = 5.4 ppm, range = 4.4 – 6.1 ppm), the reference Killdeer eggs (mean = 3.6 ppm, range = 3.0 – 4.2 ppm), and the combined recurvirostrid eggs from the project site (mean = 6.0 ppm, range = 4.9 – 10 ppm), were above the 3 ppm dry weight background level. The presence of elevated boron-egg content indicates that boron should continue to be monitored in eggs collected from the project site.

INTRODUCTION

The Panoche Drainage District implemented Phase I of the San Joaquin River Water Quality Improvement Project (SJRIP) to reduce the amount of salt and selenium delivered to the San Luis Drain and Mud Slough through the Grassland Bypass Project+. The Panoche Drainage district, acting as the lead agency under the California Environmental Quality Act (CEQA), prepared a Negative Declaration for this project in September 2000. The Negative Declaration included the provision that a biological monitoring program would be developed, in collaboration with the U. S. Fish and Wildlife Service (USFWS), that would be capable of detecting migratory bird impacts resulting from the project. This report represents the biological monitoring results for the second year (2002) of Phase I of the SJRIP.

PROJECT DESCRIPTION AND SETTING

Only a portion of Phase I was put into effect in 2002. Approximately 1,800 acres of crops were planted on the roughly 4,000 acres obtained by the Panoche Drainage District. The project site is located west of the city of Firebaugh in Fresno County, California. The irregularly shaped project site is bordered on the north by the Main Canal and on the south by the Delta-Mendota Canal. Russell Avenue borders the eastern edge, and the western edge extends nearly to Fairfax Avenue (Figure 1).

The project is the initial development of an In-Valley Treatment/Drainage Reuse Facility on up to 6,200 acres of land within the Grassland Drainage Area (GDA) (Figure 1). The reuse facility would dedicate specific lands for the irrigation of salt-tolerant crops with subsurface drainwater to reduce drainwater volume; treat the concentrated drainwater to remove salt, selenium, and boron; and eventually dispose of the removed salts to prevent them from discharging into the San Joaquin River. The facility will process up to one-quarter of the total drainwater produced in the GDA (25 percent of 52,000 acre-feet or approximately 15,000 acre-feet) and would be implemented in three phases, described in more detail below:

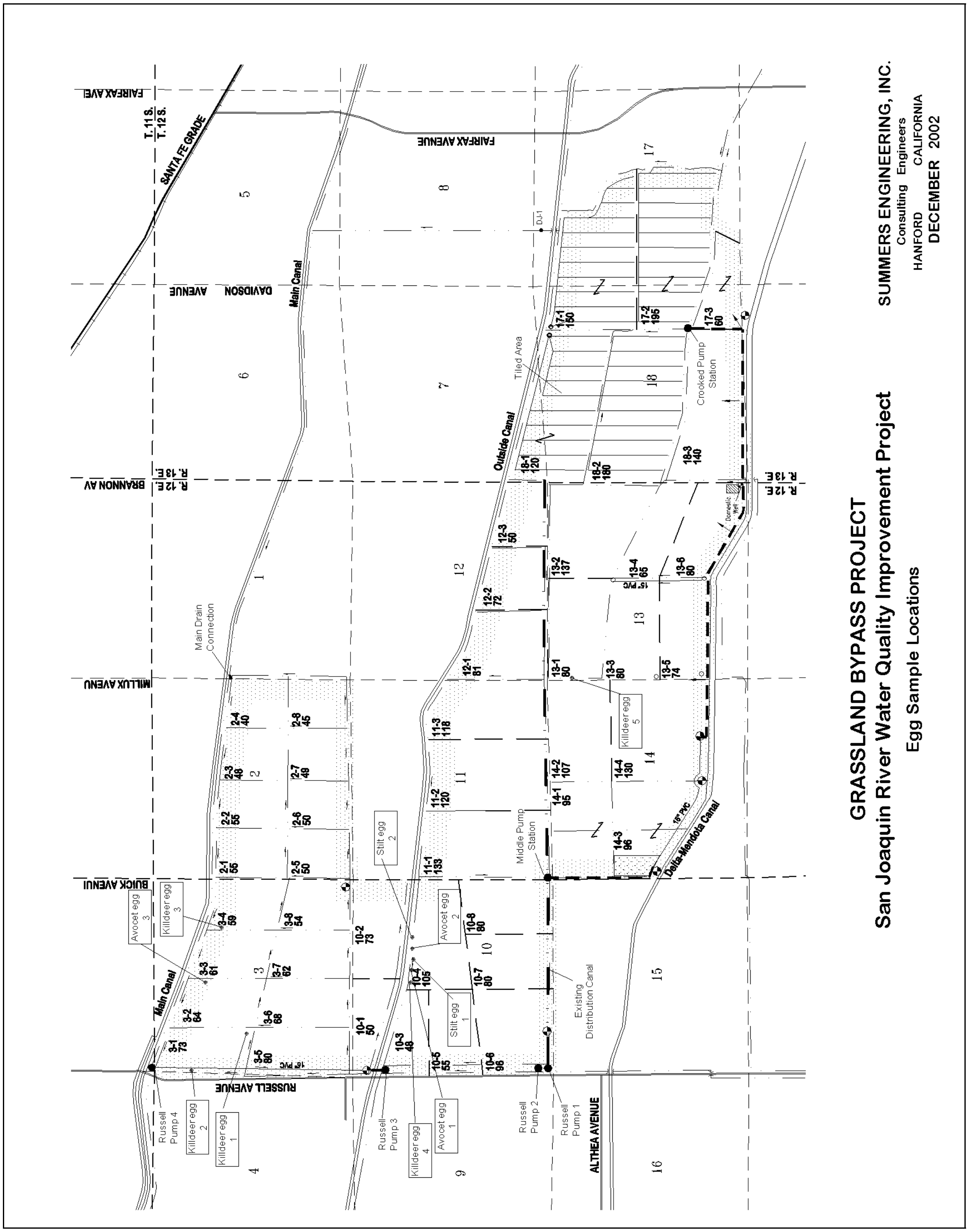
- Phase I: Purchase of land and planting of salt-tolerant crops

