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April 7, 2011

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Subject: San Joaquin River Water Quality Improvement Project, 2010 Wildlife Monitoring Report

Enclosed is the 2010 Monitoring Report (2010 Report) for the San Joaquin River Water Quality Improvement Project (SJRIP) prepared by H. T. Harvey & Associates. This is the tenth year of bird egg monitoring at the project site. Eggs were collected from recurvirostrids (black-necked stilt and American avocet), killdeer, and red-winged blackbirds.

Also reported is the third year of the tiered contaminant monitoring program designed to detect potential selenium exposure to San Joaquin kit foxes by monitoring selenium levels in vegetation, small mammals and a coyote. The coyote sampling selenium levels in both blood and hair were within normal background levels for mammals and also below the thresholds that would require compensation habitat for San Joaquin kit fox established in the Final Biological Opinion for the 2010-2019 Use Agreement for the Grassland Bypass Project completed in December 2009.

The attached figures summarize the monitoring results.

Panoche Drainage District acquired 1,901 acres of additional lands in 2007. Monitoring on these lands began in 2008 even though application of drainwater to the newly acquired lands has not yet begun. The results from 2008 and 2009 will provide data that describes the baseline (pre-project) conditions of these 1,901 acres.

Hazing birds during the nesting season, diligent water management, and modification of drains to discourage avian use continued during this reporting period. Only 2 recurvirostrid nesting attempts occurred in the entire 4,000 acre eastern project area. There were no recurvirostrid nesting attempts in the recently acquired 1,901 acre western project area. Hazing and closing drains will continue as part of the operation of the improvement project in future years.

The following measures were implemented in 2007 and continued in 2010 to reduce exposure potential and mitigate exposure to birds.

1) Reduced exposure potential by reducing attractiveness of drainage ditches for nesting.
2) Reduced exposure potential by hazing birds from nesting near, and foraging in, irrigation (and drainage) ditches.
3) Flooded field contingency plan.
4) Provide mitigation breeding habitat.
5) Reducing exposure to open drains.

In 2010 the mitigation site was continued at the same location as in 2008 and 2009. This resulted in 18 times more recurvirostrid nest-attempts at the mitigation site as on the project site.

Questions regarding this data should be directed toward Joe McGahan, Drainage Coordinator for the Grassland Bypass Project. He can be reached at 559-582-9237.

Very truly yours,

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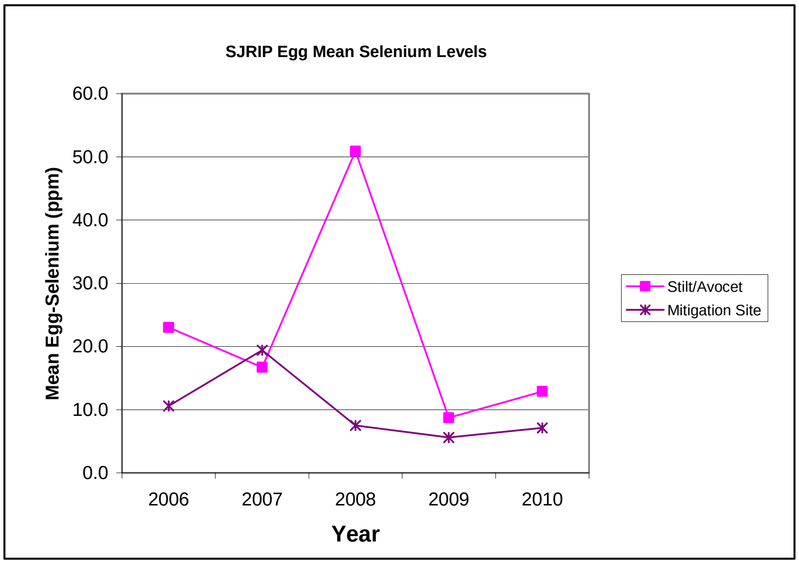
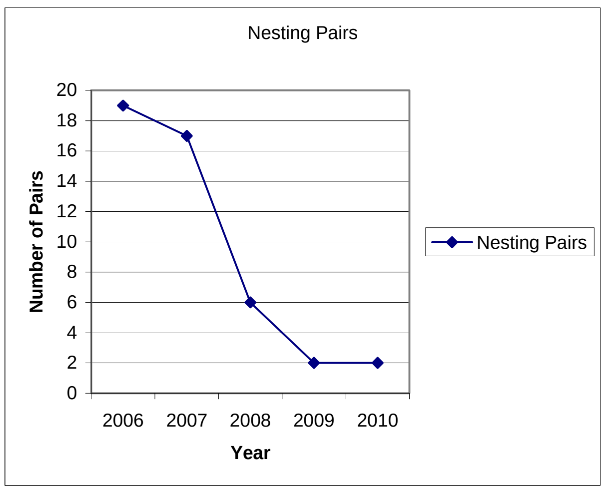
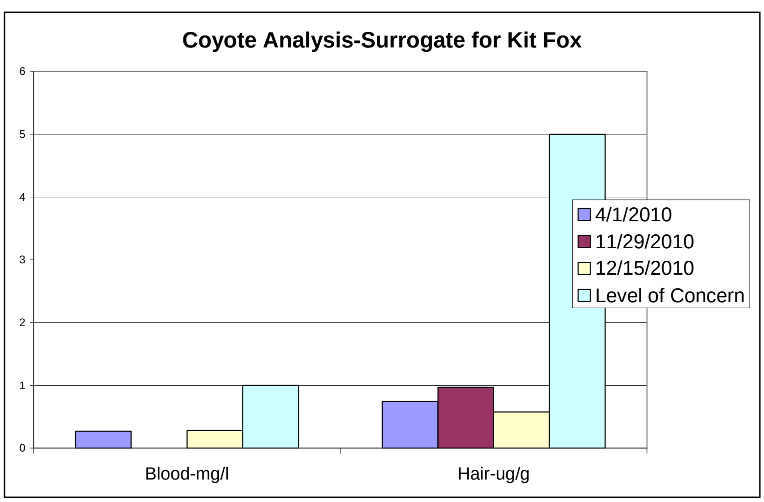

SJRIP Egg Mean Selenium Levels
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Mean Egg-Selenium (ppm)
2006
2007
2008
2009
2010
Year
Stilt/Avocet
Mitigation Site


Nesting Pairs
20
18
16
14
12
10
8
6
4
2
0
Number of Pairs
2006
2007
2008
2009
2010
Year
Nesting Pairs


Coyote Analysis-Surrogate for Kit Fox
6
5
4
3
2
1
0
Blood-mg/l
Hair-ug/g
4/1/2010
11/29/2010
12/15/2010
Level of Concern

SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT, PHASE I WILDLIFE MONITORING REPORT 2010

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TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

CONTRIBUTORS

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David Zajanc, M.A., Wildlife Ecologist

EXECUTIVE SUMMARY

The results of the 10th year of biological monitoring for Phase I of the San Joaquin River Water Quality Improvement Project are presented in this report. The San Joaquin River Water Quality Improvement Project is designed to reduce the amount of salt and selenium delivered to the San Luis Drain and Mud Slough through the Grassland Bypass. At this point in the project, approximately 3873 acres of the original 4000-acre project site have been planted with salt-tolerant crops and irrigated with agricultural drainwater. Hereafter these 4000 acres are referred to as the eastern project area, as they occur east of Russell Avenue. An additional 1901 acres acquired in 2008 for future inclusion in the project, but not yet planted with salt-tolerant crops or irrigated with agricultural drainwater, were also monitored to determine baseline conditions. These 1901 acres are hereafter referred to as the western project area as they occur west of Russell Avenue.

The continuation of the avian monitoring conducted in 2010 included: bird use of the eastern and western project areas; numbers and outcomes of nesting killdeer, black-necked stilts, and American avocets; and selenium, boron, and mercury content of eggs of killdeer, black-necked stilts, American avocets, and red-winged blackbirds nesting on the project areas, pilot mitigation site, and reference area. In addition, the third year of a tiered contaminant monitoring program designed to detect potential selenium exposure to San Joaquin kit foxes by monitoring selenium levels in vegetation, small mammals, and coyotes was conducted within the eastern and western project areas.

An ornithologist from H. T. Harvey & Associates monitored bird use of the eastern and western project areas on 6 occasions from 6 May to 24 June 2010. The diversity of avian species detected and the number of individuals observed remained relatively low.

Habitat modifications combined with hazing precluded all but 2 recurvirostrid (black-necked stilt and American avocet combined) and 9 killdeer nest attempts within the eastern project area in 2010. Only 2 Killdeer and no recurvirostrids were detected nesting in the western project area in 2010. The Panoche Drainage District initiated management practices to avoid and minimize impacts to nesting shorebirds in 2006, including hazing of shorebirds from the project site, modification of open drains to discourage shorebirds from using traditional nest sites, and installation of a pilot mitigation site to provide clean-water nesting habitat for shorebirds. A total of 8.5 mi of drain have been filled, 1 mi of drain has been netted, and 1.3 mi has been reduced in size since 2006.

Eggs were collected for each of 3 avian species groups. These included 4 killdeer, 2 recurvirostrid, and 11 red-winged blackbird eggs from the eastern project area; 5 recurvirostrid eggs from the pilot mitigation site; and 15 killdeer, 14 recurvirostrid, and 11 red-winged blackbird eggs from the reference area. Eggs collected from the project areas, pilot mitigation site, and reference area were analyzed for selenium, boron, and mercury concentrations. Eggs from the reference area were collected to provide data on the local "background" concentrations of selenium, boron, and mercury.

Nearly all analyzed eggs contained at least partially elevated selenium concentrations. The geometric mean egg-selenium concentrations from the eastern project area were: 6.2 ppm for killdeer, 12.9 ppm for recurvirostrids, and 7.4 ppm for red-winged blackbirds. For the western project area, the geometric mean egg-selenium concentrations were 4.9 ppm, 11.2 ppm, and 4.2 ppm for killdeer, recurvirostrids, and red-winged blackbirds, respectively. The mean selenium levels in eggs collected from the eastern project area were significantly higher than those from the reference area in red-winged blackbirds. The geometric mean selenium concentration of recurvirostrid eggs from the mitigation site was 7.1 ppm.

The boron analysis of eggs collected from the eastern project area revealed that red-winged blackbirds had egg boron concentrations above the 3 ppm dry weight considered background. The geometric mean egg-boron concentrations from the eastern project area were 1.3 ppm for killdeer, 1.8 ppm for recurvirostrids, and 11.1 ppm for red-winged blackbirds. Western project area egg-boron concentrations were 1.3 ppm for Killdeer, 1.9 ppm for recurvirostrids, and 5.3 ppm for red-winged blackbirds. There was no significant difference in mean boron levels in eggs collected from the eastern project area and eggs collected from the reference area for either killdeer or recurvirostrids in 2010, though there was a significant difference for red-winged blackbirds.

Eggs collected were analyzed for mercury for the second year in 2010. All of the eggs sampled were within published recommended guidelines for egg-mercury concentrations (<0.5 ppm wet weight). The geometric mean egg-mercury concentrations (wet weight) from the eastern project area were 0.103 ppm for killdeer, 0.134 ppm for recurvirostrids, and 0.011 ppm for red-winged blackbirds. Western project area egg-mercury concentrations were 0.062 ppm for Killdeer, 0.136 ppm for recurvirostrids, and 0.017 ppm for red-winged blackbirds. There was no significant difference in mean mercury levels in eggs collected from the eastern project area and eggs collected from the reference area for all three groups.

Results of the Tiered Contaminant Monitoring Program included geometric means of 2.1 ppm selenium in vegetation and 4.4 ppm in small mammals collected from the eastern project area and 0.41 ppm selenium in vegetation and 1.4 ppm. The selenium level detected in 6 of 16 vegetation samples and 9 of 14 small mammal samples exceeded the threshold of 3 ppm, triggering the next level of monitoring in the Tiered Biological Monitoring Program, which is to monitor selenium levels in coyotes. Three coyotes were sampled in 2010. Blood samples were obtained from 2 of the coyotes and hair samples were obtained from all 3. The blood samples had selenium levels of 0.269 ppm (dry wt.) and 0.282 ppm, and the hair samples ranged from 0.578 ppm to 0.970 ppm. The whole blood and hair samples from these coyotes were well below the thresholds that would require compensation habitat for San Joaquin kit fox established in The Final Biological Opinion, 2010-2019 Use Agreement for the Grasslands Bypass Project completed in December 2010 (BO).

INTRODUCTION

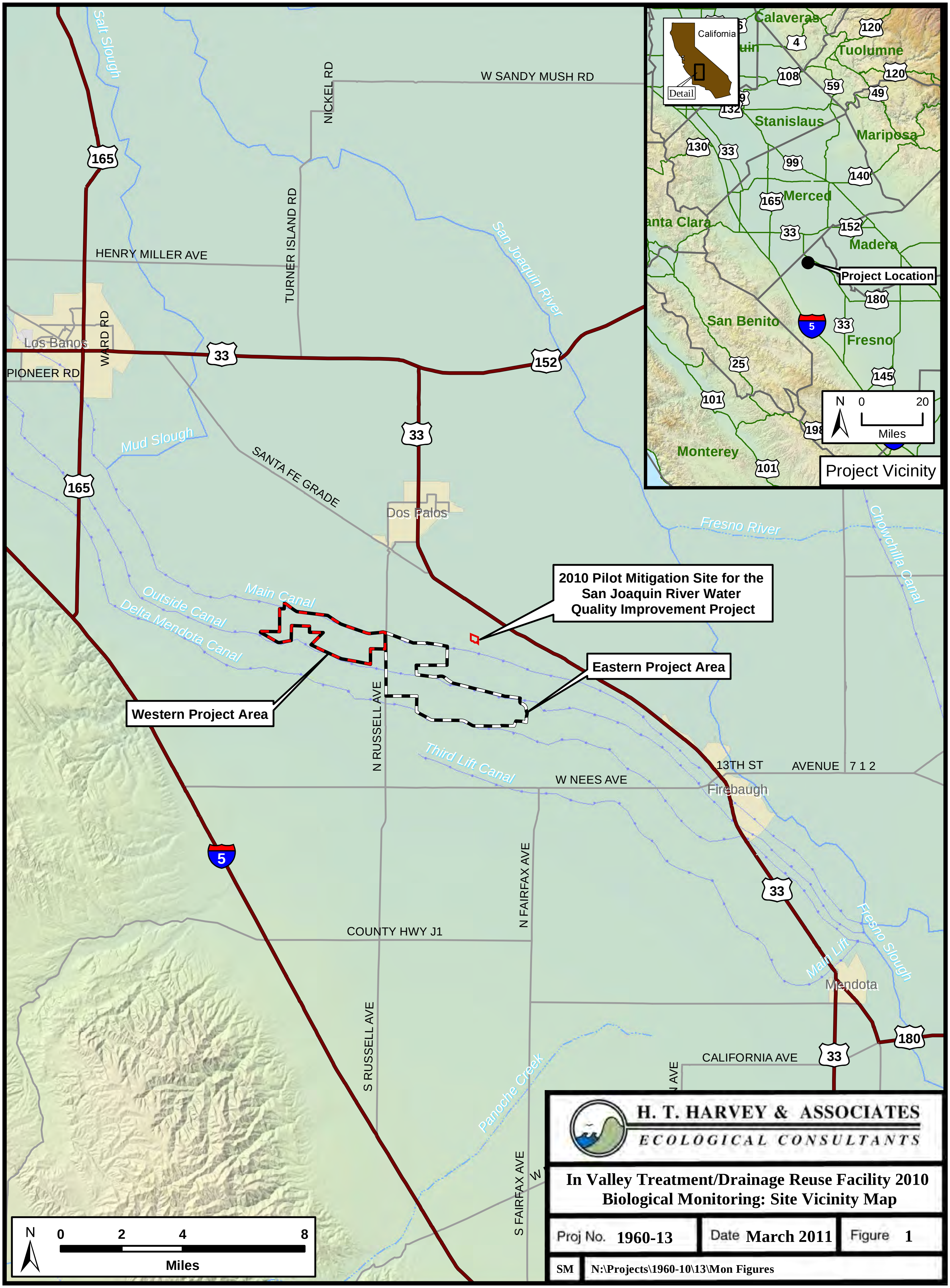
To reduce the amount of salt and selenium delivered to the San Luis Drain and Mud Slough through the Grassland Bypass Project, the San Luis and Delta Mendota Water Authority Grassland Basin Drainers implemented Phase I of the San Joaquin River Water Quality Improvement Project (SJRIP). The Panoche Drainage District, acting as the lead agency under the California Environmental Quality Act (CEQA), prepared a Negative Declaration for SJRIP in September 2000. The Negative Declaration included the provision for the development, in collaboration with the U.S. Fish and Wildlife Service (Service), of a biological monitoring program that would detect potential impacts to migratory birds resulting from exposure to elevated levels of selenium due to the project. This report represents the biological monitoring results for the 10th year (2010) of Phase I of the SJRIP.

The Final Biological Opinion for the Grasslands Bypass Project, October 1, 2001 – December 31, 2010 (BO) stipulates that a monitoring program and contingency plan be designed with consultation with the Service to address potential San Joaquin kit fox (*Vulpes macrotis mutica*) exposure to selenium at the SJRIP. A tiered contaminant monitoring program to measure selenium levels within constituents of the San Joaquin kit fox food chain was, therefore, implemented in 2008. The BO was updated in 2009 to cover the period from 2010 through 2019.

PROJECT DESCRIPTION AND SETTING

The eastern project area, the active portion of the project site, is located west of the city of Firebaugh in Fresno County, California (Figure 1). 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 western edge of the eastern project area and the western edge extends nearly to Fairfax Avenue (Figure 2).

The project is the initial development of an In-Valley Treatment/Drainage Reuse Facility on up to 6200 acres of land within the Grassland Drainage Area (GDA). The 6200 acres of GDA land is made up of 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 southeast corner at 164 ft above mean sea level, while the lowest point is found near a north-central point at 136 ft above mean sea level. Thus, the elevation change within the 6200-acre property is approximately 28 ft. The shape of the property is irregular, conforming to the area’s adjacent canals. Russell Avenue provides access to the property via a paved county road. Typical, improved farm roads provide access to the interior of the site.



H. T. HARVEY & ASSOCIATES

ECOLOGICAL CONSULTANTS

In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Site Vicinity Map

Proj No.	1960-13	Date	March 2011	Figure	1
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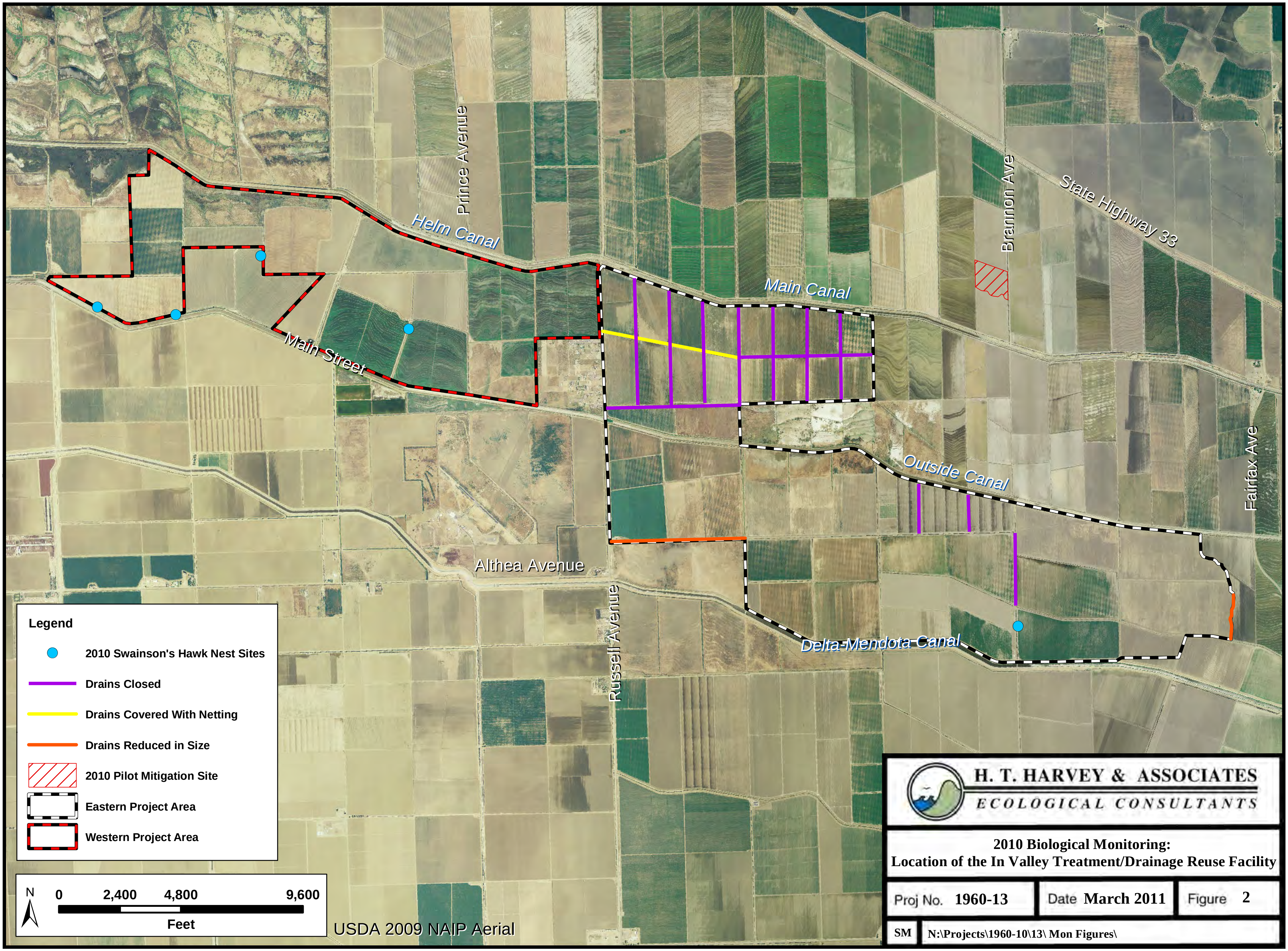

2010 Biological Monitoring:
Location of the In Valley Treatment/Drainage Reuse Facility

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The reuse facility dedicates 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 elements to prevent discharge into the San Joaquin River. The reuse facility will eventually process up to one-quarter of the total drainwater produced in the GDA (25% of 52,000 acre-feet or approximately 15,000 acre-feet) and will be implemented in 3 phases:

- 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 ideally situated land. Channels containing collected drainwater flow adjacent to this location, so water can easily be captured and placed on the land. Also, because this land is at the lowest elevation within the drainage area, collected water can be applied without excessive pumping costs.