- Phase II: Installation of subsurface drainage and collection systems, initial treatment system

- Phase III: Complete construction of treatment removal and salt disposal systems

In phase I, subsurface drainwater from the GDA is used to irrigate salt-tolerant crops on land ideally situated for this purpose. The land is adjacent to the channels containing collected drainwater, so the water can easily be captured and placed on the land. Since this land is also the lowest in elevation within the drainage area, collected water can be applied without excessive pumping costs. Four thousand acres have been purchased to

Figure 1. Location of the Panoche Drainage District's San Joaquin River Water Quality Improvement Project.



date. Approximately 1,800 acres were planted in 2001 and irrigated with water that otherwise would have been discharged to the San Joaquin River. Ongoing monitoring of soil and water constituents will occur to prevent irreversible changes and to protect groundwater.

Under Phase II, saline water will continue to be applied to the lands developed in Phase I. Subsurface drainage systems will be installed to leach the land and maintain a favorable salt balance. The water percolating below the root zone would be captured in the drainage system and passed on to the next, more salt-tolerant crop. In Phase II, the system would sequentially reuse drainwater on increasingly salt-tolerant crops to concentrate and decrease the volume of drainwater. The salt, selenium, and other constituents would be collected in the water coming out of the subsurface drainage systems. An initial treatment phase would remove the salt and the selenium, and much of the other constituents from the water, leaving usable water for agriculture or possibly other beneficial uses. The treatment system will be designed to incorporate into any point in the reuse system. The salt would be deposited in approved waste units and not discharged to the San Joaquin River, resulting in additional reductions in salt and selenium discharges to the river.

The final Phase III would provide for maximum improvement of water quality in the San Joaquin River and meet the ultimate reductions needed to meet future water-quality objectives. This phase includes expanding the initial treatment (under Phase II) with additional treatment facilities and waste-disposal units.

Each phase of the facility would significantly reduce the quantity of drainwater discharged to the San Joaquin River. The treatment systems could also produce water sufficient in quality for reuse on agricultural lands within the GDA. The project would be designed to help the Grasslands Area Farmers meet applicable water quality objectives for Water Year 2006 (October 1, 2005). The applicable annual selenium load limit for 2006 (based on the current applicable total maximum monthly load) is 3,087 pounds. In comparison, the load value in the existing 1995 Use Agreement for Water Year 2001 is 5,661 lbs. Such a large reduction requires implementation of additional methods of drainage management.

Phase I of the facility was evaluated in an Initial Study and Negative Declaration adopted September 9, 2000 by Panoche Drainage District. Phases II and III of the facility were evaluated in the Grassland Bypass Project EIS/EIR finalized May 25, 2001. The current project (Phase I) has independent utility and does not foreclose consideration of alternatives to the larger project or to the project site. Even if the In-Valley Treatment/Drainage Reuse Project were to stop at Phase I without the later phases being implemented, it has value on its own for drainage management in the Panoche Drainage District and in the GDA. In addition, the changes in proposed cropping patterns are not irreversible should the later phases not be implemented.

A portion of the project site was evaluated for conversion to salt-tolerant crops and drainage reuse in 1997 by Mercy Springs Water District, which encompasses 3,392 acres

(55 percent of the site). The District prepared an Environmental Assessment for transfer of its Central Valley Project Class I water supply to Pajaro Valley Water Management Agency (ESA 1997). A Finding of No Significant Impact approved the transfer of 13,300 acre-feet of annual water supply to Pajaro Valley Water Management Agency on November 6, 1998. In 1999, a Final Environmental Assessment and Finding of No Significant Impact was approved for the transfer of 6,260 acre-feet per year of its annual Central Valley Project contract water to Pajaro Valley Water Management Agency, Santa Clara Valley Water District, and Westlands Water District (Provost & Pritchard 1999). These environmental documents covered the impacts of the water transfers including drainwater reuse, groundwater pumping, and cumulative effects. The current In-Valley Project Phase I proposal does not include any water transfers or additional groundwater pumping over existing conditions.

The 6,200 acres designated for purchase is devoted entirely to irrigated field crops and related irrigation ditches, drain ditches, conveyance canals, and farm structures. The topography is nearly level to grade and flood/furrow irrigated. The highest elevation is found near the southeasterly corner at 164 feet above mean sea level, while the lowest point is found near a northcentral point at 136 feet above mean sea level. Thus, the elevation change within the subject property is approximately 28 feet over the 6,200-acre area. The shape of the property is irregular, conforming to the adjacent canals of the area. Access to the property is via Russell Avenue, a paved county road. Typical improved farm roads provide access to the interior of the site.