Approximately 6000 acres had been purchased prior to 2010. Since 2001, approximately 3873 acres have been planted in crops and irrigated with water that otherwise would have been discharged into the San Joaquin River. Soil and water constituents at this project site are monitored to prevent irreversible soil changes and to protect groundwater from contamination.

In Phase II of the SJRIP, the application of saline water to lands developed in Phase I will continue. Subsurface drainage systems will be installed to leach the land and maintain a favorable salt balance. The water percolating below the root zone will be captured in the drainage system and passed on to more salt-tolerant crops to concentrate and decrease the volume of drainwater produced. Salt, selenium, and other constituents will be conveyed by water exiting the subsurface drainage systems. The final treatment phase of the SJRIP will remove the salt, selenium, and much of the other constituents, leaving water for beneficial uses, such as agriculture. The treatment system will be designed to incorporate into the reuse system. The remaining salt will be deposited into approved waste units that will result in additional reductions in salt and selenium discharges into the San Joaquin River and will maximize improvement in water-quality and meet reductions needed for future water-quality objectives.

Each phase of the facility will significantly reduce the amount of drainwater discharged to the San Joaquin River. Water sufficient for reuse on GDA agricultural lands could also be produced by the treatment systems. The project was designed to assist Grasslands Area Farmers in meeting applicable water-quality objectives for the 2010 calendar water year. The 2010 annual selenium-load limit, based on the current applicable total maximum monthly load, was 3545 lbs. In comparison, the load value for the 2001 water year was 5661 lbs. This reduction in load size required implementation of additional methods to manage drainage.

An Initial Study and Negative Declaration adopted 9 September 2000 by Panoche Drainage District, evaluated Phase I of the facility. The second and third phases of the facility were evaluated in the Grassland Bypass Project EIS/EIR, finalized 25 May 2001, and a Biological Opinion issued by the Service on 27 September 2001. Phase I is independent and does not exclude the consideration of alternatives to the larger project or project site. Even if the In-

Valley Treatment/Drainage Reuse Project progress were to halt at Phase I, the drainage management alone would be valuable. In addition, the proposed cropping patterns are reversible should later phases of the project not be implemented.

The Panoche Drainage District acquired 1901 acres of Phase I lands in 2008 (Figures 1 and 2) located west of Russell Avenue between the Main and Outside canals. Monitoring of avian numbers and selenium content of bird eggs, vegetation, and small mammals on these 1901 acres began in 2008, even though application of drainwater to the western project site has not yet begun. The results from 2008 to 2010 will provide data comprising the baseline (pre-project) conditions of these 1901 acres.

Pilot Mitigation Site

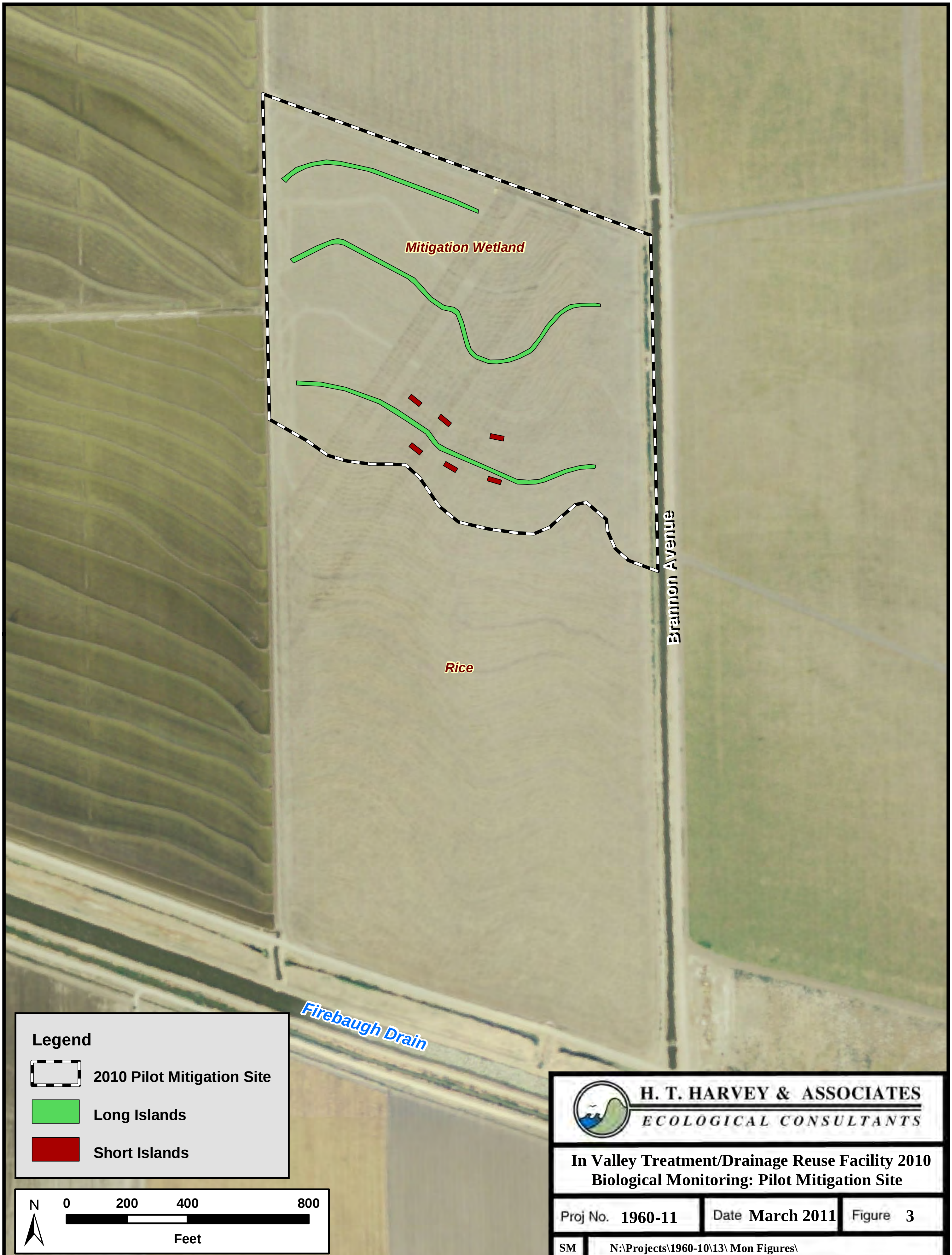
The Negative Declaration for SJRIP adopted in September 2000 included provisions for wildlife monitoring capable of assessing project-related impacts to wildlife. Provisions were also included for the adaptation of mitigation measures if the monitoring program detected negative project-related impacts.

Based on waterborne and egg-selenium levels within the eastern project area, lethal and sublethal effects on waterbirds breeding at project site are probable. Water samples from the sources of drainwater used to irrigate the eastern project area ranged from 43 to 761-ppb selenium from 2003 to 2005 (Panoche Drainage District data). Such levels are well above the level of waterborne selenium (32-ppb) associated with a high probability of reduced hatchability and increased probability of teratogenesis (CH2MHill et al. 1993). Egg-selenium monitoring at the eastern project site has found elevated egg-selenium levels in both recurvirostrid and killdeer eggs. Egg-selenium levels in both groups have been higher than in similar sets of reference eggs collected from the project vicinity. Annual geometric mean egg-selenium levels from recurvirostrid eggs have varied, but from 2003 to 2009, most means were also above the level (18-ppm) associated with an increased probability of reduced hatchability and teratogenesis.

Beginning in 2006, 3 mitigation measures were implemented to reduce impacts to nesting shorebirds. The first measure consisted of dredging the bottom of open drains consistently used by shorebirds to eliminate potential feeding and nesting substrates. The next measure consisted of Panoche Drainage District personnel discharging cracker shells to discourage shorebird use where shorebird nesting had been concentrated in the past. These hazers patrolled the project site throughout the day to discourage breeding birds from establishing nests. The third measure consisted of enhancing habitat for nesting shorebirds outside the project site at a site with clean (non-seleniferous) water.

These measures were continued and enhanced in 2007. Several drains were filled in the northern portion of the eastern project area (Sections 2 and 3) where killdeer and recurvirostrid nesting had been concentrated in recent years, and drains that could not be filled were covered with netting to prevent bird use. Drain closure and netting expanded into the southern portion of the eastern project area in 2008. To date, a total of 8.5 mi of drain have been filled in, 1 mi of drain has been netted, and 1.3 mi of drains have been re-contoured and reduced in size (Figure 2).

Approximately 50 acres of improved shorebird breeding habitat comprising nesting islands within cultivated rice has been provided as mitigation since 2006. In 2010, the pilot mitigation site was at the northern edge of a rice field north of the Main Canal (Figures 2 and 3). As in 2009, rice was not planted within the pilot mitigation site, to provide a more open wetland habitat more amenable to shorebird foraging and nesting. The connecting ends of 3 of the interior contour dikes were removed to provide nesting islands for shorebirds. A cluster of six smaller islands were also present (Figure 3).



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In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Pilot Mitigation Site

Proj No. 1960-11	Date March 2011	Figure 3
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MATERIALS AND METHODS

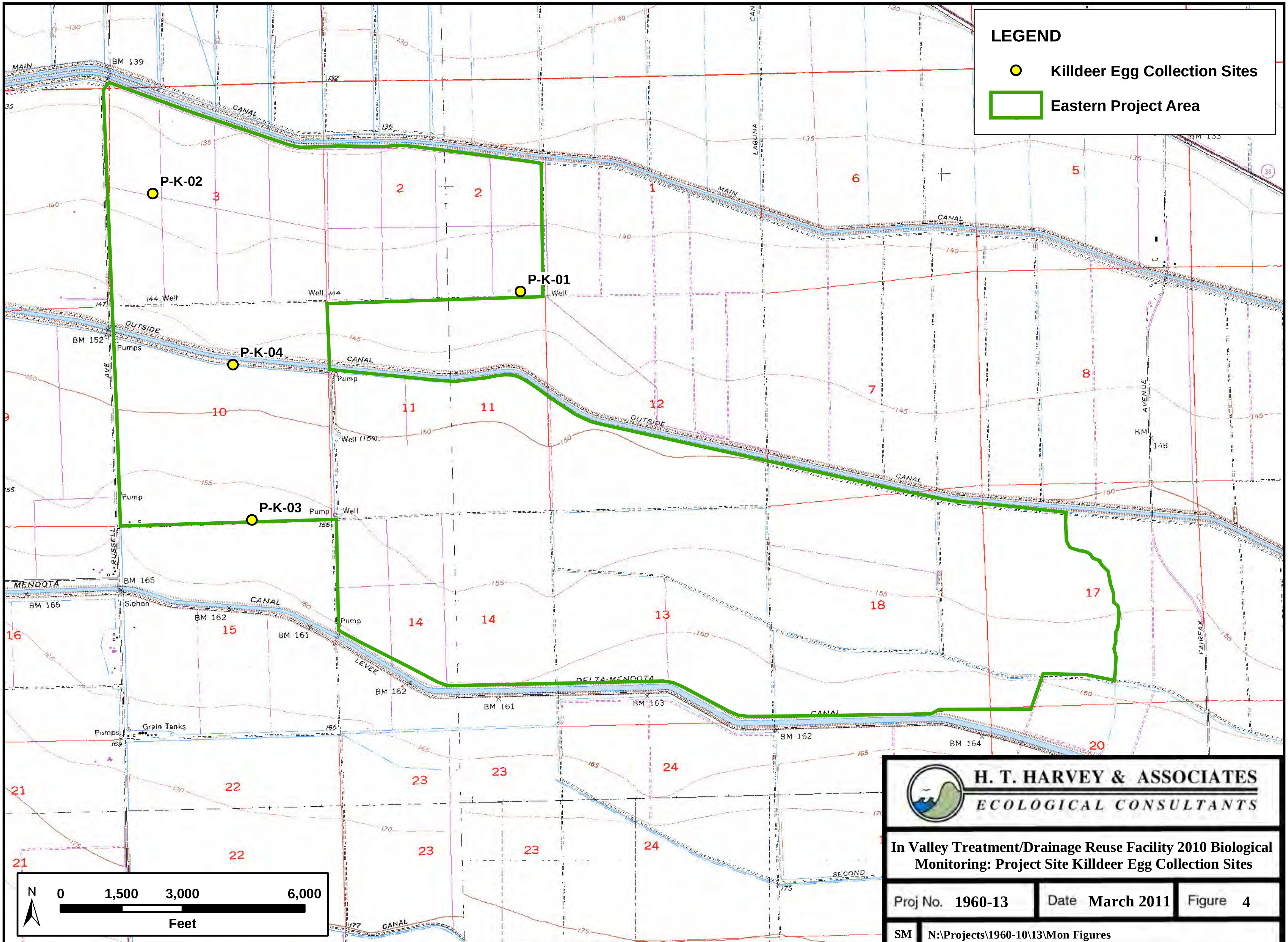
BIRD CENSUSES

An ornithologist from H. T. Harvey & Associates monitored bird use at the project site on 6 occasions from 6 May to 24 June 2010. Censuses were completed by driving the perimeter roads of each field. Birds were identified and counted using 10X binoculars and a 20-60X spotting scope mounted on a tripod. Censuses were conducted to determine species composition and relative abundance of bird species on the eastern and western project areas during the breeding season.

EGG COLLECTION AND PROCESSING

Five killdeer (*Charadrius vociferus*) eggs, 2 recurvirostrid eggs (American avocets [*Recurvirostra americana*] or black-necked stilts [*Himantopus mexicanus*]), and 11 red-winged blackbird (*Agelaius phoeniceus*) eggs were collected from the eastern project area for selenium, boron, and mercury analysis. The locations from which killdeer, recurvirostrid, and red-winged blackbird eggs were collected from the eastern project area are illustrated in Figures 4, 5, and 6; respectively. Scientific collecting permits were obtained from the California Department of Fish and Game (CDFG) and the Service for the collection of bird eggs on the site. One egg was randomly collected from separate, full-clutch (4 eggs) nests. Three additional sets of 15 reference killdeer eggs (Figure 7), 14 recurvirostrid eggs (Figure 8), and 11 red-winged blackbird eggs (Figure 9) were collected from the project vicinity to provide reference data on regional selenium, boron, and mercury concentrations outside the project area. The red-winged blackbird eggs and 2 of the killdeer eggs were collected from the western project area to provide data on the baseline contaminant exposure prior to the site being part of the drainage re-use portion of the San Joaquin Water Quality improvement Project. There was not enough embryo material to accurately analyze selenium, boron, or mercury for 1 of the red-winged blackbird eggs collected from the western project area. No recurvirostrid nests or killdeer nests beyond the 2 reported were located on the western project area. No recurvirostrids were observed there and the few killdeer that were observed were typically located near the boundaries of the site. One black-necked stilt and 4 American avocet eggs were also collected from the mitigation site for selenium, boron, and mercury analysis.

Collected eggs were labeled with a permanent marker, and all of the egg contents, including membranes, were removed from the shell and transferred to 1-oz Dynalon jars. The embryo was examined for morphological abnormalities, and the stage of incubation was established using photographs of known-age embryos. The embryo was also examined to determine if it was alive or dead and photographed. The egg contents were stored by freezing.



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In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Project Site Killdeer Egg Collection Sites

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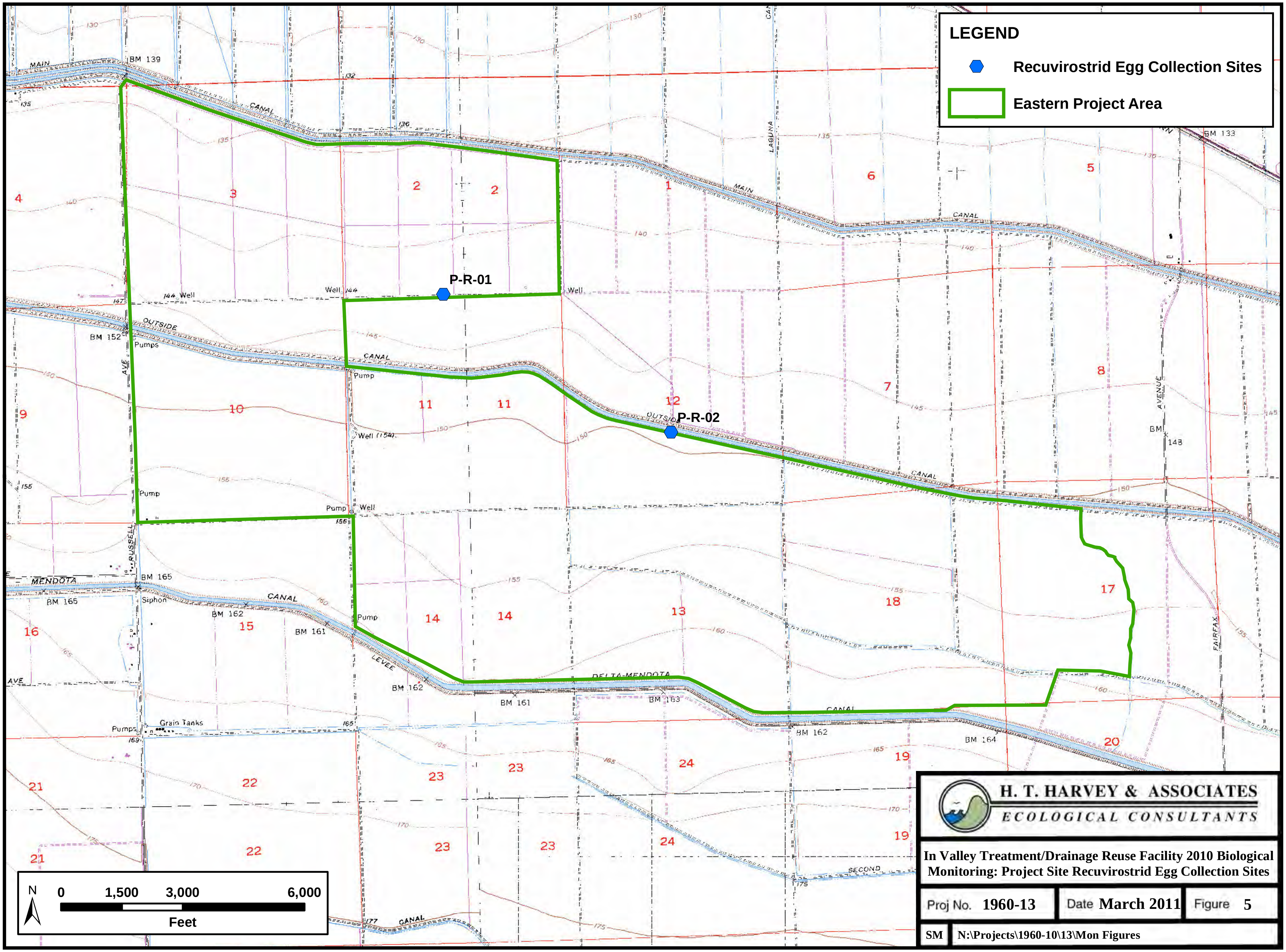

In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Project Site Recuvirostrid Egg Collection Sites

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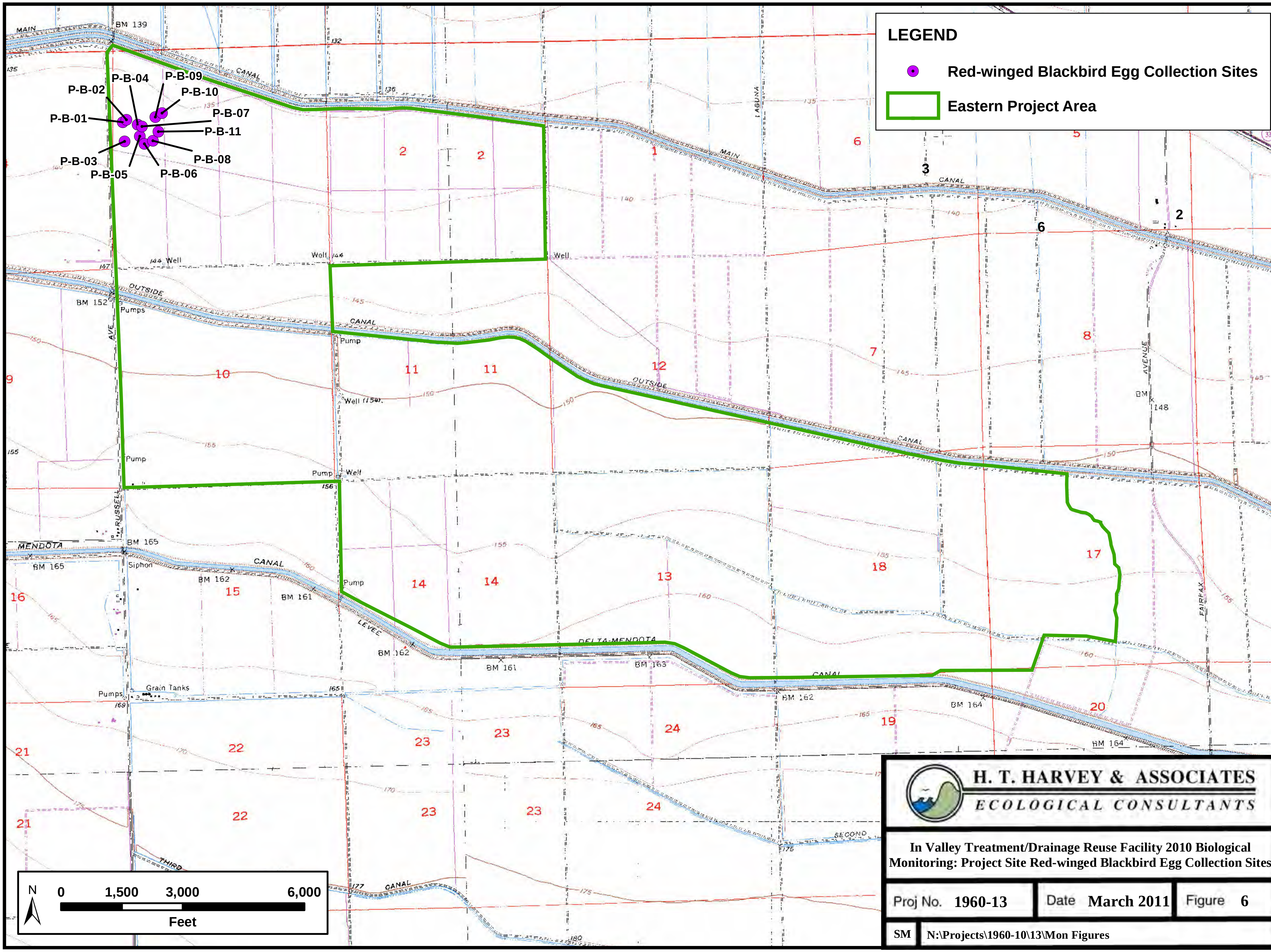

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In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Project Site Red-winged Blackbird Egg Collection Sites

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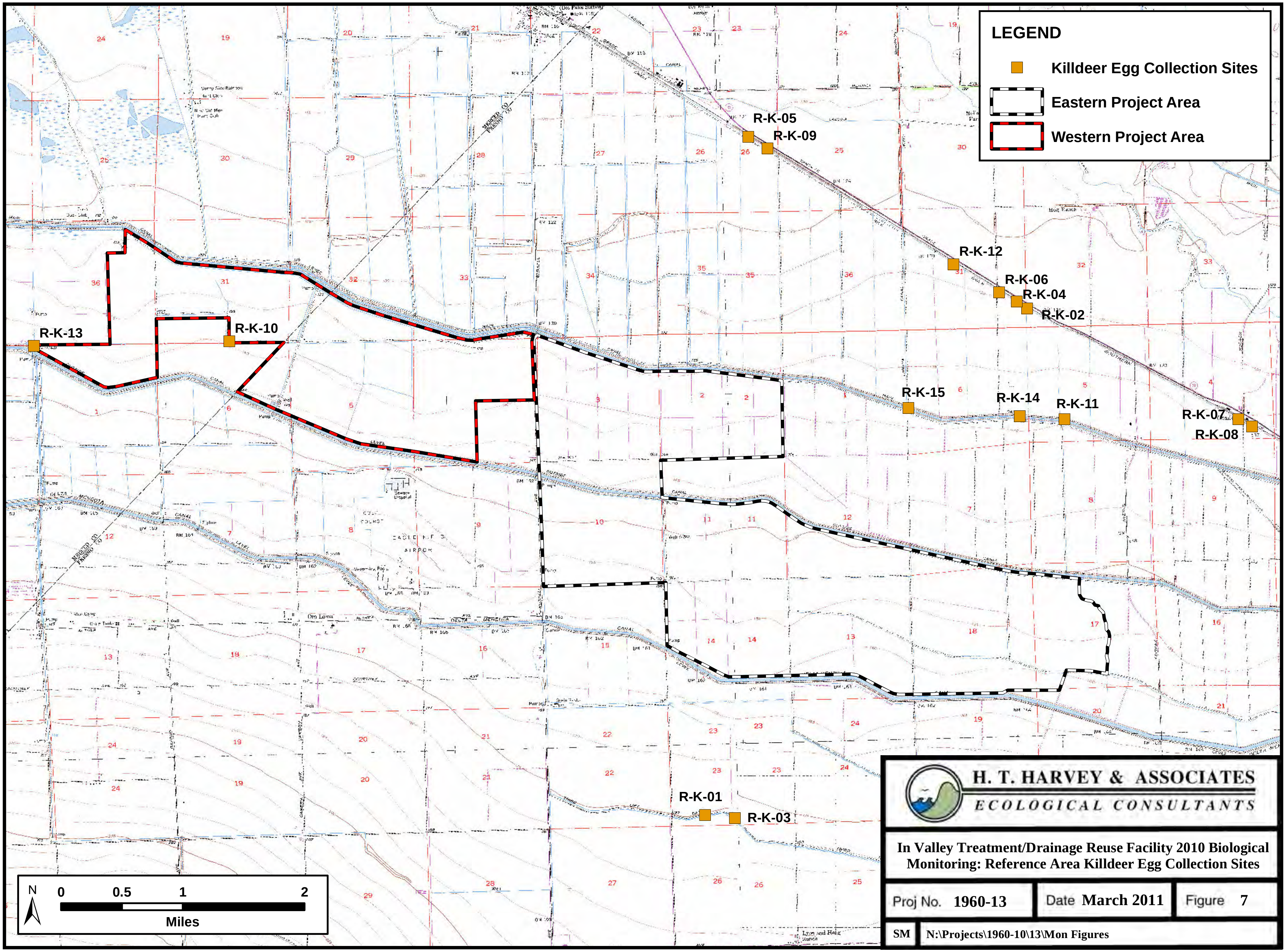

In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Reference Area Killdeer Egg Collection Sites

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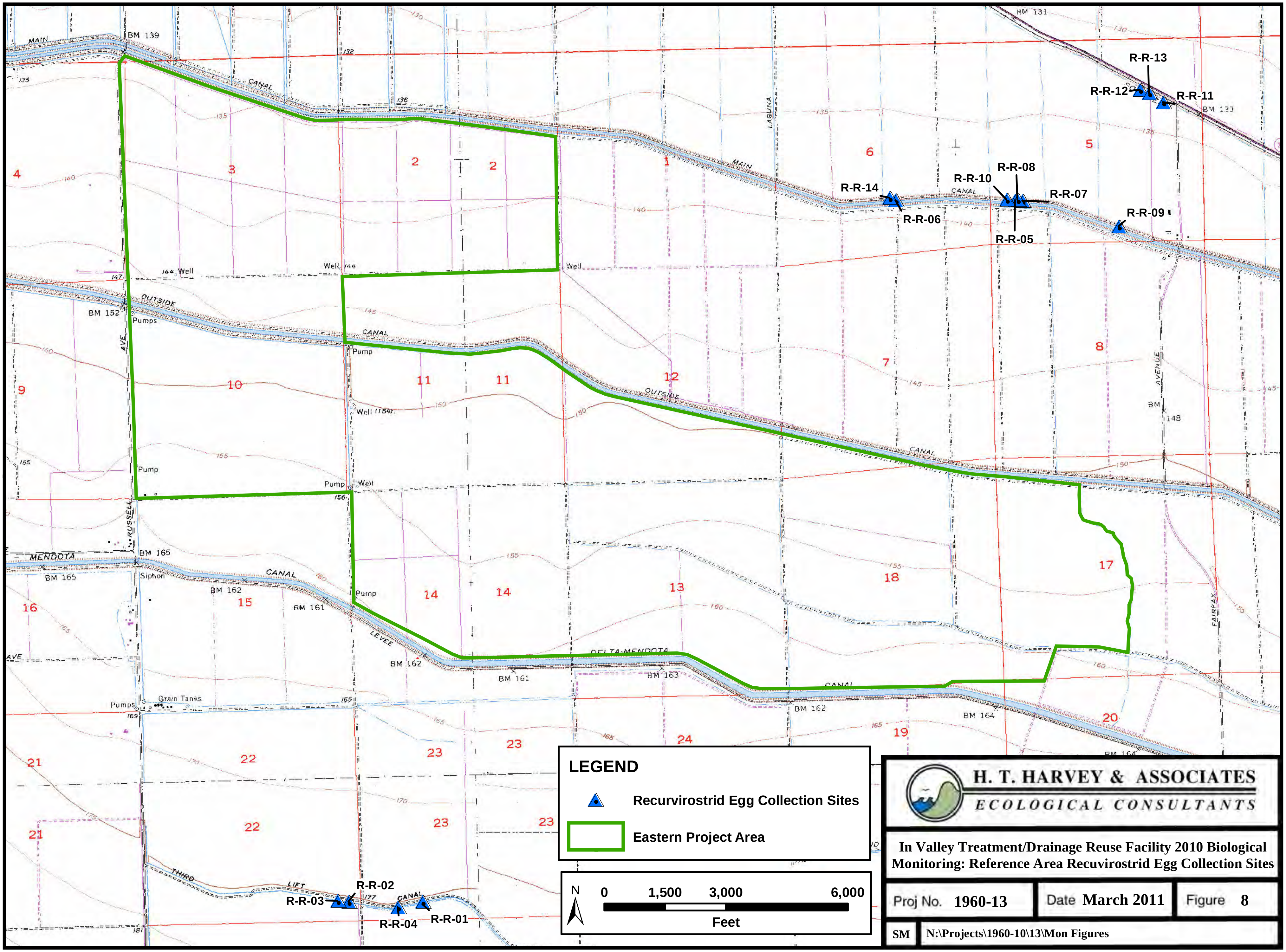

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In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Reference Area Recuvirostrid Egg Collection Sites

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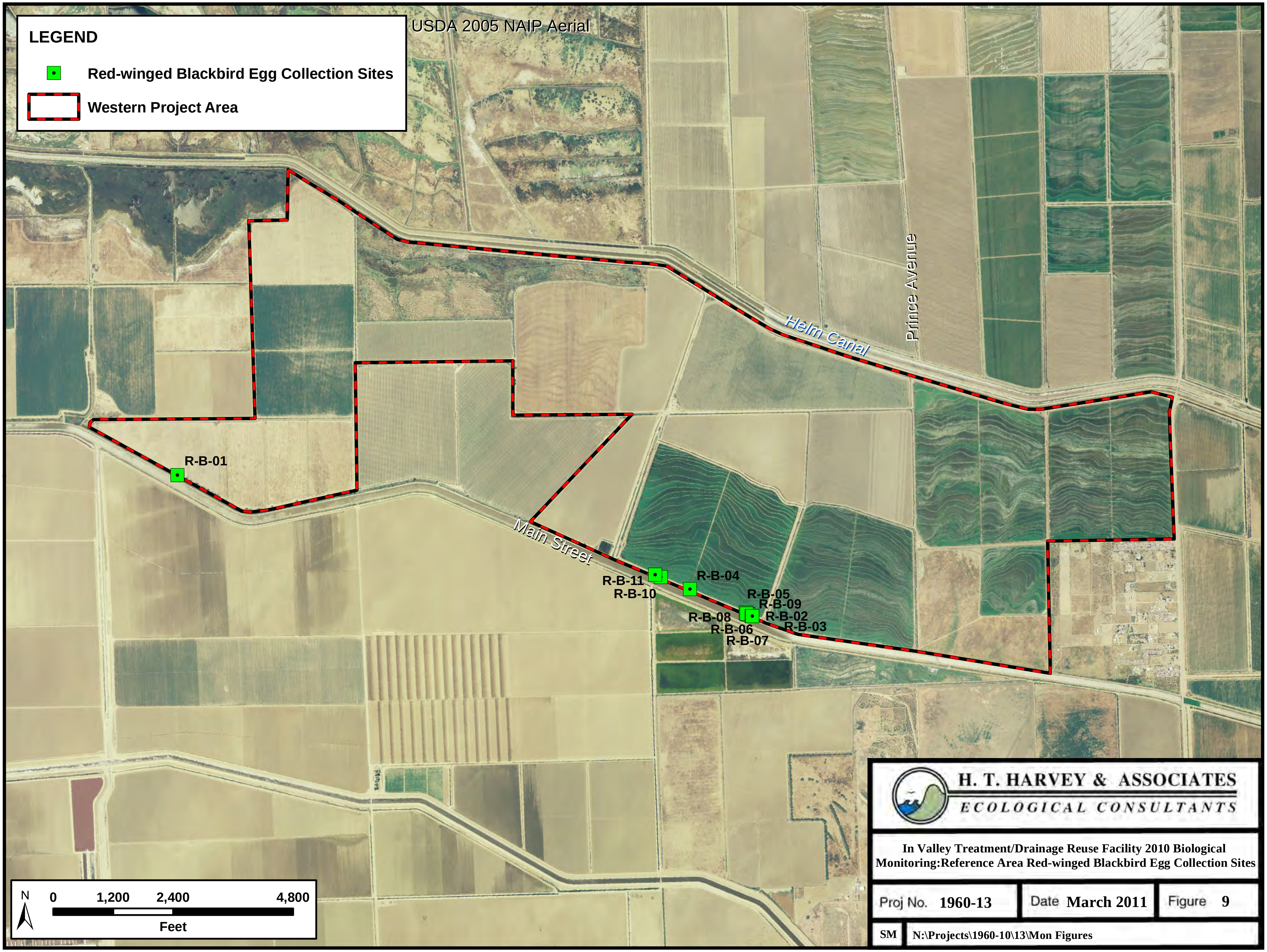

In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring:Reference Area Red-winged Blackbird Egg Collection Sites

Proj No. 1960-13 | Date March 2011 | Figure 9

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EGG CHEMISTRY ANALYSIS

All egg contents collected by H. T. Harvey & Associates were shipped overnight on dry ice to the Oscar E. Olson Biochemical Laboratory at South Dakota State University. Selenium concentrations were determined using the Association of Official Analytical Chemists method 996.16. Boron levels were quantitated by a nitric acid/peroxide digest in a microwave oven and an inductively coupled plasma optical emission spectrometer. All egg-selenium and egg-boron concentrations were presented and in parts per million (ppm) based on dry tissue weight (dry weight). Whole mercury concentrations were determined using Cold Vapor Atomic Fluorescence Spectroscopy. Egg-mercury results were analyzed based on dry weight values in parts per billion (ppb). Egg-mercury results in ppm based on wet weight are also presented because that is the format most published toxicity thresholds for egg-mercury are presented. For quality control, selected sub-samples were divided into 2 aliquots. The duplicate was spiked with known amounts of selenium, boron, or mercury and the samples were tested to determine the accuracy of the analysis.

Analyses of 2010 Data

Descriptive statistics for chemical concentrations of selenium, boron, and mercury in sampled eggs from 2010 were calculated (geometric mean and range of raw data, and confidence intervals and means for log-transformed data), and chemical concentrations in eggs were compared between eastern project area and reference sites for killdeer, recurvirostrids, and red-winged blackbird. All chemical concentrations were log-transformed ($log_{10}(x+1)$, where x is the concentration) to homogenize variance as much as possible. We used 1-way ANOVA to test for the effect of location (project and reference only) on selenium, boron, and mercury concentrations in killdeer, recurvirostrids, and red-winged blackbirds, eggs collected in 2010. For all tests conducted, a p-value of less than 5% ($P<0.05$) was considered significant, a p-value between 5% and 10% ($0.05<P<0.10$) was considered inconclusive, and a p-value greater than 10% ($P>0.10$) was considered not significant.

We also used 1-way ANOVA to evaluate egg-chemical concentrations for recurvirostrids at mitigation sites compared to the eastern project area and the reference site. If the initial results from the ANOVA were significant or inconclusive, Tukey's multiple comparison tests (based on honest significant differences) were used to evaluate potential differences between pairs of sites.

Analyses Across Years

Linear mixed effects models were used to evaluate egg-selenium and egg-boron concentrations due to location and time for killdeer, recurvirostrids, and red-winged blackbird, based on data from 2002 to 2010. Egg-selenium or egg-boron concentration was the dependent variable; egg-selenium and egg-boron concentrations were log-transformed ($log_{10}(x+1)$, where x is the concentration) to homogenize variance as much as possible. Location, time, and the interaction between location and time were treated as fixed effects; time was also treated as a random effect to account for annual variability. Mixed-effects models allow for modeling variation due to random effects (i.e., associated with sampling units drawn randomly from a population) (Pinheiro and Bates 2004) that potentially interfere with interpretation of the effects of greatest interest to the experiment (i.e., fixed effects). Assumptions of the model regarding homogeneity of variance and normality of the error term were assessed graphically to evaluate the appropriateness of the model being used. If the assumptions appeared to be violated, Kruskal-Wallis non-parametric tests were conducted to examine the effects of location and time on egg chemical concentrations. Results were summarized in terms of the significance of each of the possible fixed effects, based on likelihood ratio tests comparing models with and without the fixed effect.

NEST FATE

In addition to egg-selenium monitoring, killdeer and recurvirostrid nests within the eastern project area and mitigation sites were monitored to determine nest fate. Active nests were located by conducting vehicle surveys for adult killdeer and recurvirostrids. Once located, adults were monitored with a spotting scope or binoculars until a nest location could be determined. Nests were located at the mitigation site by walking searches of the levees and the islands. Nest locations were marked using a GPS unit (Garmin GPS 12 CX, 12 Channel, Olathe, KS). Nest location, stratum, date, number of eggs present, nest status, nest/clutch fate, and nest agent were recorded for each nest encountered. The nests were monitored to completion and nest fates were recorded. A completed nest was one that was empty (chicks presumed to have hatched or a predator took the eggs), chicks were present, the nest was abandoned, or the nest was destroyed.

PILOT MITIGATION SITE WATER QUALITY

Water samples were collected from the inlet, center, and outlet of the mitigation site on 12 July 2010. The samples were sent to the Agriculture & Priority Pollutants Laboratories, Inc. in Clovis, California to be analyzed for total dissolved solids, selenium, and boron content.