MATERIALS AND METHODS

BIRD CENSUSES

The project site was monitored for bird use by an ornithologist from H. T. Harvey & Associates on six occasions from April 10 to June 13, 2002. Censuses were completed by driving the roads forming the perimeters of each field. Birds were identified and counted using 10X binoculars and a 20-60X spotting scope mounted on a tripod. The purpose of these censuses was to determine the species composition and relative abundance of bird species occurring on the project site during the breeding season.

EGG COLLECTION AND PROCESSING

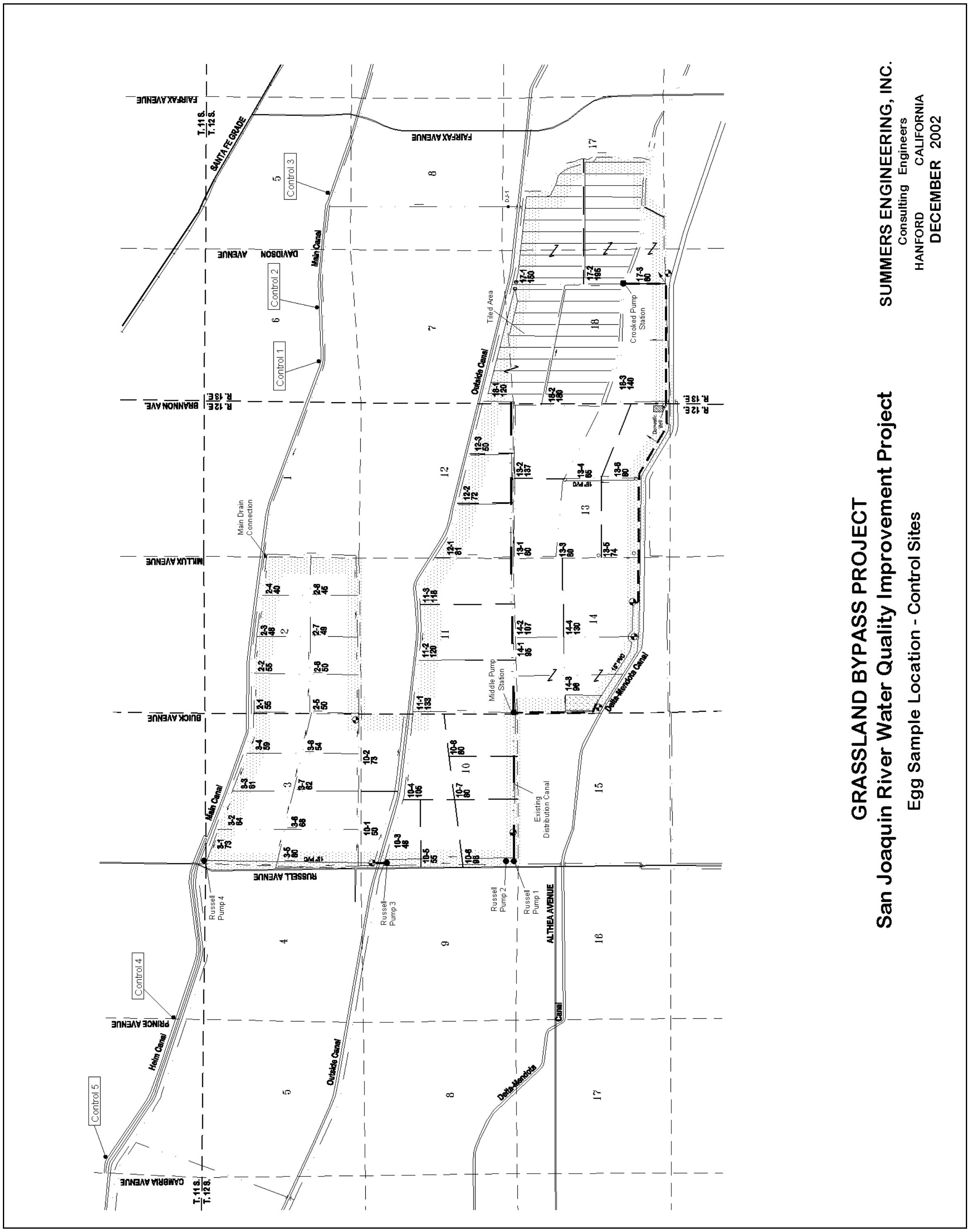
Five Killdeer (*Charadrius vociferus*) eggs, three American Avocet (*Recurvirostra americana*) eggs and two Black-necked Stilt (*Himantopus mexicanus*) eggs were collected from the project site for selenium and boron analysis. The locations of the nests from which eggs were collected are illustrated in Figure 1. A scientific collecting permit was obtained from the California Department of Fish and Game for the collection of bird eggs at the site. One egg was randomly collected from separate, full-clutch (4 eggs) nests. An additional set of five reference Killdeer eggs was collected off of the project site (Figure 2), but from the project vicinity to provide background selenium and boron information.

All eggs were labeled with a permanent marker, placed in an egg carton, and transported from the field. All of the egg contents (including membranes) were removed from the shell and transferred to 1 oz. Dynalon jars. The embryo was photographed and examined for abnormalities and stage of incubation (age). The embryo was also examined to determine if it was alive or dead. The egg contents were stored by freezing (0^{o} C.).

EGG-SELENIUM ANALYSIS

Egg contents collected by H. T. Harvey & Associates were shipped overnight, on dry ice, to the California Animal Health and Food Safety Laboratory at the University of California, Davis. This lab that is not utilized by the USFWS, but Dr. Joseph Skorupa (USFWS) indicated in a phone conversation that the lab is acceptable. Selected sub-samples were divided into two aliquots. The duplicate was spiked (known amounts of selenium were added to the aliquot) and the samples were tested to determine the accuracy of analysis. Selenium concentrations were determined using hydride generation atomic absorption. All egg-selenium concentrations were presented as parts per million (ppm) based on dry tissue weight (dry wt). T-tests or one-way ANOVAs (followed by Sidak multiple comparisons tests [an improved version of the Bonferonni test; SAS Inst. 1985]) were used to compare means for egg-selenium and boron levels between Killdeer eggs collected on the project site and Killdeer eggs collected off the project site (significance threshold at $P < 0.05$; see above).

Figure 2. Location of reference eggs for Killdeer collected in the vicinity of the Panoche Drainage District's San Joaquin River Water Quality Improvement Project.



RESULTS

BIRD CENSUSES

Forty-one avian species were observed within the Phase I area between April 10 and June 13, 2002 (Table 1). Avian numbers were highest in April, when Cattle Egrets (*Bublucus ibis*) and migrating Whimbrels (*Nunenius phaeopus*) were present (Table 1). Red-winged Blackbirds (*Agelaius phoeniceus*) were the most numerous species observed on the project site. Fifteen species were either observed nesting on the site, or nesting was suspected based on observations of courtship behavior or young. Numbers declined in May and June as fewer migrants were detected.

EGG COLLECTION AND PROCESSING

Ten eggs (five Killdeer, three American Avocet, and two Black-necked Stilt) were collected from within the project site. Two of the Killdeer embryos from the project site were alive but too young (6-9 days old) to determine their condition. The remaining three Killdeer embryos from the project site were less than three days old (Table 2). One of the stilt eggs contained a live, normal embryo between 12 and 15 days old. The remaining stilt and avocet embryos were too young (<9 days old) to determine the embryo condition, though three were old enough (>3 days old) to determine that they were alive (Table 3).

Five Killdeer eggs were collected from off of the site, but within the vicinity of the project. These samples are referred to as reference eggs. Three of the reference eggs for Killdeer each contained a live, normal embryo between 15 and 18 days old. The remaining two embryos were too young (<9 days old) to determine the embryo condition, though one was old enough (>3 days old) to determine that it was alive (Table 2).

EGG-SELENIUM ANALYSIS

Selenium results for Black-necked Stilts and American Avocets were pooled together to form one sample since past data has shown little difference in egg-selenium concentrations (J. P. Skorupa pers. comm). The geometric mean egg-selenium content of stilts and avocets combined was 13.6 ppm dry weight (range 6.2 to 33 ppm) (Table 3).

The geometric mean egg-selenium content was 11.3 ppm dry weight for the five Killdeer eggs collected within the project site (range 8.4 to 16 ppm) (Table 2). The reference eggs for Killdeer had a geometric mean egg-selenium content of 6.7 ppm (range 5.2 to 8.6 ppm). Mean egg-selenium levels in the reference eggs for Killdeer were significantly lower than those from the project site (t =2.91, df = 8, P <0.02,).

Table 1. Avian census results at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

		2002					
	Species	**April 10**	**April 24**	**May 03**	**May 17**	**May 30**	**June 13**
	Great Blue Heron	2		1	1	1	
	Great Egret	1	1			3	1
	Snowy Egret	3	2	4	2	3	
	Cattle Egret	68	6	6	25	17	
	White-faced Ibis	43	11	43	26	23	
	Mallard	9	8	8	6	8	8
	Northern Pintail			2			
	Cinnamon Teal	2	1	4	2	2	2
	Northern Harrier	3	4	5	4	2	5
	Swainson's Hawk	1	3	1	2	1	2
*	Red-tailed Hawk	7	9	10	4	8	10
	American Kestrel	1	1	1	2	1	1
*	Ring-necked Pheasant	1		2	2	11	
*	Killdeer	18	20	36	36	26	31
*	Black-necked Stilt	2	2	6	11	8	10
*	American Avocet		2	6	10	9	11
	Greater Yellowlegs		3				
	Whimbrel	142	146	83	23	7	
	Least Sandpiper	2	3				
	Black Tern				3	2	1
	Mourning Dove	9	15	14	12	7	5
*	Burrowing Owl	6	6	6	6	6	6
*	Western Kingbird	22	22	27	23	23	24
*	Loggerhead Shrike	4	4	5	4	4	5
	Common Raven	6	8	11	9	8	6
*	Horned Lark	12	12	6	2	2	
	Tree Swallow		7				
	Barn Swallow		2	6	2	2	
	Cliff Swallow				3		
	American Pipit	74	69				
	Lark Sparrow			4			
	Savannah Sparrow	25	6				
*	Song Sparrow	12	12	10	9	10	9
*	Red-winged Blackbird	247	265	252	203	219	186
	Tricolored Blackbird		8	7			
*	Western Meadowlark	21	23	11	20	31	24
*	Brewer's Blackbird	58	29	64	27	23	31
	Brown-headed Cowbird	30	12	23	20	22	6
*	House Finch	17	16	18	23	16	4
	American Goldfinch	6					
*	House Sparrow	8	11	17	11	16	8
	Total	**862**	**749**	**699**	**533**	**521**	**396**
	* = Species for which evidence of nesting on the project site was observed this year.						