TIERED BIOLOGICAL MONITORING PROGRAM

Vegetation Sampling

We collected 25 plant samples, one from each crop type present within each section of land within the SJRIP, in August 2010 (Figure 10). Sampling was stratified by crop type because no natural lands would be irrigated. The pastures within the project area contain native and non-native plants, both of which comprised samples from pasture lands. Sections comprising less than 25% project lands were exempted unless there was a unique crop present. Plant samples included vegetative structures (leaves and stalks) and/or fruiting parts (flowers, seeds, or fruits) that were collected when plants were green and showing no signs of water stress. The samples were placed in labeled plastic bags and stored on ice for return to the H. T. Harvey & Associates laboratory. The samples were cleaned, dried, placed into Whirl-Pak sterile sample bags, and frozen before shipment to an analytical facility.

All plant samples were shipped overnight on dry ice to the Oscar E. Olson Biochemical Laboratory at South Dakota State University. The samples were homogenized and analyzed for selenium content. The results include selenium content by wet weight, sample percent moisture, sample dry weight, selenium content by dry weight, and sample detection limit. A report of duplicates, spikes, and reference samples was provided for quality control. Selenium results were reported on a dry-weight basis.

Small Mammal Sampling

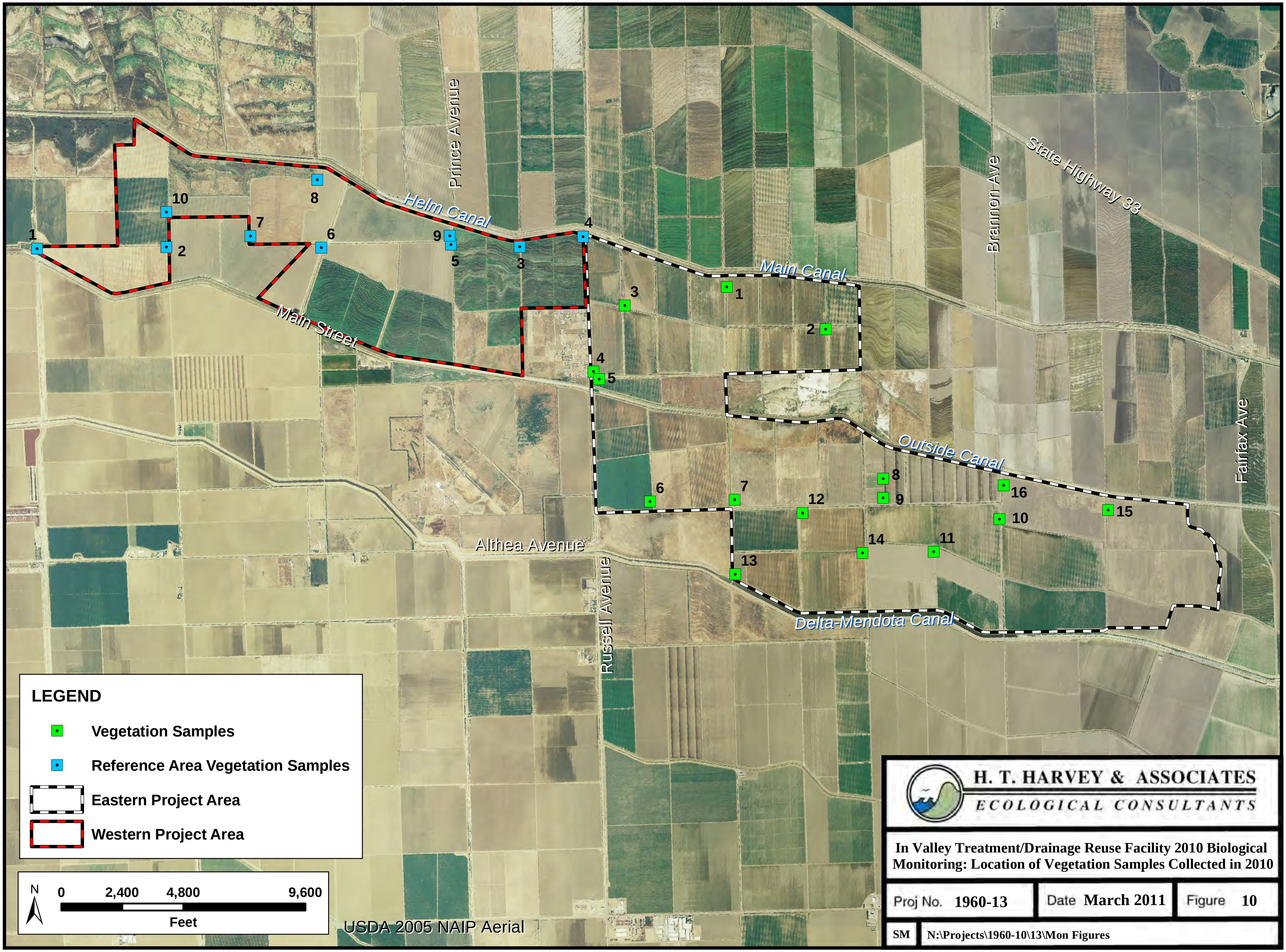
Small mammal sampling was similar in design to the vegetation sampling, taking one sample from each crop type within each section for a total of 25 sample locations (Figure 11). At each sample location, we established a 360-ft linear transect with 13 stations spaced 30 ft apart. All stations were located a minimum distance of 50 ft from the plot boundary. At each station, a single Sherman LFA live trap was placed on the ground and baited with a mixture of millet and sunflower seeds. From 23 July through 7 August 2010, traps were set each evening, checked for captured animals each morning, and closed during the daytime. Six sample locations were excluded from our small mammal analysis because no small mammals were captured there following 50 trap-nights.

Captured mice were euthanized by cardiopulmonary compression, individually bagged, labeled, and placed on ice for shipment to the laboratory. Within H. T. Harvey & Associates' laboratory, collected mice were cleaned and measured for total weight, total length, tail length, and ear length. We also noted the age (juvenile, adult) of each captured individual based on pelage characteristics.

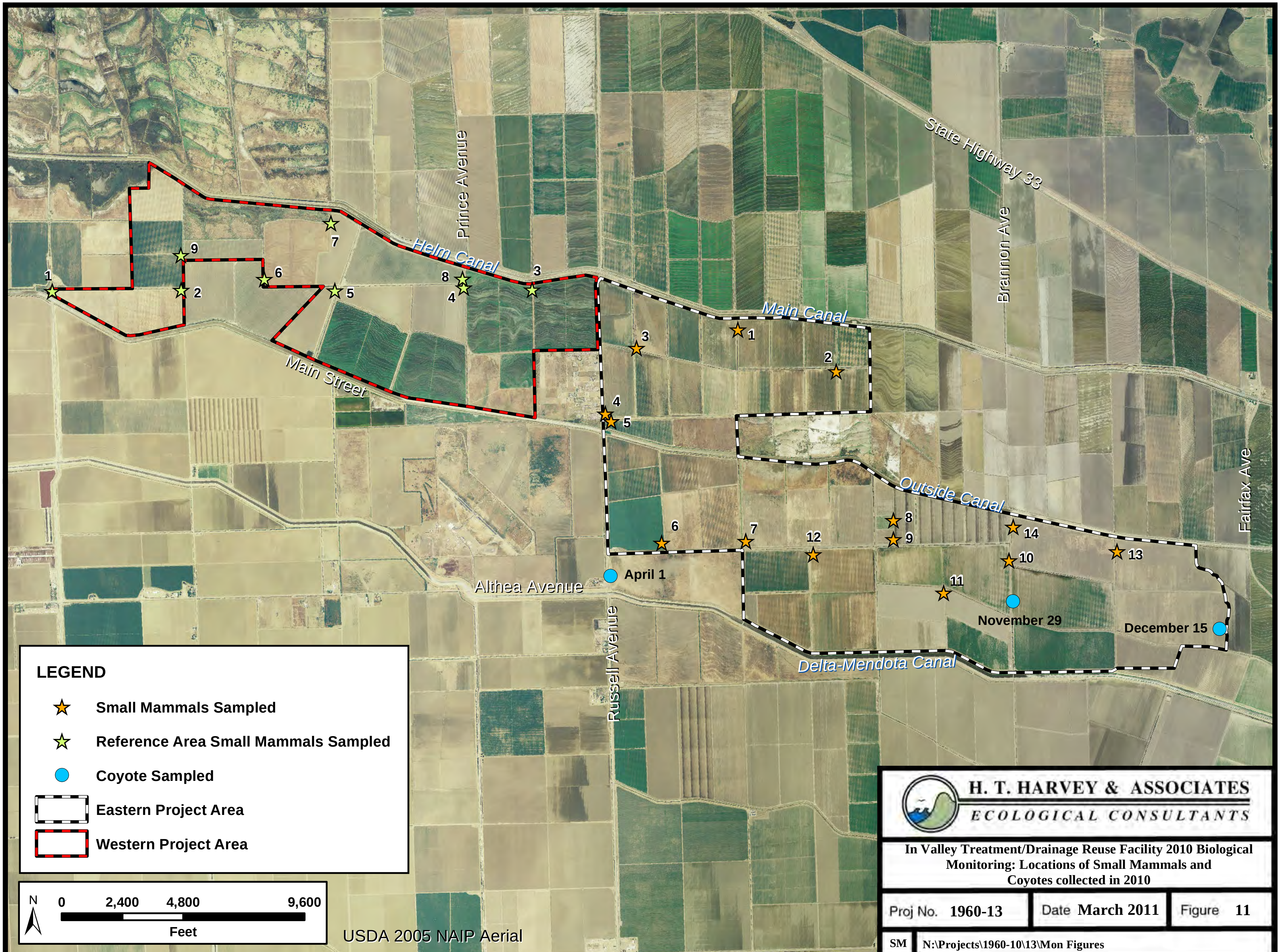
Whole mice samples were shipped overnight on dry ice to the Oscar E. Olson Biochemical Laboratory at South Dakota State University. The samples were homogenized and analyzed for selenium content using the Association of Official Analytical Chemists method 996.16. The results included selenium content by wet weight, sample percent moisture, sample dry weight, selenium content by dry weight, and sample detection limit. A report of duplicates, spikes, and reference samples were noted for quality control. Selenium results were reported on a dry-weight basis.

Plant and Small Mammal Chemistry Analysis

We used two-way ANOVA to test for the effect of site (eastern project area, western project area) and year on plant-selenium and small mammal-selenium concentrations. Plant and small mammal selenium concentrations based on 2010 samples were Log_{10} transformed (Log_{10}[plant and small mammal selenium concentration +1]) to improve the fit to parametric assumptions of homoscedasticity and normality. For all tests conducted, $p<0.05$ was considered significant, $0.10<p<0.05$ inconclusive, and $p>0.10$ not significant.



In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Location of Vegetation Samples Collected in 2010



In Valley Treatment/Drainage Reuse Facility 2010 Biological Monitoring: Locations of Small Mammals and Coyotes collected in 2010

Coyote Tissue sampling

The results from the 2008 small mammal trapping necessitated the next level of tiered monitoring (H. T. Harvey & Associates 2009), which consists of monitoring selenium levels in coyotes (*Canis latrans*) using the project site. No coyotes or coyote dens were encountered during the 2010 avian monitoring, or during vegetation and small mammal trapping associated with the tiered contaminant monitoring. Coyotes and coyote sign have previously been observed on the project site but irrigating, disking field edges for weed maintenance, and harvesting activities in the reuse area likely prevent coyotes from maintaining dens within the fields. Furthermore, levee and drain maintenance discourage coyote dens from the remainder of the project site.

We obtained tissue samples for selenium analysis from 3 coyotes shot and killed by District Personnel on 1 April, 29 November, and 15 December 2010. A blood sample was taken from the coyotes killed in April and December, but unfortunately the blood of the coyote killed in November coagulated before a biologist could arrive to obtain the sample. Hair samples were obtained from all three coyotes. The coyotes were collected on or immediately adjacent to the eastern project area (Figure 11). The April coyote was a male and the other 2 were female and all appeared to be adults based on canine wear.

The blood sample was drawn from within the heart cavity using a sterile hypodermic needle and collected into an evacuated glass blood-collection vial containing ethylenediaminetetraacetic acid (EDTA) as an anticoagulant and designed for trace element analysis (royal blue-top Monoject® Trace Element Blood Collection Tube, product number 8881-307022). The blood vial was labeled and stored on ice.

The hair samples were collected from the dorsal neck area of the animal and placed in a labeled, plastic bag and stored on ice for return to the laboratory, where the sample was washed with isopropyl alcohol (70%) and rinsed in distilled water. The hair was then dried at room temperature, placed in clean bags, and frozen.

The blood and hair samples were shipped overnight on dry ice to the Oscar E. Olson Biochemical Laboratory at South Dakota State University, where they were analyzed for selenium using cold-vapor atomic absorption spectrometry (Association of Official Analytical Chemists method 996.16).

RESULTS

BIRD CENSUSES

In the eastern project area, 35 avian species were observed between 6 May and 24 June 2010 (Table 1). Avian numbers were highest in late May, when red-winged blackbirds were fledging young (Table 1). The red-winged blackbird was the most numerous avian species observed on the eastern project area. Eighteen species were either observed nesting, or were suspected of nesting, based on observations of courtship behavior or young. Total bird numbers declined in June as fewer migrants were detected and birds dispersed post breeding. Species composition of the western project area was similar to that of the eastern project area, with a few notable differences (Table 2). Black-necked stilts and American avocets were absent from the western project area. Species that rely on riparian and marsh habitats such as the black phoebe (*Sayornis nigricans*), marsh wren (*Cistothorus palustris*), and Bullock's oriole (*Icterus bullockii*) were absent from the eastern project area, but present within small narrow strips of marsh and riparian habitat present parallel to ditches within, and on the periphery of, the western project area. Additionally, overall bird use of eastern project area site as described by observed densities (birds/acre) was approximately 3 times lower than in the western project area (Tables 1 and 2).

EGG COLLECTION AND PROCESSING

Seventeen eggs, comprising 4 killdeer, 2 recurvirostrid (both black-necked stilt) eggs, and 11 red-winged blackbird eggs were collected from the eastern project area. All 4 killdeer embryos were 12 days old or older and were alive and in normal condition (Table 3). One black-necked stilt egg contained a live, normal 9-day-old embryo and the other contained an embryo that was alive, but too young (less than 9 days old) to determine the embryo status (Table 4). Four red-winged blackbird eggs contained live, normal embryos 7 days old or older. The 7 remaining red-winged blackbird embryos were too young (approximately 6 days old for red-winged blackbirds) to determine the embryo status, though 4 were old enough to determine that they were alive (Table 5).

Forty eggs (15 killdeer, 14 recurvirostrid, and 11 red-winged blackbird) were collected from the vicinity of the project site. Six killdeer embryos from the reference area were 9 days old or older and were alive and in normal condition. The remaining 9 killdeer embryos were too young to determine the embryo status, though 4 were old enough to determine that they were alive (Table 6). Four of the reference area recurvirostrid eggs contained live, normal embryos 15 days old or older. The 10 remaining recurvirostrid embryos were too young (less than 9 days old) to determine the embryo status, though 3 were old enough (3 days old or older) to determine that they were alive (Table 7). Five red-winged blackbird embryos from the reference area were 7 days old or older and were alive and in normal condition. The remaining 6 red-winged blackbird embryos were too young to determine the embryo status, though 2 were old enough to determine that they were alive (Table 8).

Five recurvirostrid (1 black-necked stilt and 4 American avocets) eggs were collected from the mitigation site. The black-necked stilt egg contained a live, normal 17-day-old embryo. The 4 American avocet embryos were too young to determine the embryo status, though 2 were old enough to determine that they were alive (Table 9).

Table 1. Avian census results at San Joaquin River Water Quality Improvement Project Site Eastern Project Area.

	2010					
Species	**May 6**	**May 13**	**May21**	**May 27**	**June 10**	**June 24**
Great Blue Heron	2	1	1		1	
Great Egret	3		1	1	1	
Snowy Egret	2	1	16	3	4	7
Cattle Egret	7	11		6		
White-faced Ibis				18	41	
Mallard	6	3	8		2	
Northern Harrier		1	2		1	
* Swainson's Hawk	2	2	2	4	4	3
Red-tailed Hawk	3	1	1	2	1	1
American Kestrel	1	1	1	2	2	1
* Killdeer	15	19	18	16	17	22
* Black-necked Stilt	4	9	4	4	2	2
American Avocet	6	2	4		3	
Whimbrel	4					
Long-billed Curlew						13
* Mourning Dove	16	9	9	13	8	23
* Barn Owl	3	3	3	1	1	1
* Burrowing Owl	8	10	10	17	12	10
* Western Kingbird	14	20	21	19	22	25
* Loggerhead Shrike	5	3	3	6	5	3
Common Raven	10	14	26	10	9	3
* Horned Lark	12	10	11	8		
Northern Rough-winged Swallow		2	4	3		
* Barn Swallow	6	10	12	12	13	4
Cliff Swallow	17	16	15	22	9	10
Savannah Sparrow	7					
* Song Sparrow	1	1	3	2	2	1
* Blue Grosbeak		1	2	1	1	1
* Red-winged Blackbird	308	336	367	340	262	196
* Western Meadowlark	11	18	14	7	9	13
* Brewer's Blackbird	22	23	26	21	35	14
* Brown-headed Cowbird	6	10	13	21	24	28
Bullock's Oriole	2	1	1	1	1	1
* House Finch	17	24	18	19	42	21
* House Sparrow	11	8	20	14	14	7
Total	**531**	**570**	**636**	**593**	**548**	**410**
Observed Density (birds/acre)	**0.133**	**0.143**	**0.159**	**0.148**	**0.137**	**0.103**

*Species for which evidence of nesting was observed this year.

Table 2. Avian census results at the San Joaquin River Water Quality Improvement Project Site Western Project Area.

2010						
Species	**May 6**	**May 13**	**May21**	**May 27**	**June 10**	**June 24**
Great Blue Heron	2	1	2	1	6	2
Great Egret	18	9	10	12	6	6
Snowy Egret	9	8	17	3		6
Cattle Egret	44	17	10	9	3	
Black-crowned Night Heron	9	10	5	3	1	5
White-faced Ibis	7	37	44	12		
Mallard			2	6		2
*Northern Harrier	3	2	2	1	1	1
*Swainson's Hawk	9	7	6	11	12	14
Red-tailed Hawk	1	1	1		2	
American Kestrel	2	2	2	2	1	1
Killdeer	5	8	9	6	6	9
Whimbrel	9					
Long-billed Curlew				46	73	162
Greater Yellowlegs						3
*Mourning Dove	24	26	28	32	23	9
Great-horned Owl	2	3	3	1		1
*Black Phoebe	2	5	6	4	6	3
*Western Kingbird	14	17	20	23	28	26
*Loggerhead Shrike	8	10	10	17	14	9
Common Raven	15	73	62	121	6	19
*Horned Lark	14	16	22	20	14	9
Northern Rough-winged Swallow	6	4	7	10	10	5
Barn Swallow	2	4	3	2	5	4
Cliff Swallow	22	6	14		6	
House Wren	2	1				
*Marsh Wren	5	4	7	4	3	6
American Pipit	1					
Yellow Warbler	1	4				
Savannah Sparrow	6	9				
*Song Sparrow	16	14	22	21	9	14
Black-headed Grosbeak	1	2				
*Blue Grosbeak	1	3	2	4	3	2
*Red-winged Blackbird	208	266	340	384	407	379
Tricolored Blackbird	156		400			
*Western Meadowlark	7	10	12	8	10	11
*Yellow-headed Blackbird		4	2	6	1	
*Brewer's Blackbird	42	29	25	26	31	21
*Brown-headed Cowbird	13	14	16	21	17	15
*Bullock's Oriole	6	6	5	4	6	5
*House Finch	38	34	46	56	54	41
House Sparrow	13	17	10	6	5	8
Total	**743**	**683**	**1172**	**882**	**769**	**798**
Observed Density (birds/acre)	**0.391**	**0.359**	**0.617**	**0.464**	**0.405**	**0.420**

*Species for which evidence of nesting was observed this year.