Table 2. Killdeer egg-selenium concentrations at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

ID Number	Field Number PDD	Species	Date 2002	Embryo Status [a] and Condition [b]	Embryo Age (days)	Percent Moisture	Selenium (ppm dry wt)	Log base 10	Anti-log
Project Site									
01	PK1	Killdeer	May 3	UU	<3	73	9.1	0.9590	
02	PK2	Killdeer	May 3	UU	<3	73	8.4	0.9258	
03	PK3	Killdeer	May 17	UU	<3	72	13	1.1139	
04	PK4	Killdeer	May 30	LU	6-9	71	16	1.2122	
05	PK5	Killdeer	May 30	LU	6-9	72	10	1.0086	
Arith/Geo Mean						72.2	11.4	1.0527	11.3
SD						1.01	3.25	0.1342	1.4
SE								0.0600	1.1
95% CI								0.9351	8.6
								1.1704	14.8
ID Number	**Field Number PDD**	**Species**	**Date: 2002**	**Embryo Status [a] and Condition [b]**	**Embryo Age (days)**	**Percent Moisture**	**Selenium (ppm dry wt)**	**Log base 10**	**Anti-log**
Reference Eggs									
01	CK1	Killdeer	May 3	LN	15+	73	7.6	0.8814	
02	CK2	Killdeer	May 3	LN	18+	73	8.6	0.9335	
03	CK3	Killdeer	May 3	UU	<3	72	7.1	0.8537	
04	CK4	Killdeer	May 3	LU	<6	73	5.4	0.7348	
05	CK5	Killdeer	May 3	LN	17-18	69	5.2	0.7118	
Arith/Geo Mean						72.1	6.8	0.8230	6.7
SD						1.57	1.46	0.0841	1.2
SE								0.0376	1.1
95% CI								0.7493	5.6
								0.8968	7.9

[a] L= Live, D= Dead.
[b] N= Normal, A= Abnormal, U= Unknown.

Table 3. American Avocet and Black-necked Stilt egg-selenium and egg-boron concentrations at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

ID Number	Field Number PDD	Species	Date: 2002	Embryo Status [a] and Condition [b]	Embryo Age (days)	Percent Moisture	Selenium (ppm dry wt)	Log base 10	Anti-log
Project Site									
06	A1	American Avocet	May 17	LU	<6	74	33	1.5159	
07	A2	American Avocet	May 30	LU	<6	75	11	1.0492	
08	S1	Black-necked Stilt	May 30	LN	12-15	73	8.2	0.9133	
09	S2	Black-necked Stilt	May 30	UU	<3	74	12	1.0607	
10	A3	American Avocet	June 12	LU	6	75	6.2	0.7889	
Arith/Geo Mean						74.1	14.0	1.1348	13.6
SD						0.62	10.76	0.2627	1.8
SE								0.1175	1.3
95% CI								0.9045	8.0
								1.3651	23.2
ID Number	**Field Number PDD**	**Species**	**Date: 2002**	**Embryo Status [a] and Condition [b]**	**Embryo Age (days)**	**Percent Moisture**	**Boron (ppm dry wt)**	**Log base 10**	**Anti-log**
Project Site									
06	A1	American Avocet	May 17	LU	<6	74	10	1.0000	
07	A2	American Avocet	May 30	LU	<6	75	5.6	0.7482	
08	S1	Black-necked Stilt	May 30	LN	12-15	73	5.0	0.6990	
09	S2	Black-necked Stilt	May 30	UU	<3	74	5.8	0.7634	
10	A3	American Avocet	June 12	LU	6	75	4.9	0.6902	
Arith/Geo Mean						74.1	6.3	0.7802	6.0
SD						0.62	2.13	0.1344	1.4
SE								0.0601	1.1
95% CI								0.6623	4.6

[a] L= Live, D= Dead.
[b] N= Normal, A= Abnormal, U= Unknown.

EGG-BORON ANALYSIS

The geometric mean egg-boron content of stilts and avocets combined was 6.0 ppm (range 4.9 to 10 ppm) (Table 3). The geometric mean-boron content of Killdeer eggs collected at the project site was 5.4 ppm boron dry weight (range 4.4 to 6.1 ppm) (Table 4). This sample set contained significantly higher levels of boron than the reference eggs for Killdeer collected from off the project site (t =4.56, df = 8, $P < 0.01$,), which contained 3.6 ppm boron dry weight (range 3.0 to 4.2 ppm) (Tables 4 and 5).

QUALITY ASSURANCE/QUALITY CONTROL ANALYSIS

The quality assurance/quality control analysis was conducted by the California Animal Health and Food Safety Laboratory at the University of California, Davis. The selenium recovery rate for the liver and blood samples spiked with 1.0 ppm selenium was between 98 and 99%(Table 6). The selenium recovery rate for egg samples spiked with 5.0 ppm selenium was 94% and the selenium recovery rate for egg samples spiked with 50 ppm selenium was 85% (Table 6). The standard deviation of selenium results from duplicate egg samples ranged between 0.0003 and 1.530 (Table 7).

The standard deviation of boron results from duplicate egg samples ranged between 0.049 and 0.698 (Table 8). The boron recovery rate for egg samples spiked with 10.0 ppm selenium was 96% (Table 8).

Table 4. Killdeer egg-boron concentrations at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

ID Number	Field Number PDD	Species	Date: 2002	Embryo Status [a] and Condition [b]	Embryo Age (days)	Percent Moisture	Boron (ppm dry wt)	Log base 10	Anti-log
Project Site									
01	PK1	Killdeer	May 3	UU	<3	73	6.1	0.7853	
02	PK2	Killdeer	May 3	UU	<3	73	4.4	0.6435	
03	PK3	Killdeer	May 17	UU	<3	72	5.2	0.7160	
04	PK4	Killdeer	May 30	LU	6-9	71	6.0	0.7782	
05	PK5	Killdeer	May 30	LU	6-9	72	5.7	0.7559	
Arith/Geo Mean						72.2	5.5	0.7307	5.4
SD						1.01	0.70	0.0660	1.2
SE								0.0295	1.1
95% CI								0.6729	4.7
								0.7886	6.1
ID Number	**Field Number PDD**	**Species**	**Date: 2002**	**Embryo Status [a] and Condition [b]**	**Embryo Age (days)**	**Percent Moisture**	**Boron (ppm dry wt)**	**Log base 10**	**Anti-log**
Reference Eggs									
01	CK1	Killdeer	May 3	LN	15+	73	4.2	0.6232	
02	CK2	Killdeer	May 3	LN	18+	73	4.0	0.6021	
03	CK3	Killdeer	May 3	UU	<3	72	3.0	0.4771	
04	CK4	Killdeer	May 3	LU	<6	73	4.0	0.6021	
05	CK5	Killdeer	May 3	LN	17-18	69	3.2	0.5051	
Arith/Geo Mean						72.1	3.7	0.5619	3.6
SD						1.57	0.54	0.0668	1.2
SE								0.0299	1.1
95% CI								0.5034	3.2
								0.6204	4.2

[a] L= Live, D= Dead.
[b] N= Normal, A= Abnormal, U= Unknown.

Table 5. Geometric mean Killdeer egg-selenium and egg-boron concentrations from Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

Selenium			
Location	**n**	**Geo. Mean ppm Se (dry wt)**	**Range**
Project Site	5	11.3	8.4--16
Off-site Reference Samples	5	6.7	5.2--8.6
Significant difference (t = 3.24, df = 8, P <0.02) between sites.			

Boron			
Location	**n**	**Geo. Mean ppm B (dry wt)**	**Range**
Project Site	5	5.4	4.4--6.1
Off-site Reference Samples	5	3.6	3.2--4.2
Significance difference (t =4.42, df = 8, P <0.01) between sites.			

Table 6. Summary of 2002 quality assurance/quality control data for selenium control spikes.

Selenium Control Spikes				
ID Number	**Tissue**	**Spiked Selenium**	**Result Selenium**	**Percent Recovery**
control	blood	0	0.1748	
control-sp	blood	1	1.1530	98
D0209747 099	liver	0	0.3204	
D0209747 099-sp	liver	1	1.3067	99
control	egg	0	1.7087	
control-sp1	egg	5	6.4300	*94*
control-sp2	egg	50	44.1829	85

Table 7. Summary of 2002 quality assurance/quality control data for selenium duplicates.

Selenium Duplicates				Selenium Duplicates		
ID Number	**Tissue**	**Result**		**ID Number**	**Tissue**	**Result**
		Selenium				***Selenium***
control-bld	blood	0.1748		EGG 26	embryo	3.0296
control-bld-dp	blood	0.1728		EGG 26DP	embryo	2.9649
SD*		***0.0014***		***SD***		***0.0457***
control-liv	liver	0.3204		EGG 37	embryo	1.6571
control-liv-dp	liver	0.3208		EGG 37DP	embryo	1.6761
SD		***0.0003***		***SD***		***0.0134***
control-egg	egg	0.6280		EGG 42	embryo	2.3519
control-egg-dp	egg	0.5890		EGG 42DP	embryo	2.3957
SD		***0.0276***		***SD***		***0.0310***
EGG 1	embryo	44.9348		EGG 48	embryo	2.1610
EGG 1DP	embryo	44.1291		EGG 48DP	embryo	2.1410
SD		***0.5697***		***SD***		***0.0141***
EGG 12	embryo	49.8232		EGG 56	embryo	11.2839
EGG 12DP	embryo	49.8953		EGG 56-DP	embryo	11.2047
SD		***0.0510***		***SD***		***0.0560***
EGG 20	embryo	2.2151				
EGG 20DP	embryo	2.1540				
SD		***1.5303***				
* = Standard Deviation						

Table 8. Summary of 2002 quality assurance/quality control data for boron control spikes and duplicates.

Boron Control Spikes				
ID Number	**Tissue**	**Spiked Boron**	**Result Boron**	**Percent Recovery**
control	egg	0	3.154	
control-sp	egg	10	12.731	96
Boron Duplicates				
ID Number	**Tissue**	**Result Boron**		
control-egg	egg	3.557		
control-egg-dp	egg	2.570		
SD*		***0.698***		
EGG 55	embryo	9.774		
EGG 55DP	embryo	10.175		
SD		***0.284***		
EGG 59	embryo	4.964		
EGG 59DP	embryo	4.894		
SD		***0.049***		
* = Standard Deviation				

DISCUSSION

The census data indicate that the project site is utilized by bird species common in agricultural habitats in the San Joaquin Valley. Both species diversity and relative abundance are lower than would be expected in native, undisturbed habitats. The tall vegetation within the pasture in Section 2 provided nesting habitat for Red-winged Blackbirds (*Agelaius phoeniceus*). The irrigation of pastures and alfalfa provide temporary foraging opportunities for birds such and White-faced Ibis (*Plegadis chihi*), Whimbrels (*Numenius phaeopus*), and blackbirds. Swainson's Hawks, which are listed as threatened by the State of California, were observed foraging on the project site and one pair successfully nested just north of the project site. Three species listed as "species of concern" by the State of California, the Burrowing Owl (*Athene cunicularia*), the Loggerhead Shrike (*Lanius ludovicianus*), and the California Horned Lark (*Eremophila alpestris actia*) were observed nesting on the project site, and White-faced Ibis, another "species of concern" were observed foraging, but not nesting on the project site.