Table 3. Eastern project area killdeer egg-selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Field Number	Date 2010	Embryo		Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
			Condition[a]	Status[b]				
01		July 7	L	N	17	6.83	0.8344	
02		July 7	L	N	15	6.01	0.7789	
03		July 7	L	N	12	5.92	0.7723	
04		July 7	L	N	15	6.22	0.7938	
Arith/**Geo Mean**						6.2	0.7949	***6.2***
SD						0.4	0.0279	***1.1***
SE							0.0125	***1.0***
Lower Limit of 95% Confidence Interval							0.7704	***5.9***
Upper Limit of 95% Confidence Interval							0.8193	***6.6***

[a] L = live, D = dead, U = unknown [b] N = normal, A = abnormal, U = unknown

Table 4. Eastern project area recurvirostrid egg-selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Field Number	Date 2010	Embryo		Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
			Condition[a]	Status[b]				
Black-necked Stilt								
01	S-01	May 13	L	N	9	6.49	0.8122	
02	S-02	June 8	L	U	6-9	25.6	1.4082	
Arith/**Geo Mean**						16.0	1.1102	***12.9***
SD						13.5	0.4214	***2.6***
SE							0.1885	**1.5**
Lower Limit of 95% Confidence Interval							0.7408	**5.5**
Upper Limit of 95% Confidence Interval							1.4796	**30.2**

[a] L = live, D = dead, U = unknown [b] N = normal, A = abnormal, U = unknown

Table 5. Eastern project area red-winged blackbird egg-selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Date 2010	Embryo		Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
		Condition[a]	Status[b]				
01	May 25	L	U	3	5.76	0.7604	
02	May 25	U	U	1	8.17	0.9122	
03	May 25	L	N	9	5.37	0.7300	
04	May 25	L	N	7	7.75	0.8893	
05	May 25	U	U	1	8.24	0.9159	
06	May 25	U	U	1	7.33	0.8651	
07	May 25	L	U	3	6.46	0.8102	
08	May 25	L	U	4	11.1	1.0453	
09	May 25	L	U	5	8.18	0.9128	
10	May 25	L	N	7	7.22	0.8585	
11	May 27	L	N	7	7.41	0.8698	
Arith/**Geo Mean**					7.5	0.8700	***7.4***
SD					1.5	0.0850	***1.2***
SE						0.0380	***1.1***
Lower Limit of 95% Confidence Interval						0.7955	***6.2***
Upper Limit of 95% Confidence Interval						0.9444	***8.8***

[a] L = live, D = dead, U = unknown   [b] N = normal, A = abnormal, U = unknown

Table 6. Reference area killdeer egg-selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Date 2010	Embryo		Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
		Condition[a]	Status[b]				
01	May 11	U	U	1	16.8	1.2253	
02	May 11	U	U	1	3.99	0.6010	
03	May 13	L	N	15	3.01	0.4786	
04	May 21	L	N	20	3.67	0.5647	
05	May 21	L	N	12-15	2.92	0.4654	
06	May 21	U	U	1	4.19	0.6222	
07	June 8	L	U	6	4.33	0.6365	
08	June 8	L	U	3	4.06	0.6085	
09	June 8	L	U	6	5.37	0.7300	
10	June 22	L	N	12-15	8.73	0.9410	
11	June 22	U	U	1	6.44	0.8089	
12	June 29	L	U	3	3.13	0.4955	
13	July 7	L	U	6-9	4.77	0.6785	
14	July 7	L	N	9+	5.72	0.7574	
15	July 7	L	N	9+	5.64	0.7513	
Arith/**Geo Mean**					5.52	0.6910	***4.9***
SD					3.5	0.1972	***1.6***
SE						0.0882	***1.2***
Lower Limit of 95% Confidence Interval						0.5181	***3.3***
Upper Limit of 95% Confidence Interval						0.8638	***7.3***

[a] L = live, D = dead, U = unknown [b] N = normal, A = abnormal, U = unknown

Table 7. Reference area recurvirostrid egg-selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Species	Date 2010	Embryo		Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
			Condition[a]	Status[b]				
01	Black-necked Stilt	May 11	U	U	1	26.2	1.4183	
02	Black-necked Stilt	May 11	U	U	1	30.4	1.4829	
03	Black-necked Stilt	May 11	L	U	6	9.56	0.9805	
04	Black-necked Stilt	May 18	L	U	3-6	16.0	1.2041	
05	American Avocet	May 21	U	U	1	24.3	1.3856	
06	American Avocet	May 21	L	U	6-9	20.8	1.3181	
07	Black-necked Stilt	May 21	U	U	1	5.79	0.7627	
08	Black-necked Stilt	May 27	L	N	15	32.0	1.5051	
09	American Avocet	May 27	U	U	1	23.2	1.3655	
10	Black-necked Stilt	June 3	U	U	1	3.46	0.5391	
11	Black-necked Stilt	June 22	L	N	17	4.50	0.6532	
12	Black-necked Stilt	June 22	L	N	19	4.98	0.6972	
13	Black-necked Stilt	June 22	L	N	16	4.78	0.6794	
14	Black-necked Stilt	June 28	U	U	1	4.89	0.6893	
Arith/**Geo Mean**						15.1	1.0486	***11.2***
SD						10.8	0.3654	***2.3***
SE							0.1634	***1.5***
Lower Limit of 95% Confidence Interval							0.7284	***5.4***
Upper Limit of 95% Confidence Interval							1.3689	***23.4***

[a] L = live, D = dead, U = unknown

[b] N = normal, A = abnormal, U = unknown

Table 8. Reference area red-winged blackbird egg-selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Date 2010	Embryo		Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
		Condition[a]	Status[b]				
01	June 1	L	N	8	3.93	0.5944	
02	June 3	U	U	1	NA [c]		
03	June 3	L	N	8	6.32	0.8007	
04	June 3	L	N	9	4.60	0.6628	
05	June 15	L	U	3	3.77	0.5763	
06	June 15	L	U	1	4.34	0.6375	
07	June 15	L	N	7	4.42	0.6454	
08	June 15	U	U	1	3.07	0.4871	
09	June 15	L	N	7	3.35	0.5250	
10	June 15	U	U	1	4.75	0.6767	
11	June 15	L	U	3	3.94	0.5955	
Arith/**Geo Mean**					4.2	0.6201	***4.2***
SD					0.9	0.0872	***1.2***
SE						0.0390	***1.1***
Lower Limit of 95% Confidence Interval						0.5437	***3.5***
Upper Limit of 95% Confidence Interval						0.6966	***5.0***

[a] L = live, D = dead, U = unknown [b] N = normal, A = abnormal, U = unknown [c] Insufficient sample

Table 9. Mitigation site recurvirostrid egg-selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Field Number	Date 2010	Embryo		Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
			Condition[a]	Status[b]				
Black-necked Stilt								
01		June 10	L	N	17	5.50	0.7404	
American Avocet								
01		June 1	U	U	1	10.9	1.0374	
02		June 10	U	U	1	6.01	0.7789	
03		June 10	L	U	6-9	8.73	0.9410	
04		June 10	L	U	6	5.60	0.7482	
Arith/**Geo Mean**						7.3	0.8492	***7.1***
SD						2.4	0.1331	***1.4***
SE							0.0595	***1.1***
Lower Limit of 95% Confidence Interval							0.7325	***5.4***
Upper Limit of 95% Confidence Interval							0.9658	***9.2***

[a] L = live, D = dead, U = unknown [b] N = normal, A = abnormal, U = unknown

EGG CHEMISTRY ANALYSIS

2010 Egg-Selenium Data Analysis Between Sites

In 2010, egg-selenium concentrations varied considerably between locations and species. Egg-selenium concentrations were significantly higher in eggs collected from the eastern project area than from eggs collected from the reference area for red-winged blackbirds (P<0.0001), but not for killdeer (P=0.3534) or recurvirostrids (P=0.8390) (Table 10). The 2010 sample size for recurvirostrids at the eastern project area was small (n = 2).

Table 10. 2010 geometric mean egg-selenium concentrations from the San Joaquin River Water Quality Improvement Project.

Location	n	Geo. Mean ppm se (dry wt)	Range
Killdeer			
Eastern project area	4	6.2	5.92-6.83
Off-site reference sample	15	4.9	2.92-16.80
No Significant difference ($F_{1,17}$ = 0.911, P = 0.3534) between sites			
Recurvirostrids			
Eastern project area	2	12.9	6.49-25.60
Off-site reference sample	14	11.2	3.46-32.00
No Significant difference ($F_{1,14}$ = 0.043, P = 0.8390) between sites			
Red-winged blackbirds			
Eastern project area	11	7.4	5.37-11.10
Western project area	10	4.2	3.07-6.32
Significant difference ($F_{1,19}$ = 43.714, P < 0.0001) between sites			

Egg-Selenium Data Analysis Across Years

Killdeer egg-selenium concentrations were consistently greater at the eastern project area than the reference site (Figure 12). Significant effects due to location and year were indicated by the linear mixed-effects model analyses; the interaction between location and year was also significant, indicating differences in the location effect among years (Table 11). Due to non-normality of residuals, Kruskal-Wallis tests were conducted to further evaluate the location and time effects; a significant location effect (P<0.0001; χ^2 =119.6357, df=1) and year effect (P=0.0100; χ^2 =12.9661, df=7) were detected, consistent with the linear mixed-effects model analyses.

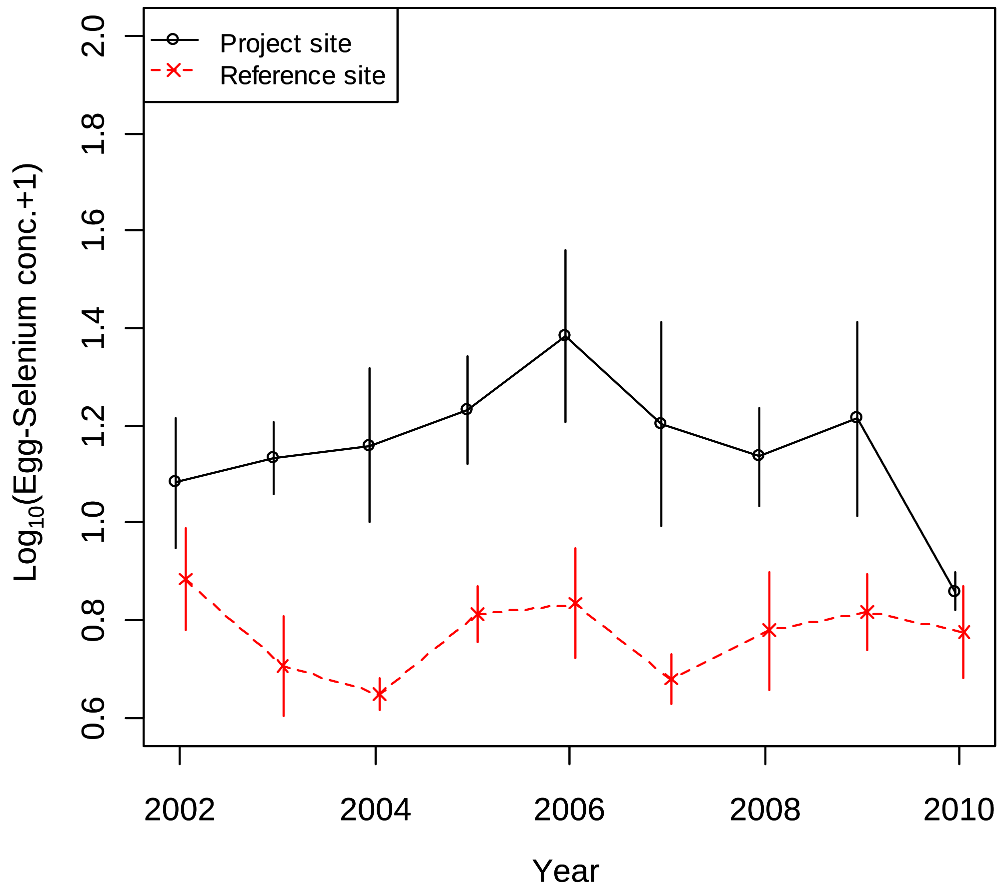


Figure 12. Mean ± 95% confidence interval egg-selenium concentration for killdeer at the San Joaquin River Water Quality Improvement Project (2002 to 2010).

Table 11. Results of linear mixed-effects models regarding effects of location and year on egg-selenium concentration in killdeer, recurvirostrids, and red-winged blackbirds at the San Joaquin River Water Quality Improvement Project (2003 to 2010).

Avian species group	Element	Term	X^2	Df*	*P*
Killdeer	Selenium	location	168.0278	1	<0.0001
		year	18.2592	8	0.0194
		location x year	22.1548	8	0.0046
Recurvirostrids	Selenium	location	53.3315	1	<0.0001
		year	18.1534	7	0.0113
		location x year	19.7612	7	0.0061
Red-winged blackbird	Selenium	location	133.0421	1	<0.0001
		year	11.8894	6	0.0645
		location x year	27.5569	6	0.0001

*Df=degrees of freedom

Recurvirostrid egg-selenium concentrations were typically greater at the eastern project area than the reference site (Figure 13), and linear mixed-effects model analyses also showed a significant location effect (Table 11). Year and interaction between location and year were also significant, indicating some differences in concentrations across years within a given site, and that the location effect differs by year.

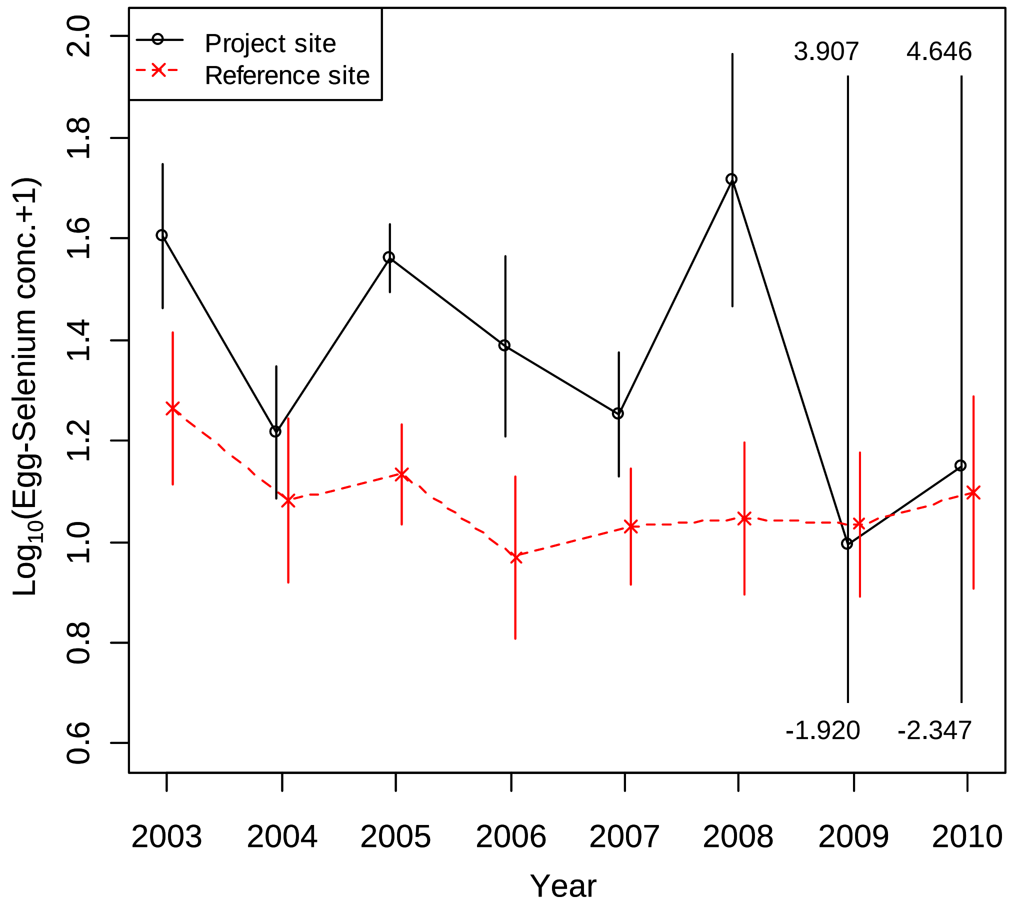


Figure 13. Mean ± 95% confidence interval egg-selenium concentration for recurvirostrids at the San Joaquin River Water Quality Improvement Project (2003 to 2010).

Red-winged blackbird egg-selenium concentrations appeared to be typically greater at the eastern project area than the western project area (Figure 14), and linear mixed-effects model analyses showed a significant location effect (Table 11). The test result for the year effect was inconclusive, though the interaction term was strongly significant. Due to non-normality of the residuals, Kruskal-Wallis tests were conducted; results from these tests were consistent with respect to a significant location effect ($P<0.0001$, χ^2 =92.7844, df=1), but the year effect was not significant ($P=0.7350$, χ^2 =3.5671, df=6). Overall, these results suggest that within a site, there were not yearly differences; however, a location effect exists which differs by year.

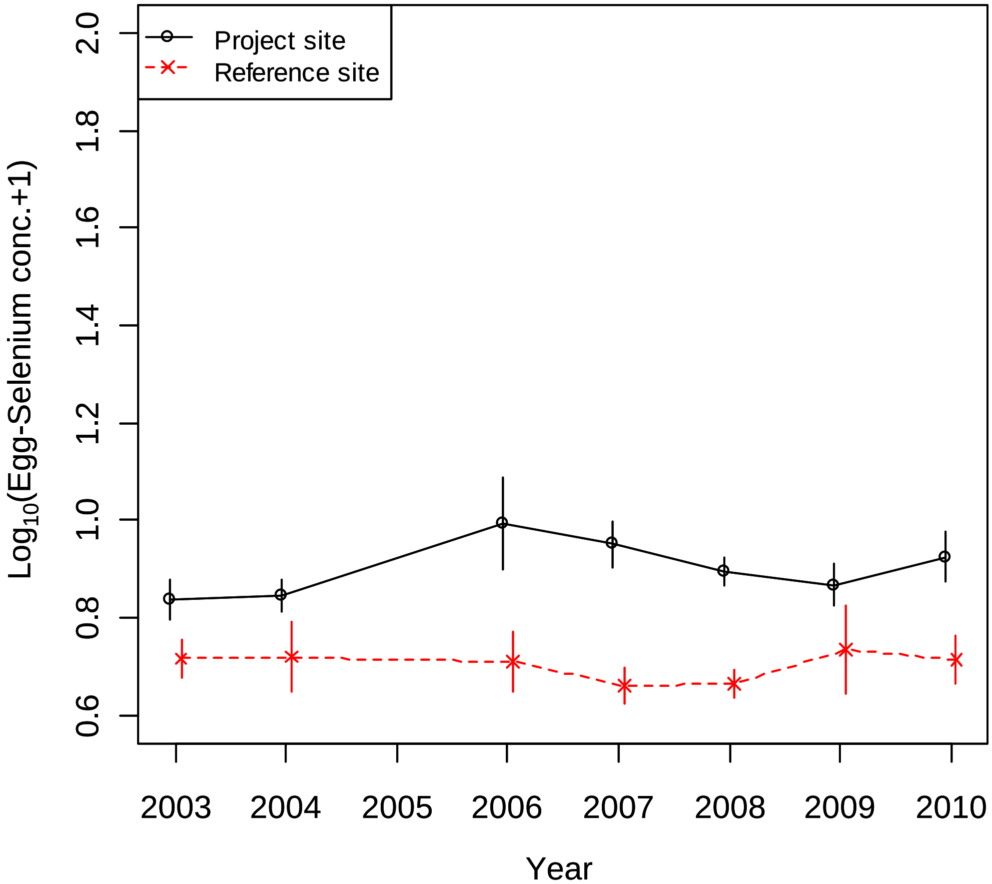


Figure 14. Mean ± 95% confidence interval egg-selenium concentration for red-winged blackbirds at the San Joaquin River Water Quality Improvement Project (2003 to 2010).

Recurvirostrid Mitigation Site Selenium Concentrations

In 2010, egg-selenium concentrations in recurvirostrids did not differ among sites based on 1-way ANOVA ($F_{2,18}$ = 0.8265, P = 0.4535), similar to 2009 (H.T. Harvey & Associates 2010). The 95% confidence intervals in 2010 were large for the project site (Figure 15), due to the small number of nests sampled (n=2); the power of the test is low as a result.

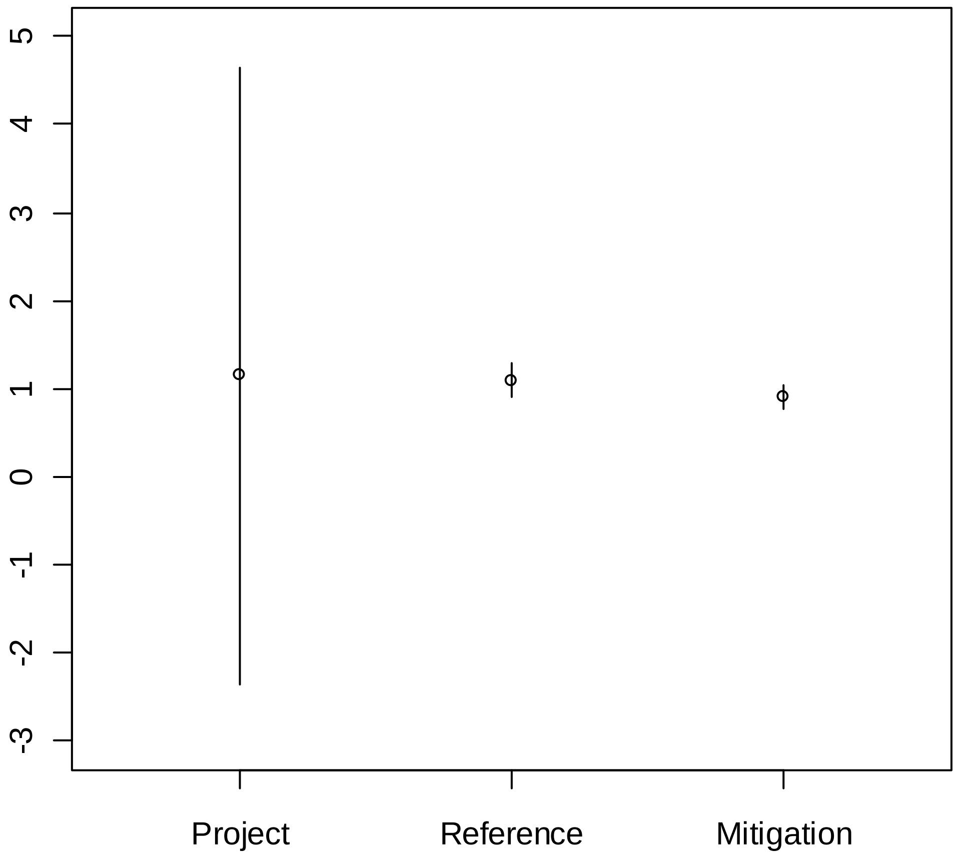


Figure 15. Mean ± 95% confidence interval egg-selenium concentration for recurvirostrids at the San Joaquin River Water Quality Improvement Project (2010).

EGG-BORON ANALYSIS

Egg-Boron Data Analysis Between Sites

There was no statistical difference in boron concentrations between eggs collected from the eastern project area and eggs collected from the reference area for either killdeer or recurvirostrids in 2010, though there was a significant difference for red-winged blackbirds (Table 12). Raw boron data are presented in Appendices A, B, and C.

Table 12. 2010 geometric mean egg-boron concentrations from the San Joaquin River Water Quality Improvement Project.

Location	n	Geo. Mean Ppm se (dry wt)	Range
Killdeer			
Eastern project area	4	1.3	0.69-2.26
Off-site reference sample	15	1.3	0.53-3.53
No Significant difference ($F_{1,17}$ =0.0050, P =0.9445) between sites			
Recurvirostrids			
Eastern project area	2	1.8	0.99-3.34
Off-site reference sample	14	1.9	0.81-5.58
No Significant difference ($F_{1,14}$ =0.0079, P = 0.9303) between sites			
Red-winged blackbirds			
Eastern project area	11	11.1	6.64-16.80
Western project area	10	5.3	2.25-28.80
Significant difference ($F_{1,19}$ =8.0306, P = 0.0106) between sites			

Egg-Boron Data Analysis Across Years

Killdeer egg-boron concentrations were greater at the eastern project area than the reference site in all years before 2010; egg-boron concentrations were similar in 2010 (Figure 16). Significant effects due to location and year were indicated by the linear mixed-effects model analyses; the interaction between location and year was not significant however (Table 13). Due to non-normality of residuals, Kruskal-Wallis tests were conducted to further evaluate the location and time effects; consistent with the linear mixed-effects model analyses, a significant location effect ($P<0.0001$; χ^2 =44.0546, df=1) and year effect ($P<0.0001$; χ^2 =40.9558, df=8) were detected.

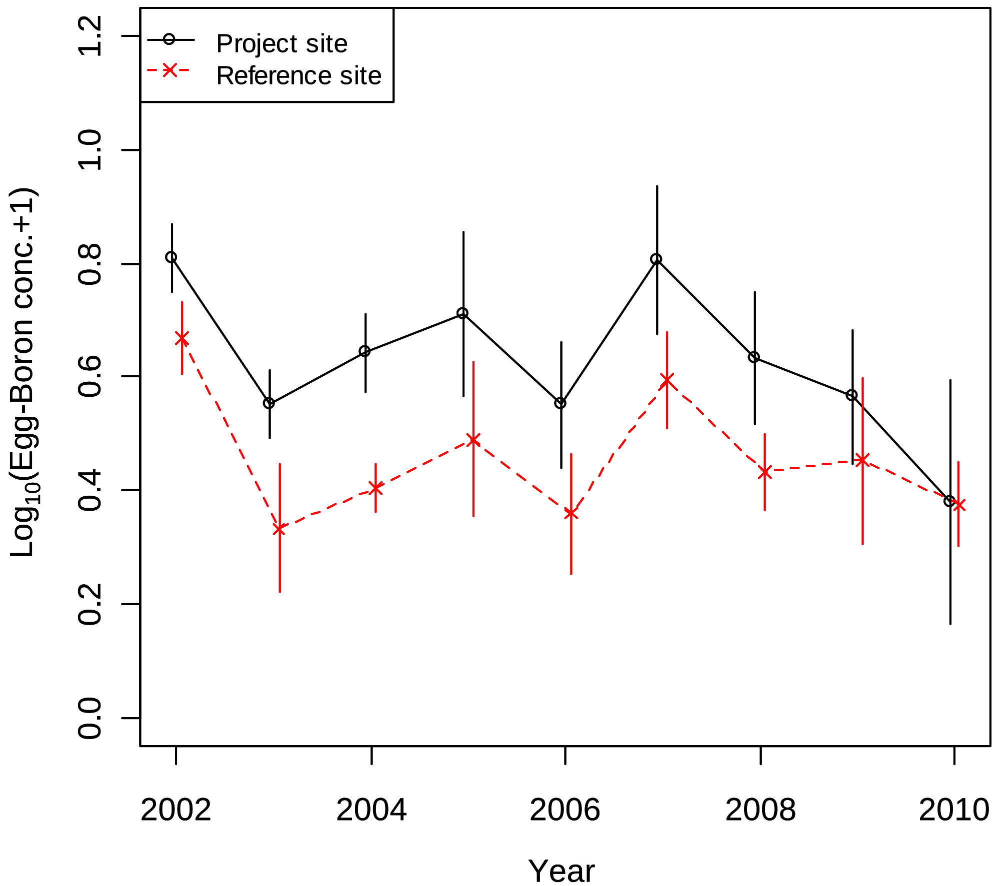


Figure 16. Mean ± 95% confidence interval egg-boron concentration for killdeer at the San Joaquin River Water Quality Improvement Project (2002 to 2010).

Table 13. Results of linear mixed-effects models regarding effects of location and year on egg-boron concentration in killdeer, recurvirostrids, and red-winged blackbirds at the San Joaquin River Water Quality Improvement Project (2003 to 2010).

Avian species group	Element	Term	χ^2	Df	*P*
Killdeer	Boron	location	55.2563	1	<0.0001
		year	27.8225	8	0.0005
		location x year	6.3460	8	0.6085
Recurvirostrids	Boron	location	1.2690	1	0.2600
		year	18.3530	7	0.0105
		location x year	25.0865	7	0.0007
Red-winged blackbird	Boron	location	19.7686	1	<0.0001
		year	19.9418	6	0.0028
		location x year	45.7876	6	<0.0001

* Df=degrees of freedom

Recurvirostrid egg-boron concentrations were typically greater at the eastern project area than the reference site, though the patterns with time differed considerably (Figure 17). Linear mixed-effects model analyses showed no significant location effect (Table 13). Year and interaction between location and year were also significant, indicating some differences in concentrations across years within a given site, and that the location effect differs by year. Due to non-normality of residuals, Kruskal-Wallis tests were conducted to further evaluate the location and time effects; a significant location effect (P=0.0046; χ^2 =8.0401, df=1) and year effect (P <0.0001; χ^2 =32.9206, df=7) were detected.

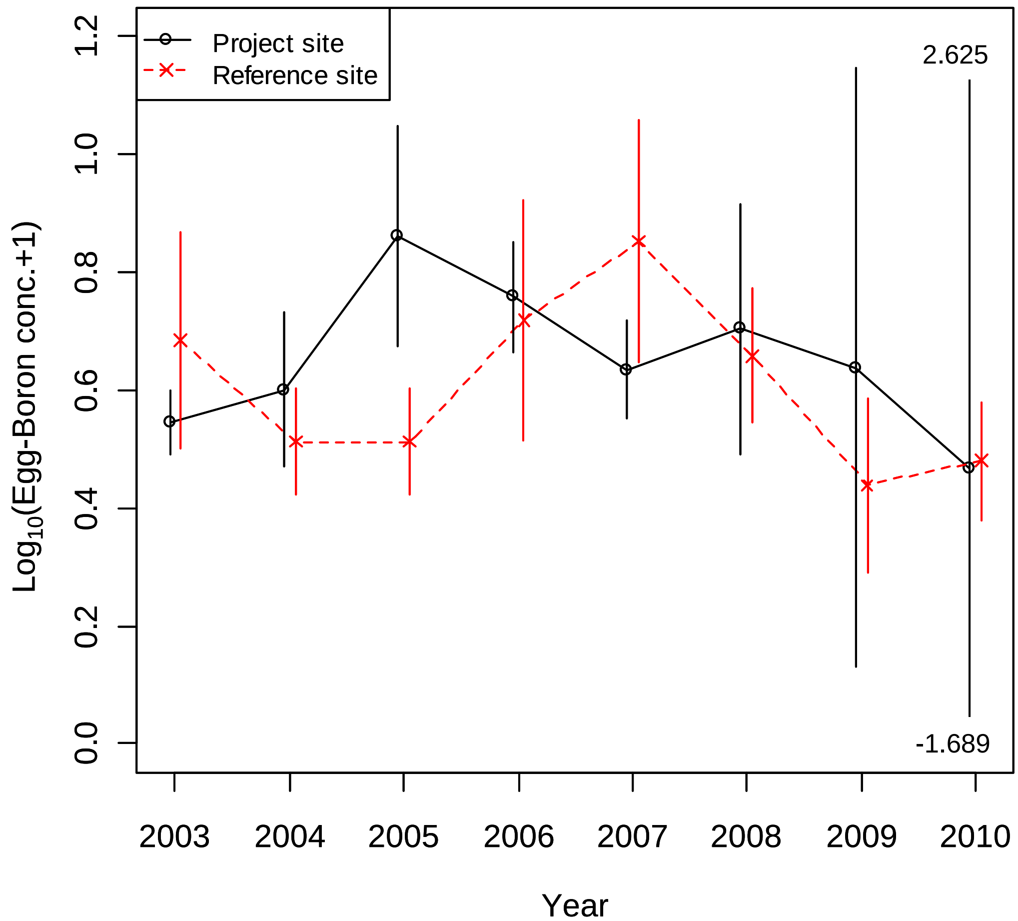


Figure 17. Mean ± 95% confidence interval egg-boron concentration for recurvirostrids at the San Joaquin River Water Quality Improvement Project (2003 to 2010).

Red-winged blackbird egg-boron concentrations appeared to be typically greater at the eastern project area than the western project area, though patterns were variable (Figure 18). Linear mixed-effects model analyses showed a significant location effect (Table 13). Year and interaction between location and year were also significant, indicating some differences in concentrations across years within a given site, and that the location effect differs by year. Due to non-normality of residuals, Kruskal-Wallis tests were conducted to further evaluate the location and time effects; consistent with the linear mixed-effects model analyses, a significant location effect (P<0.0001; χ^2 =15.5837, df=1) and year effect (P<0.0001; χ^2 =33.8433, df=6) were detected.

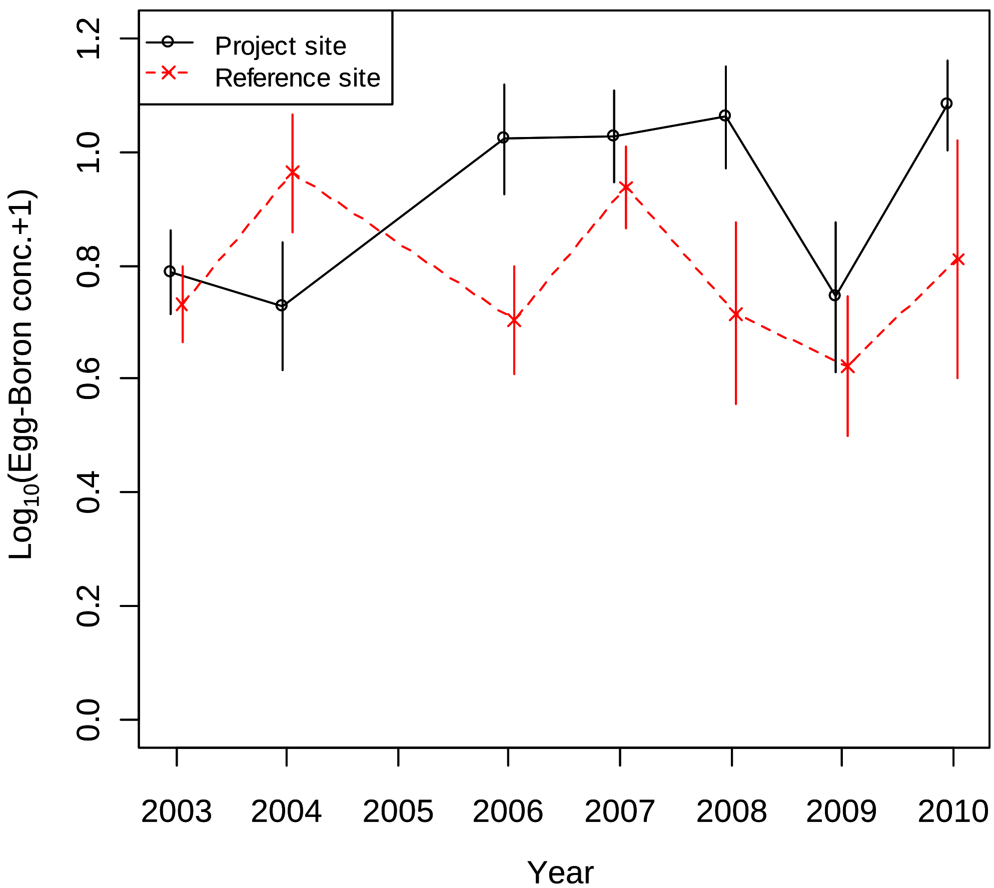


Figure 18. Mean ± 95% confidence interval egg-boron concentration for red-winged blackbirds at the San Joaquin River Water Quality Improvement Project (2003 to 2010).

Recurvirostrid Mitigation Site Boron Concentrations

In 2010, egg-boron concentrations in recurvirostrids did not differ among sites based on 1-way ANOVA ($F_{2,18}$ = 1.4039, P = 0.2713), similar to 2009 (H.T. Harvey & Associates 2009). The 95% confidence intervals in 2010 were large for the eastern project area (Figure 19), due to the small number of nests present (n=2); the power of the test is low as a result.

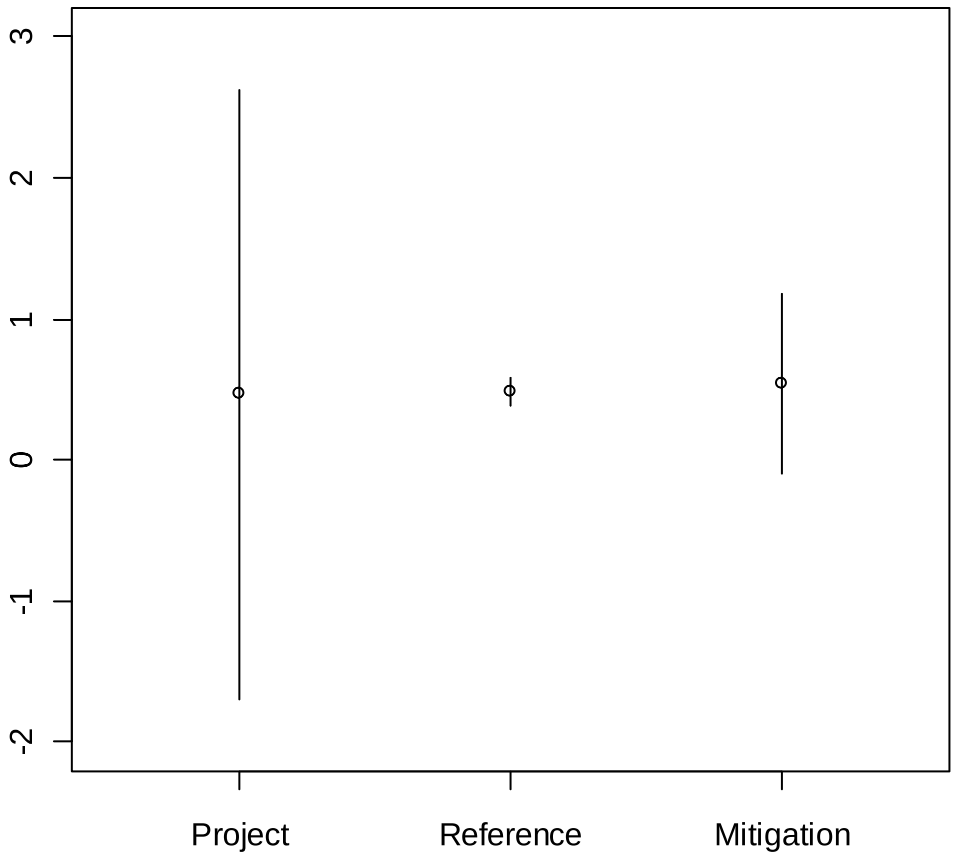


Figure 19. Mean ± 95% confidence interval egg-boron concentration for recurvirostrids at the San Joaquin River Water Quality Improvement Project (2010).

Egg-Mercury Data Analysis Between Sites

Comparison of egg-mercury concentrations between locations based on 1-way ANOVA of 2010 data did not show any significant differences for killdeer, recurvirostrids, or red-winged blackbirds (Table 14). The 2010 sample size for recurvirostrids at the project site was small (n = 2), lowering the statistical power of this comparison. Raw mercury data are presented in Appendices D, E, and F.

Table 14. 2010 geometric mean egg-mercury concentrations from the San Joaquin River Water Quality Improvement Project.

Location	n	Geo. Mean ppb hg (dry wt)	Range
Killdeer			
Eastern Project area	4	383.7	291-529
Off-site reference sample	15	224.8	97-729
No Significance difference ($\boldsymbol{F}_{1,17}$ *=2.5844, P =0.1263) between sites*			
Recurvirostrids			
Eastern Project area	2	519.4	512-527
Off-site reference sample	14	520.5	299-1150
No Significance difference ($\boldsymbol{F}_{1,14}$ *=0.0001, P = 0.9934) between sites*			
Red-winged blackbirds			
Eastern Project area	11	97.7	26-391
Western Project area	10	132.2	29-334
No Significance difference ($\boldsymbol{F}_{1,19}$ *=0.8366, P = 0.3718) between sites*			

Recurvirostrid Mitigation Site Mercury Concentrations

In 2010, egg-mercury concentrations in recurvirostrids did not differ significantly among sites based on 1-way ANOVA ($F_{2,18}$ = 0.0020, P = 0.9980). The 95% confidence intervals in 2010 were large for the mitigation site (Figure 20), due to great variability in egg-mercury concentrations among the eggs sampled. In addition, there were a small number of nests present (n=2) for the eastern project area; the power of the test is low as a result.