Eggs are the best biotic indicator for selenium transfer and toxic biological effects (Skorupa and Ohlendorf 1991, Ohlendorf *et al.* 1993). Less than 3 ppm (dry wt) egg-selenium is the accepted population (or *geometric mean*) background level for birds (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993, Maier and Knight 1994). Eight ppm (dry wt) egg-selenium is considered the threshold level at which the probability of decreased hatchability increases (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993, Maier and Knight 1994). Eight ppm selenium is the approximate lower boundary for mean egg selenium levels associated with impaired hatchability for stilts and avocets in the Tulare Lake Basin (Skorupa and Ohlendorf 1991). Ten ppm (dry wt) selenium is the lower boundary for an individual egg associated with impaired embryo viability (Skorupa and Ohlendorf 1991). The threshold for mean egg-selenium associated with increased teratogenic effects in bird populations ranges from 13 to 24 ppm (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993). The Cumulative Impact Report on impacts of agricultural evaporation basins in the southern San Joaquin Valley (CH2M-Hill *et al.* 1993) used the midpoint of 18 ppm selenium as the teratogenic threshold. Ohlendorf *et al.* (1993) reported that mean egg-selenium concentrations greater than 20 ppm were associated with increased reproductive impairment at the population level.

Based on additional data since 1993, the embryotoxicity threshold for Black-necked Stilts is between 6 and 7 ppm selenium (Skorupa 1998). Since stilt embryos have been shown to be more sensitive than avocets to *in ovo* selenium exposure (Skorupa 1998), it is assumed that it is safe to apply this threshold to recurvirostrids as a whole. In addition, based on updated recurvirostrid egg-selenium data, the USFWS has proposed increasing the performance standard for mitigation sites to a maximum geometric mean of 4.0 ppm selenium (J. Skorupa, pers. comm.).

More recently, additional papers on selenium toxicity thresholds have been published. A recent analysis of laboratory data for Mallards (CH2M-Hill 2000) suggests that there is a 10% depression in egg hatchability at 8.4 ppm egg-selenium concentration. Fairbrother *et al.* (1999) and Adams *et al.* (2002) have posited alternative selenium toxicity thresholds for birds. Adams *et al.* (2002) argue that about 12 to 15 ppm selenium in Mallard eggs is required to create a 10% depression in egg hatchability based on a review of lab studies. The authors also argue that, based on their analysis of USFWS field data on stilts, a 10% depression in egg hatchability does not occur until a 21 to 31 ppm selenium threshold is reached. The above authors calculated threshold findings based on locating the EC 10 (*i.e.*, the concentration level at which ten per cent of the population is effected) level, whereas, Skorupa (1998) calculated the 6 to 7 ppm threshold by locating the EC 3 level.

All of the eggs sent for analysis by H. T. Harvey & Associates, including the reference eggs for Killdeer collected off the site, contained egg-selenium concentrations above the background level (3 ppm dry wt.) for shorebirds (CH2M-Hill et al. 1993). The Killdeer eggs from the project site contained selenium concentrations within the range (8-18 ppm dry wt) associated with an increased probability of reduced hatchability (CH2M-Hill et al. 1993). One of the reference Killdeer eggs contained selenium concentrations within that same range. The remaining four reference eggs for Killdeer contained selenium concentrations within the range (3 to 7.9 ppm) that has been associated with an increased probability of effects on avian reproduction. The combined recurvirostrid eggs from the project site contained one egg within the range (3 to 7.9 ppm) that has been associated with an increased probability of effects on avian reproduction, three eggs within the range (8-18 ppm dry wt) associated with an increased probability of reduced hatchability, and one egg was in the range (>18 ppm) that has been associated with a high probability of reproductive effects, including reduced hatchability and increased occurrence of embryo deformities (teratogenesis).

Previously collected data from various freshwater sites in the San Joaquin Valley detected low levels of egg-selenium content within Killdeer eggs (Table 9). Fifteen of these 18 Killdeer eggs (83%) contained less than 2 ppm selenium. Seventeen of these 18 eggs (94%) contained less than 2.3 ppm selenium. The median geometric mean egg-selenium content for these 11 reference sites is 1.7 ppm. The elevated selenium levels found in the reference eggs for Killdeer collected from off the project site (mean = 6.7 ppm, range 5.2 - 8.6 ppm) indicates that this set of eggs is not a true background but rather an indicator of the ambient selenium exposure from the project area. All of the Killdeer nests from which eggs were collected both on and off the project site were adjacent to or in close proximity to open drainwater ditches. These drainwater ditches were likely the source of the elevated selenium found in the sampled eggs.

Boron has been suggested to cause impacts to wildlife at the evaporation basins in the San Joaquin Valley (Ohlendorf *et al.* 1993). Boron has only one oxidation state (+3) with boric acid being the primary form in evaporation basins, but may convert to borax as evaporation concentrates the salts (Tanji and Grismer 1989). Boron bioconcentrates in aquatic organisms (plants and invertebrates), but evidence is lacking that biomagnification occurs in aquatic ecosystems (Maier and Knight 1991). Most sets of avian eggs from evaporation basins average <5 ppm boron (Ohlendorf *et al.* 1993). Current information indicates that slightly elevated egg boron does not cause embryotoxicity (Ohlendorf *et al.* 1993).