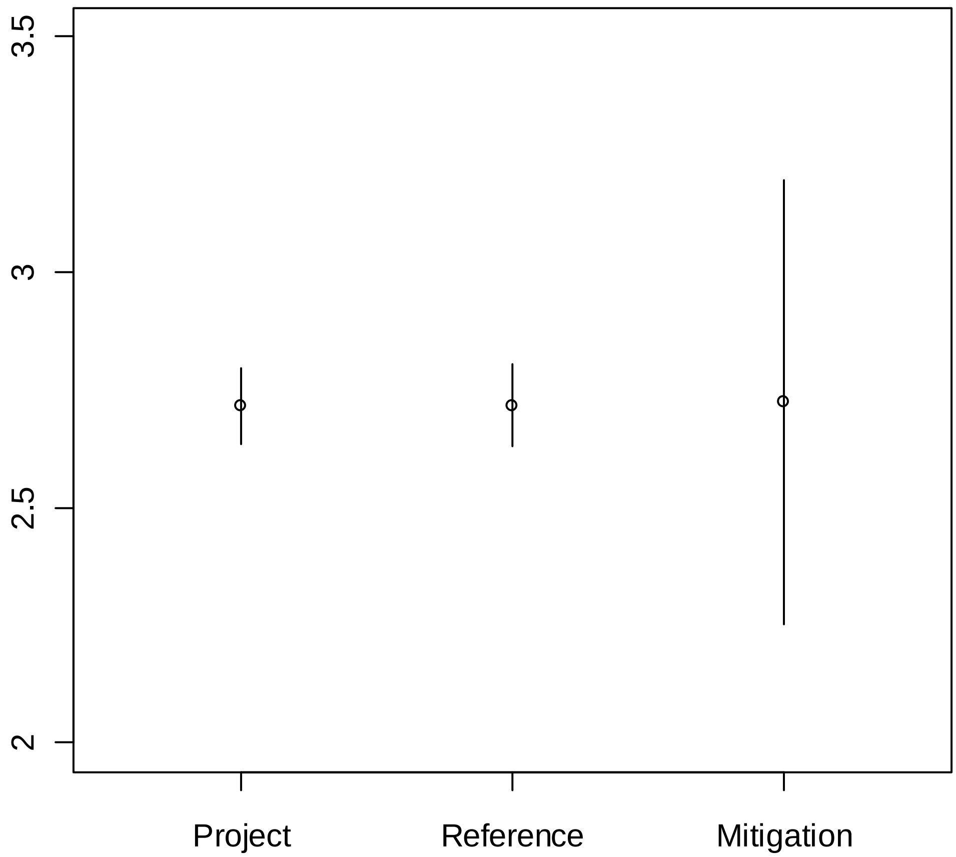


Figure 20. Mean ± 95% confidence interval egg-mercury concentration for recurvirostrids at the San Joaquin River Water Quality Improvement Project (2010).

CONTROL EGGS

The selenium recovery rate for 10 egg samples spiked with selenium ranged between 82.7% and 110% with a mean selenium recovery rate of 98.3% (Appendix G). An average value of 1.92 ug/mL selenium was obtained on NIST Standard Reference Material 2976 (Mussel, certified value = 1.80 + 0.15 ug/mL). The standard deviation of selenium results from 77 duplicate egg samples ranged between 0.0000 and 2.9698 with a mean standard deviation of 0.3335 (Appendix H).

The boron recovery rate for 4 egg samples spiked with boron ranged between 97% and 100%, with a mean boron recovery rate of 98.3% (Appendix I). The standard deviation of boron results from 17 duplicate egg samples ranged between 0.0028 and 1.6612, and the mean standard deviation was 0.3642 (Appendix I). The mercury recovery rate for 1 egg sample spiked with mercury was 98% (Appendix J). The standard deviation of mercury results from 8 duplicate egg samples ranged between 8.485 and 298.4, and the mean standard deviation was 63.11 (Appendix J).

NEST FATE

Nine killdeer and 2 black-necked stilt nests were followed to completion within the eastern project area in 2010 (Table 15, Appendix K). Three of the killdeer nests hatched, 3 were inadvertently destroyed by farming activities, and 3 were lost to predators. Both of the black-necked stilt nests were lost to predators (Appendix K).

Three killdeer nests and 17 recurvirostrid nests were monitored at the mitigation site. Two of the killdeer nests and 4 of the recurvirostrid nests hatched successfully. Predators took the remaining 13 recurvirostrid nests (Table 15, Appendix K).

Table 15. Nest fates and agents that caused nest/clutch success or failure at the San Joaquin River Water Quality Improvement Project Site and Mitigation Site in 2010.

Species	Hatched		Depredated		Abandoned		Vehicle		Total
	Nests	%	Nests	%	Nests	%	Nests	%	
Eastern Project Area									
Killdeer	3	*33*	3	*33*			3	*33*	9
Recurvirostrids			2	*100*					2
Black-necked stilt			*(2)**						*(2)*
American avocet									*(0)*
Total	**3**	*27*	**5**	*45*			**3**	*27*	**11**
Mitigation Site									
Killdeer	2	*67*	1	*33*					**3**
Recurvirostrids	4	*24*	13	*76*					**17**
Black-necked stilt	*(1)*		*(2)*						*(3)*
American avocet	*(3)*		*(11)*						*(14)*
Total	**6**	*30*	**14**	*70*					**20**

*Numbers in parenthesis are the subset of each species of the total number for recurvirostrids

PILOT MITIGATION SITE WATER QUALITY

The results of the water-quality analysis for the mitigation site are summarized in Table 16. Selenium and boron concentrations in the water sample from the mitigation site were well below the 2.3 ppb selenium and 5 ppm boron thresholds for safe exposure to wildlife in freshwater (Eisler 1990, Skorupa and Ohlendorf 1991, and Suter 1996).

Table 16. Water quality in samples from the pilot mitigation site.

	Electrical Conductivity (μhmo/cm)	Boron (mg/l)	Selenium (μg/l)
Freshwater Thresholds[a]		5	2.3
12 July 2010			
Inlet	235	0.109	< 1
Middle	270	0.159	< 1
Outlet	12,000	0.283	< 1

[a] From Eisler 1990, Skorupa and Ohlendorf 1991, and Suter 1996.

TIERED BIOLOGICAL MONITORING PROGRAM

Vegetation Sampling and Selenium Analysis

Twenty-six vegetation samples were analyzed for selenium, including 16 samples from 4 crop types from the eastern project area (Table 17) and 10 samples from 5 crop types from the western project area (Table 18). The eastern project area samples were Jose tall wheatgrass, pasture, alfalfa, and pistachio. The crop types sampled from the western project area were Jose tall wheatgrass, alfalfa, pasture, cotton, and sorghum.

Six plant samples exceeded the 3 ppm threshold of concern for dietary effects on mammals established in the BO (Table 17). All six samples were from the eastern project area; 3 were pasture, 2 were Jose tall wheatgrass, and 1 was pistachio.

Plant-selenium concentrations were significantly higher in plants collected from the eastern project area relative to plants collected from the western project area, which have not been irrigated with drain water ($P<0.0001$; Table 18). Selenium levels appeared to be similar between Jose tall wheatgrass, pasture, and pistachio samples from the eastern project area, and similar between cotton, Jose tall wheatgrass, pasture, and sorghum from the western project area (Table 19). In both locations, the concentration of selenium in alfalfa was substantially less than for other species.

Table 17. Project site vegetation selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Crop	Date 2009	Sample Location	Selenium (ppm dry wt)	Log base 10	Anti-log
Eastern project area						
01	Jose Tall Wheatgrass	August 4	Field 2-1	1.22	0.0864	
02	Pasture	August 5	Field 2-7	1.86	0.2695	
03	Jose Tall Wheatgrass	August 11	Field 3-2	3.21	0.5065	
04	Pasture	August 11	Field 3-5	3.99	0.6010	
05	Pasture	August 5	Field 10-1	0.996	-0.0017	
06	Jose Tall Wheatgrass	August 10	Field 10-6	2.84	0.4533	
07	Jose Tall Wheatgrass	August 4	Field 11-1	2.86	0.4564	
08	Pasture	August 3	Field 12-1A	3.09	0.4900	
09	Pasture	August 4	Field 12-1B	2.32	0.3655	
10	Alfalfa	August 3	Field 13-2	0.685	-0.1643	
11	Jose Tall Wheatgrass	August 3	Field 13-3	1.24	0.0934	
12	Jose Tall Wheatgrass	August 4	Field 14-2	1.72	0.2355	
13	Pistachio	August 11	Field 14-3	3.04	0.4829	
14	Pasture	August 4	Field 14-4	3.01	0.4786	
15	Jose Tall Wheatgrass	August 3	Field 17-1	3.15	0.4983	
16	Jose Tall Wheatgrass	August 4	Field 18-1	2.53	0.4031	
Arith/**Geo Mean**				2.360	0.3284	***2.1***
SD				0.960	0.2197	***1.7***
SE					0.0982	***1.3***
Lower Limit of 95% Confidence Interval					0.1358	***1.4***
Upper Limit of 95% Confidence Interval					0.5210	***3.3***
Western project area						
01	Jose Tall Wheatgrass	August 10	Field 1-1	0.305	-0.5157	
02	Pasture	August 10	Field 1-2	0.602	-0.2204	
03	Sorghum	August 5	Field 4-2	0.453	-0.3439	
04	Cotton	August 11	Field 4-4	0.498	-0.3028	
05	Alfalfa	August 6	Field 5-4	0.172	-0.7645	
06	Alfalfa	August 6	Field 6-1	0.277	-0.5575	
07	Jose Tall Wheatgrass	August 6	Field 31-3	0.939	-0.0273	
08	Jose Tall Wheatgrass	August 10	Field 32-1	0.699	-0.1555	
09	Alfalfa	August 6	Field 32-2	0.127	-0.8962	
10	Jose Tall Wheatgrass	August 6	Field 36-2	0.801	-0.0964	
Arith/**Geo Mean**				0.487	-0.3880	***0.41***
SD				0.273	0.2890	***1.9***
SE					0.1292	***1.3***
Lower Limit of 95% Confidence Interval					-0.6413	***0.2***
Upper Limit of 95% Confidence Interval					-0.1347	***0.7***

Table 18. 2010 Geometric mean vegetation sample selenium concentrations from the San Joaquin River Water Quality Improvement Project.

Location	N	Geo. Mean* Ppm se (dry wt)	Range
Plants			
Western project area	10	0.41	0.13-0.94
Eastern project area	16	2.13	0.69-3.99
Significant difference ($F_{1,24}$ = 50.290, P < 0.0001) between sites			

Table 19. 2010 vegetation selenium concentrations by crop type and location.

Location	Eastern Project Area		Western project area	
Crop	n	Geo. Mean* Ppm se (dry wt)	n	Geo. Mean* Ppm se (dry wt)
Jose tall wheatgrass	8	2.20	4	0.63
Pasture	5	2.76	1	0.60
Alfalfa	2	0.83	3	0.18
Pistachio	1	3.04		
Cotton			1	0.50
Sorghum			1	0.45

Across year analyses of data from 2008 to 2010 revealed that there was a significant location effect, though not a significant year effect (Table 20). Selenium concentrations were substantially higher in the eastern project area when compared to the western project area in all 3 years (Figure 21). The pattern in selenium concentrations with time was similar between the two locations (Figure 21); this was also consistent with the 2-way ANOVA results, which showed that the interaction between location and year was not significant (Table 20).

Table 20. Results of two-way ANOVA for effects of location and year on plant-selenium concentration at the San Joaquin River Water Quality Improvement Project (2008 to 2010).

Factor	*F*	Df	*P*
location	94.9491	1, 73	<0.0001
year	0.9661	1, 73	0.3289
location x year	0.2086	1, 73	0.6492

* Df=degrees of freedom

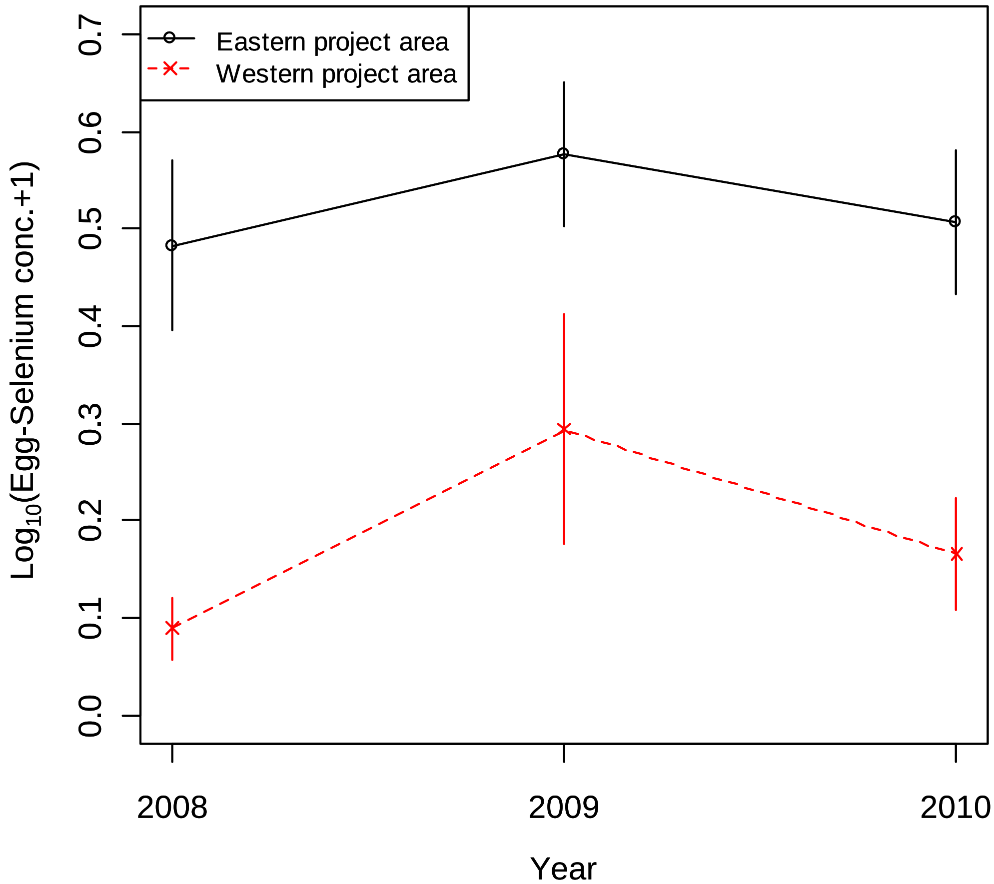


Figure 21. Mean ± 95% confidence interval plant-selenium concentration at the San Joaquin River Water Quality Improvement Project (2008 to 2010).

Small Mammal Sampling and Selenium Analysis

In 2010, 14 deer mice (*Peromyscus maniculatus*), 6 house mice (*Mus musculus*), 2 western harvest mice (*Reithrodontomys megalotis longicaudus*), and 1 california vole (*Microtus californicus*) were captured within the 23 sample locations (14 captures in the eastern project area, 9 in the western project area west of Russell Avenue). Two of the captured animals at the western project area were of undetermined age, and the remaining 21 mice were adults (Table 21).

Nine small mammal samples from the eastern project area exceeded the 3 ppm threshold of concern for dietary effects on mammals established in the BO (Table 21). No small mammal samples from the western project area exceeded the 3 ppm threshold.

Small mammal selenium concentrations were significantly higher in animals captured from the eastern project area relative to animals captured from the western project area west of Russell Avenue (P=0.0003, Table 22). Within each location, deer mice and house mice appeared to have similar selenium concentrations (Table 23).

Table 21. Small mammal selenium concentrations at the San Joaquin River Water Quality Improvement Project.

ID Number	Species	Date 2009	Sample Location	Age	Selenium (ppm dry wt)	Log base 10	Anti-log
Eastern project area							
01	Deer mouse	August 4	Field 2-1	Adult	2.83	0.4518	
02	Deer mouse	August 5	Field 2-7	Adult	3.79	0.5786	
03	Western harvest mouse	August 11	Field 3-2	Adult	3.13	0.4955	
04	House mouse	August 11	Field 3-5	Adult	7.82	0.8932	
05	House mouse	August 5	Field 10-1	Adult	5.84	0.7664	
06	House mouse	August 10	Field 10-6	Adult	2.12	0.3263	
07	Deer mouse	August 4	Field 11-1	Adult	25.2	1.4014	
08	Deer mouse	August 3	Field 12-1a	Adult	5.81	0.7642	
09	Deer mouse	August 4	Field 12-1b	Adult	5.81	0.7642	
10	Deer mouse	August 3	Field 13-2	Adult	2.91	0.4639	
11	Deer mouse	August 3	Field 13-3	Adult	2.05	0.3118	
12	Western harvest mouse	August 4	Field 14-2	Adult	2.27	0.3560	
13	Deer mouse	August 3	Field 17-1	Adult	5.39	0.7316	
14	House mouse	August 4	Field 18-1	Adult	5.88	0.7694	
Arith/**Geo Mean**					5.78	0.6482	***4.4***
SD					5.9	0.2899	***1.9***
SE						0.1297	***1.3***
Lower Limit of 95% Confidence Interval						0.3940	***2.5***
Upper Limit of 95% Confidence Interval						0.9023	***8.0***
Western project area							
01	House mouse	August 10	Field 1-1	Adult	1.38	0.1399	
02	Deer mouse	August 10	Field 1-2	Adult	1.41	0.1492	
03	Deer mouse	August 5	Field 4-2	?	1.44	0.1584	
04	Deer mouse	August 6	Field 5-4	?	0.984	-0.0070	
05	House mouse	August 6	Field 6-1	Adult	1.78	0.2504	
06	Deer mouse	August 6	Field 31-3	Adult	1.57	0.1959	
07	Deer mouse	August 10	Field 32-1	Adult	1.17	0.0682	
08	Deer mouse	August 6	Field 32-2	Adult	1.16	0.0645	
09	California vole	August 6	Field 36-2	Adult	1.96	0.2923	
Arith/**Geo Mean**					1.43	0.1457	***1.4***
SD					0.3	0.0943	***1.2***
SE						0.0422	***1.1***
Lower Limit of 95% Confidence Interval						0.0631	***1.2***
Upper Limit of 95% Confidence Interval						0.2284	***1.7***

Table 22. 2010 Geometric mean small mammal sample selenium concentrations from the San Joaquin River Water Quality Improvement Project.

Location	N	Geo. Mean* Ppm se (dry wt)	Range
Plants			
Western project area	9	1.40	0.98-1.96
Eastern project area	14	4.45	2.05-25.20
Significant difference ($F_{1,21}$ = 19.065, P = 0.0003) between sites			

Table 23. 2010 small mammal selenium concentrations by species and location.

Location	Eastern Project Area		Western project area	
Crop	n	Geo. Mean* Ppm se (dry wt)	n	Geo. Mean* Ppm se (dry wt)
Deer mouse	8	4.82	6	1.27
House mouse	4	4.88	2	1.57
Western harvest mouse	2	2.67		
California vole			1	1.96

Across year analyses of data from 2008 to 2010 showed a significant location effect (Table 24). Selenium concentrations were substantially greater in small mammal samples from the eastern project area compared to the western project area in all three years (Figure 22). Neither year nor the interaction between location and year were significant (Table 24), consistent with patterns that showed relatively little change between years at either project area (Figure 22). Due to non-normality of residuals, Kruskal-Wallis tests were conducted to further evaluate the location and year effects; consistent with the ANOVA results, a significant location effect was detected (P<0.0001; X^2 = 36.4852, df=1), and the year effect was not significant (P=0.7446; X^2 = 0.5897, df=2).

Table 24. Results of two-way ANOVA for effects of location and year on small mammal selenium concentration at the San Joaquin River Water Quality Improvement Project (2008 to 2010).

Factor	*F*	Df	*P*
location	52.7053	1, 60	<0.0001
year	0.0588	1, 60	0.8092
location x year	0.6016	1, 60	0.4410

* Df=degrees of freedom

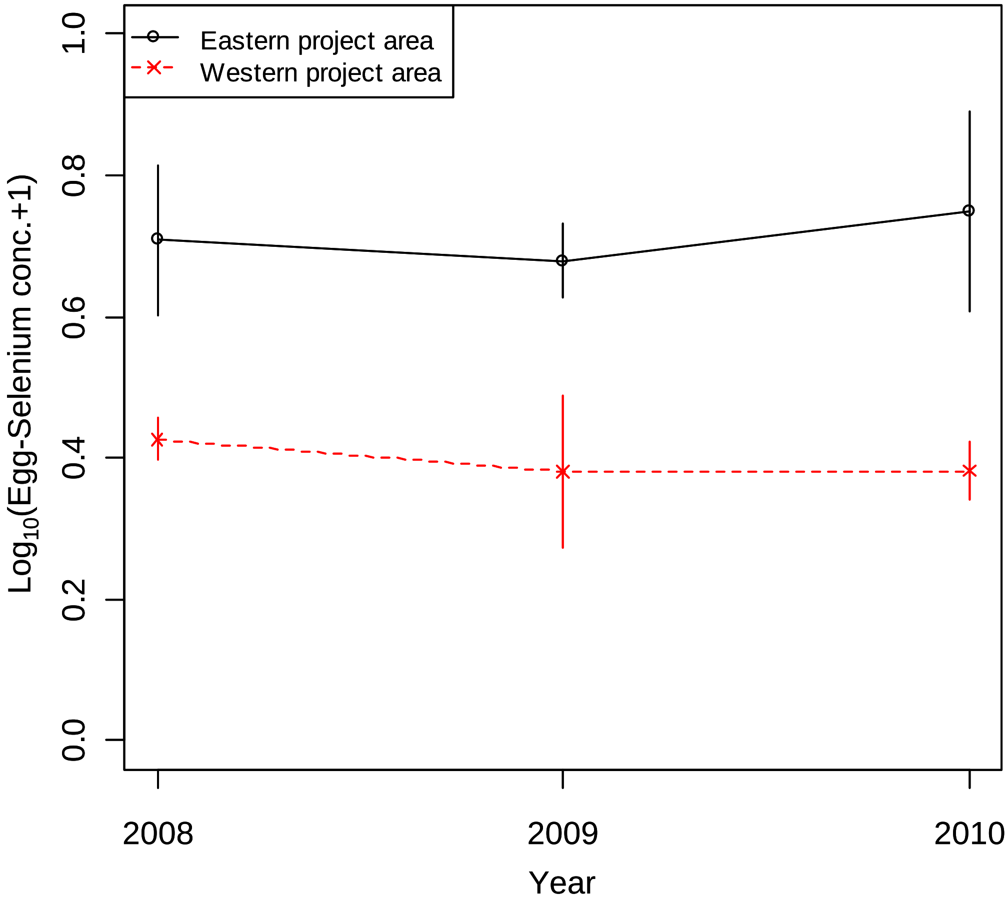


Figure 22. Mean ± 95% confidence interval small mammal-selenium concentration at the San Joaquin River Water Quality Improvement Project (2008 to 2010).