Table 9. Killdeer egg-selenium content from freshwater reference sites in the San Joaquin Valley.

Reference Site	Sample Size	Geometric Mean Egg Selenium (ppm)
1988 Semitropic Storage Basin	2	1.9
1989 Corcoran Sewage Ponds	3	1.8
1991 Corcoran Sewage Ponds	1	1.7
1991 Kern NWR	1	0.6
1993 Kern NWR	2	1.2
1993 Pixley NWR	1	1.0
1994 Westlake Demo Wetland	1	2.2
1994 Buena Vista Canal	2	1.1
1995 Hacienda East Flood Basin	1	1.7
1996 Westlake Demo Wetland	3	2.1
1997 Los Banos WMA	1	2.2

Source: J. P. Skorupa, USFWS, unpublished data.

The results of boron analysis of the five Killdeer eggs collected from the project site (mean = 5.4 ppm, range = 4.4 – 6.1 ppm), the reference Killdeer eggs (mean = 3.6 ppm, range = 3.0 – 4.2 ppm), and the combined recurvirostrid eggs from the project site (mean = 6.0 ppm, range = 4.9 – 10 ppm), were slightly above 3 ppm dry weight background level. The presence of elevated boron-egg content indicates that boron should continue to be monitored in eggs collected from the project site.

The elevated selenium levels in reference Killdeer eggs collected in the vicinity of the project site indicate that pathways to selenium exposure may exist outside of the immediate project site, especially considering the background levels in true control Killdeer eggs collected elsewhere in the San Joaquin Valley. Thus, selenium contamination at this site may be complex relative to the rather straightforward agricultural drainwater basin systems. The current egg collection sample sizes are too small to address the complexities of selenium exposure pathways on and near the site. Therefore, increasing the number of eggs collected from Killdeer and recurvirostrids in future years should be considered.

LITERATURE CITED

Adams, W. J., K. V. Brix, M. Edwards, L. M. Tear, D. K. DeForest, and A. Fairbrother. 2002. Analysis of field and laboratory data to derive selenium toxicity thresholds for birds. Parametrix, Inc. Kirkland, Washington. 32 pp.

CH2M-Hill. 2000. Relative Sensitivity of Avian Species to Selenium-related Reproductive Effects. Prepared for Chevron Richmond Refinery. 2485 Natomas Park Drive, Suite 600. Sacramento, CA 95833-2937.

CH2M-Hill, H. T. Harvey & Associates, and Gerald L. Horner. 1993. Cumulative impacts of agriculture evaporation basins on wildlife. Prepared for Department of Water Resources.

Environmental Science Associates (ESA). 1997. CVP Water Assignment from Mercy Springs District (Contract No. 14-06-200-3365A) to Pajaro Valley Water Management Agency, Preliminary Environmental Assessment. Prepared for Pajaro Valley Water Management Agency and Mercy Springs Water District. March 13, 1997.

Fairbrother, A., K. V. Brix, J. E. Toll, S. McKay, and W. J. Adams. 1999. Egg Selenium concentrations as predictors of avian toxicity. *Human and Ecological Risk Assessment*. 5:1229-1253.

Maier, K. J., and A. W. Knight. 1991. The toxicity of waterborne boron to *Daphnia magna* and *Chironomus decorus* and the effects of water hardness and sulfate on boron toxicity. Archives of Environmental Contamination and Toxicology 20:282-287.

Maier, K. J., and A. W. Knight. 1994. Ecotoxicology of selenium in freshwater systems. Reviews of Environmental Toxicology 134:31-48.

Ohlendorf, H., J. Skorupa, M. K. Saiki, and D. A. Barnum. 1993. Food-chain transfer to trace elements to wildlife. pp. 596-603 *In* (R.G. Allen and C.M.U. Neals, eds.). Management of Irrigation and Drainage Systems: Integrated Perspectives, Proceedings of the 1993 National Conference on Irrigation and Drainage Engineering, American Society of Civil Engineers, New York, N.Y.

Provost and Pritchard, Inc. 1999. CVP Water Supply Partial Contract from Mercy Springs Water District (Contract No. 14-06-200-3365A) to Pajaro Valley Water Management Agency, Santa Clara Valley Water District, and Westland Water District, Final Environmental Assessment and Finding of No Significant Impact. U. S. Bureau of Reclamation. April 12, 1999.

SAS Institute Inc. 1985. SAS User's Guide: Statistics. 5th Edition. SAS Institute Inc., Cary, NC.

Skorupa, J. 1998. Selenium poisoning of fish and wildlife in nature: twelve real-world examples. pp. 315-354 *In* (W. T. Frankenberger, Jr., and R. A. Engberg, eds.). Environmental Chemistry of Selenium. Marcel Dekker, New York, N.Y.

Skorupa, J., and H. Ohlendorf. 1991. Contaminants in drainage water and avian risk thresholds. pp. 345-368 *In* (A. Dinar and D. Zilberman, eds.). The Economics and Management of Water and Drainage in Agriculture. Kluwer Academic Publishers.

Tanji, K., and M. Grismer. 1989. Physiochemical efficacy of agricultural evaporation ponds: an interim literature review and synthesis. Prepared for Department of Water Resources, Agreement No. B-56769.