Coyote Tissue Sampling and Selenium Analysis

The hair sample from the coyote collected on 29 November 2009 contained 0.970 µg/g (ppm) selenium. The coyote collected on 15 December 2010 had a hair sample containing 0.578 µg/g selenium and a blood sample containing 0.282 mg/L (ppm) selenium (Table 22). Additionally, a coyote collected on 1 April 2010, but reported in the 2009 monitoring report (H.T. Harvey 2010), had a hair sample containing 0.743 µg/g selenium and a blood sample containing 0.269 mg/L (ppm) selenium. The selenium levels in both blood and hair samples from these coyotes are within normal background levels for mammals (Department of the Interior 1998) and are also below the thresholds that would require compensation habitat for San Joaquin kit fox established in The Final Biological Opinion, 2010-2019 Use Agreement for the Grasslands Bypass Project completed in December 2010 (BO).

Table 25. Observed Coyote Tissue Selenium Concentrations and Selenium Threshold Triggers for San Joaquin Kit Fox Compensation Habitat From the Final Biological Opinion, 2010-2019 Use Agreement for the Grasslands Bypass Project.

	Coyote Hair	Coyote Blood
Thresholds		
No mitigation requirement	<5 µg/g	≤1 mg/L
Mitigation ratio of 0.5:1	5 ≤ 10 µg/g	
Mitigation ratio of 1:1	>10 µg/g	>1 mg/L
Tissues collected in 2010		
1 April 2010	0.743	0.269
29 November 2010	0.970	NA
15 December 2010	0.578	0.282

DISCUSSION

In 2010, approximately 3873 acres of the San Joaquin River Water Quality Improvement Project were planted with salt-tolerant crops and irrigated with agricultural drainage water. Approximately 127 acres of the eastern project area and 1901 acres of western project area were not planted with salt-tolerant crops or irrigated with agricultural drainage water in 2010. Hazing birds during the nesting season, diligent water management, and modification of drains to discourage avian use continued during this reporting period. To date, 8.5 miles of drains have been filled, 1 mile of drain has been netted, and another 1.3 mile of an open drain has been re-contoured to reduce habitat quality. Hazing and closing drains will continue as part of the operation of the improvement project in future years.

The avian census data indicate the eastern project area and western project area are utilized by bird species common in San Joaquin Valley agricultural habitats. Both avian species diversity and relative abundance were lower at the eastern project area than at the western project area, which being actively farmed and irrigated with freshwater, more closely characterizes the bird habitat present in the areas surrounding the project site. In both areas the tall vegetation within some pastures provided nesting habitat for red-winged blackbirds and irrigated pastures and alfalfa fields provided temporary foraging opportunities for birds such as white-faced ibis (*Plegadis chihi*), long-billed curlews (*Numenius americanus*), and red-winged and Brewer's blackbirds (*Euphagus cyanocephalus*).

Two species listed as "species of concern" by the state of California, the burrowing owl (*Athene cunicularia*) and the loggerhead shrike (*Lanius ludovicianus*), were observed nesting on the eastern project area. The closing of drains on the project has resulted in far fewer Califronia ground squirrel colonies present, which in turn, has led to a reduction in the number of burrowing owls inhabiting the eastern project area. Loggerhead shrikes, but not burrowing owls, were also present on the western project area. Swainson's hawks (*Buteo swainsoni*), which are listed as threatened by the state of California, were also observed on the project site. One Swainson's hawk nest was observed on the eastern project area, and 4 more were found on the western project area (Figure 2). One of the nests on the western project area fledged 3 young. The remaining 4 Swainson's hawk nests successfully fledged 2 young each.

Hazing birds during the nesting season, diligent water management, and modification of drains to discourage avian use resulted in fewer killdeer and recurvirostrid nesting on the project site during this reporting period. Recurvirostrid nests in the eastern project area have decreased from over 30 in 2003 to just 2 in both 2009 and 2010. Killdeer nests had numbered greater than 15 per year from 2003, when larger scale egg sampling began, to 2006, but have been reduced to 9 or fewer since 2007.

While diligent management has reduced the number of birds exposed to selenium contamination, mean egg-selenium levels in recurvirostrid eggs at the project site in 2010 continued to be above selenium levels associated with a high probability of reproductive effects including reduced hatchability (CH2MHill et al. 1993). For a more thorough discussion of established egg-selenium thresholds, see the monitoring report for 2005 (H. T. Harvey & Associates 2006).

This monitoring period was the second to include mercury analysis of eggs. Methylmercury is known to cause embryotoxic effects (Fimreite 1971). Because most of the mercury present in bird eggs has been shown to be methylmercury (Kennamer et al. 2005), sampled eggs were analyzed for whole mercury. Methylmercury embryotoxicity thresholds are not published for the three species groups this study samples and species are known to differ in methylmercury sensitivity (Heinz et al 2010). Thresholds suggested in Eisler (1987) include less than 0.9 ppm (wet wt.) for mallards and pheasants. Based on Fimreite's 1971 methylmercury dosing experiment of ring-necked pheasants, a LOAEL (lowest observed adverse effect level) of 0.5 ppm (wet wt.) egg-methylmercury concentration is commonly adopted (Service 2003). Project site egg-mercury concentrations ranged form 0.0039 ppm to 0.146 ppm (wet wt). Project site mean egg-mercury concentrations did not statistically differ from reference area mean egg-mercury concentrations.

The pilot mitigation site initiated in 2006 was again re-contoured in 2010 to contain as many islands as possible without having to bring in additional soil. Three long contour islands were added to six smaller islands remaining from 2008. Rice was not planted in the 50-acre portion of the field designated as mitigation habitat. The vegetation free islands constructed in the pilot mitigation site provided improved nesting and foraging habitat for recurvirostrids and killdeer; resulting in 8 times more recurvirostrid nest-attempts at the mitigation site than on the project site. Predation pressure at the mitigation site was higher than in past years and likely suppressed the number of recurvirostrids nesting there. Six of the 20 shorebird nests located at the mitigation site successfully hatched, while 14 of the nests located were depredated.

Plant-selenium concentrations were significantly higher in plants collected from the eastern project area relative to plants collected from the western project area, which has not been irrigated with drain water. Six plant samples exceeded the 3 ppm threshold of concern threshold for dietary effects on mammals established in the BO.

Small mammal selenium concentrations were also significantly higher in animals captured from the eastern project area compared to animals captured from the western project area. Nine small mammal samples from the eastern project area exceeded the 3 ppm threshold of concern for dietary effects on mammals established in the BO.

Elevated selenium levels present in plant and small mammal has not resulted in elevated selenium levels in tissues sampled from coyotes on or adjacent the project site thus far. The selenium results from hair and blood samples from the 3 coyotes collected in 2010 were within normal background levels for mammals and well below the thresholds that would require compensation habitat for San Joaquin kit fox established in the BO.

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APPENDIX A.
2010 KILLDEER EGG-BORON CONCENTRATIONS AT THE SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT

Eastern Project Area				Reference Area			
ID Number	Boron (ppm dry wt)	Log Base 10	Anti-log	ID Number	Boron (ppm dry wt)	Log Base 10	Anti-log
01	1.95	0.2900		01	1.41	0.1492	
02	2.26	0.3541		02	0.793	-0.1007	
03	1.04	0.0170		03	0.529	-0.2765	
04	0.689	-0.1618		04	1.37	0.1367	
				05	0.913	-0.0395	
				06	1.08	0.0334	
				07	0.991	-0.0039	
				08	1.72	0.2355	
				09	1.11	0.0453	
				10	3.53	0.5478	
				11	0.991	-0.0039	
				12	3.13	0.4955	
				13	0.835	-0.0783	
				14	1.66	0.2201	
				15	2.23	0.3483	
Arith/**Geo Mean**	1.48	0.1248	***1.3***	Arith/**Geo Mean**	1.49	0.1139	***1.3***
SD	0.7	0.2406	***1.7***	SD	0.9	0.2259	***1.7***
SE		0.1076	***1.3***	SE		0.1010	***1.3***
95% CI		-0.0860	***0.8***	95% CI		-0.0841	***0.8***
		0.3357	***2.2***			0.3120	***2.1***

APPENDIX B.
2010 RECURVIROSTRID EGG-BORON CONCENTRATIONS AT THE SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT

Eastern Project Area				Reference Area				Mitigation Site			
ID Number	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**	**ID Number**	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**	**ID Number**	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**
01	3.34	0.5237		01	1.06	0.0253		01	9.27	0.9671	
02	0.986	-0.0061		02	3.07	0.4871		02	2.60	0.4150	
				03	3.86	0.5866		03	0.975	-0.0110	
				04	1.74	0.2405		04	1.41	0.1492	
				05	2.04	0.3096		05	14.90	1.1732	
				06	3.47	0.5403					
				07	5.58	0.7466					
				08	1.66	0.2201					
				09	3.18	0.5024					
				10	0.813	-0.0899					
				11	0.991	-0.0039					
				12	1.29	0.1106					
				13	0.838	-0.0768					
				14	2.10	0.3222					
Arith/**Geo Mean**	2.16	0.2588	***1.8***	Arith/**Geo Mean**	2.26	0.2801	***1.9***	Arith/**Geo Mean**	5.8	0.5387	***3.5***
SD	1.66	0.3747	***2.4***	SD	1.40	0.2657	***1.8***	SD	6.1	0.5136	***3.3***
SE		0.1676	***1.5***	SE		0.1188	***1.3***	SE		0.2297	***1.7***
95% CI		-0.0696	***0.9***	95% CI		0.0471	***1.1***	95% CI		0.0885	***1.2***
		0.5872	***3.9***			0.5130	***3.3***			0.9889	***9.7***

APPENDIX C.
2010 RED-WINGED BLACKBIRD EGG-BORON CONCENTRATIONS AT THE SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT

Eastern Project Area				Western Project Area			
ID Number	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**	**ID Number**	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**
01	11.1	1.0453		01	9.22	0.9647	
02	8.70	0.9395		02	Insufficient sample		
03	15.1	1.1790		03	2.88	0.4594	
04	10.1	1.0043		04	7.24	0.8597	
05	6.64	0.8222		05	5.72	0.7574	
06	12.2	1.0864		06	6.68	0.8248	
07	7.53	0.8768		07	2.61	0.4166	
08	12.1	1.0828		08	28.8	1.4594	
09	10.7	1.0294		09	2.39	0.3784	
10	15.6	1.1931		10	5.44	0.7356	
11	16.8	1.2253		11	2.25	0.3522	
Arith/**Geo Mean**	11.51	1.0440	***11.1***	Arith/**Geo Mean**	7.32	0.7208	***5.3***
SD	3.30	0.1290	***1.3***	SD	7.91	0.3417	***2.2***
SE		0.0577	***1.1***			0.1528	***1.4***
95% CI		0.9309	***8.5***			0.4213	***2.6***
		1.1571	***14.4***			1.0203	***10.5***

APPENDIX D.
2010 KILLDEER EGG-MERCURY CONCENTRATIONS AT THE SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT

Eastern Project Area				
ID Number	**Mercury**		**Log Base 10**	**Anti-log**
	(ppm wet wt)	**(ppb dry wt)**		
01	0.107	418	2.6212	
02	0.0910	337	2.5276	
03	0.080	291	2.4639	
04	0.146	529	2.7235	
Arith/**Geo Mean**	0.106/**0.103**	393.75	2.5840	***383.7***
SD	0.029	104.3	0.1132	***1.3***
SE			0.0506	***1.1***
95% CI			2.4848	***305.4***
			2.6832	***482.2***

Reference Area				
ID Number	**Mercury**		**Log Base 10**	**Anti-log**
	(ppm wet wt)	**(ppb dry wt)**		
01	0.0534	185	2.2672	
02	0.0509	192	2.2833	
03	0.0312	110	2.0414	
04	0.0430	159	2.2014	
05	0.0382	137	2.1367	
06	0.0429	161	2.2068	
07	0.0619	224	2.3502	
08	0.0425	154	2.1875	
09	0.0269	97	1.9868	
10	0.124	417	2.6201	
11	0.0709	273	2.4362	
12	0.0404	146	2.1644	
13	0.177	650	2.8129	
14	0.144	523	2.7185	
15	0.203	729	2.8627	
Arith/**Geo Mean**	0.077/**0.062**	277.13	2.3517	***224.8***
SD	0.057	203.8	0.2778	***1.9***
SE			0.1243	***1.3***
95% CI			2.1082	***128.3***
			2.5953	***393.8***

APPENDIX E.
2010 RECURVIROSTRID EGG-MERCURY CONCENTRATIONS AT THE SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT

Eastern Project Area					Reference Area					Mitigation Site				
ID Number	**Mercury**		**Log Base 10**	**Anti-log**	**ID Number**	**Mercury**		**Log Base 10**	**Anti-log**	**ID Number**	**Mercury**		**Log Base 10**	**Anti-log**
	(ppm wet wt)	**(ppb dry wt)**				**(ppm wet wt)**	**(ppb dry wt)**				**(ppm wet wt)**	**(ppb dry wt)**		
01	0.135	512	2.7093		01	0.117	455	2.6580		01	0.165	637	2.8041	
02	0.133	527	2.7218		02	0.102	381	2.5809		02	0.0372	149	2.1732	
					03	0.148	527	2.7218		03	0.0805	331	2.5198	
					04	0.103	425	2.6284		04	0.314	1250	3.0969	
					05	0.0679	299	2.4757		05	0.257	1050	3.0212	
					06	0.1230	496	2.6955						
					07	0.171	677	2.8306						
					08	0.228	790	2.8976						
					09	0.0942	378	2.5775						
					10	0.301	1150	3.0607						
					11	0.171	621	2.7931						
					12	0.121	430	2.6335						
					13	0.166	592	2.7723						
					14	0.1250	506	2.7042						
Arith/**Geo Mean**	0.134/**0.134**	519.5	2.7155	***519.4***	Arith/**Geo Mean**	0.146/**0.136**	551.9	2.7164	***520.5***	Arith/**Geo Mean**	0.171/**0.132**	683.4	2.7231	***528.5***
SD	0.001	10.6	0.0089	***1.0***	SD	0.060	215.9	0.1488	***1.4***	SD	0.116	465.7	0.3804	***2.4***
SE			0.0040	***1.0***	SE			0.0665	***1.2***	SE			0.1701	***1.5***
95% CI			2.7078	***510.2***	95% CI			2.5860	***385.5***	95% CI			2.3896	***245.2***
			2.7233	***528.8***				2.8468	***702.7***				3.0565	***1138.9***

APPENDIX F.
2010 RED-WINGED BLACKBIRD EGG-MERCURY CONCENTRATIONS AT THE SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT

Eastern Project Area				
ID Number	Mercury		Log Base 10	Anti-log
	(ppm wet wt)	(ppb dry wt)		
01	0.00390	25.8	1.4116	
02	0.00581	44.4	1.6474	
03	0.0115	89.7	1.9528	
04	0.00867	75.1	1.8756	
05	0.00909	67.0	1.8261	
06	0.0227	164	2.2148	
07	0.00750	54.9	1.7396	
08	0.0108	101	2.0043	
09	0.0520	391	2.5922	
10	0.0134	108	2.0334	
11	0.0140	391	2.5922	
Arith/**Geo Mean**	0.014/**0.011**	137.4	1.9900	***97.7***
SD	0.013	130.6	0.3652	***2.3***
SE			0.1633	***1.5***
95% CI			1.6699	***46.8***
			2.3101	***204.2***

Western Project Area				
ID Number	Mercury		Log Base 10	Anti-log
	(ppm wet wt)	(ppb dry wt)		
01	0.0114	102	2.0086	
02				
03	0.0256	165	2.2175	
04	0.0282	201	2.3032	
05	0.0118	136	2.1335	
06	0.0210	177	2.2480	
07	0.0400	334	2.5237	
08	0.0218	122	2.0864	
09	0.0137	91.2	1.9600	
10	0.0198	184	2.2648	
11	0.00430	29.3	1.4669	
Arith/**Geo Mean**	0.020/**0.017**	154.2	2.1213	***132.2***
SD	0.010	81.4	0.2807	***1.9***
SE			0.1255	***1.3***
95% CI			1.8752	***75.0***
			2.3673	***233.0***

APPENDIX G.
2010 CONTROL EGGS SELENIUM SPIKE RESULTS

ID Number	Tissue	Spiked Selenium (ug)	% Recovery
PDD-R-K-01	egg	0.08	86.9
PDD-R-K-06	egg	0.08	102
PDD-R-K-11	egg	0.08	82.7
PDD-P-R-02	egg	0.08	109
PDD-R-R-10	egg	0.08	100
PDD-R-R-12	egg	0.08	100
PDD-P-B-09	egg	0.08	110
PDD-P-B-11	egg	0.08	96.4
PDD-M-04	egg	0.08	97.6
TLDD-M-05	egg	0.08	98.3
		Mean	**98.3**
		Standard deviation	**8.5**

APPENDIX H.
2010 CONTROL EGGS SELENIUM DUPLICATE RESULTS.

ID Number	Replication	Result Selenium	ID Number	Replication	Result Selenium
PK-1	1	6.61	RK-8	1	4.09
	2	7.06		2	4.02
SD		***0.3182***	***SD***		***0.0495***
PK-2	1	5.99	RK-9	1	5.37
	2	6.03		2	5.37
SD		***0.0283***	***SD***		***0.0000***
PK-3	1	5.91	RK-10	1	8.80
	2	5.93		2	8.66
SD		***0.0141***	***SD***		***0.0990***
PK-4	1	6.24	RK-11	1	6.46
	2	6.19		2	6.42
SD		***0.0354***	***SD***		***0.0283***
RK-1	1	16.6	RK-12	1	6.46
	2	16.9		2	6.42
SD		***0.2121***	***SD***		***0.0283***
RK-2	1	3.02	RK-13	1	4.37
	2	2.97		2	4.35
SD		***0.0354***	***SD***		***0.0141***
RK-3	1	2.96	RK-14	1	4.72
	2	3.05		2	4.81
SD		***0.0636***	***SD***		***0.0636***
RK-4	1	3.34	RK-15	1	5.67
	2	3.78		2	5.77
	3	3.78	***SD***		***0.0707***
	4	3.78	PR-1	1	6.31
SD		***0.2200***		2	6.68
RK-5	1	2.90	***SD***		***0.2616***
	2	2.95	PR-2	1	25.7
SD		***0.0354***		2	25.5
RK-6	1	4.32	***SD***		***0.1414***
	2	4.06	RR-1	1	26.1
SD		***0.1838***		2	26.3
RK-7	1	4.34	***SD***		***0.1414***
	2	4.31	RR-2	1	30.1
SD		***0.0212***		2	30.8
			SD		***0.4950***

ID Number	Replication	Result Selenium	ID Number	Replication	Result Selenium
RR-3	1	9.53	PB-5	1	7.97
	2	9.77		2	8.52
SD		***0.1697***	***SD***		***0.3889***
RR-4	1	16.0	PB-8	1	11.7
	2	16.1		2	10.5
SD		***0.0707***	***SD***		***0.8485***
RR-5	1	23.7	PB-9	1	8.24
	2	25.0		2	8.12
SD		***0.9192***	***SD***		***0.0849***
RR-6	1	20.6	PB-11	1	7.30
	2	21.0		2	7.51
SD		***0.2828***	***SD***		***0.1485***
RR-7	1	5.83	BB-5	1	3.96
	2	5.75		2	3.57
SD		***0.0566***	***SD***		***0.2758***
RR-8	1	32.1	BB-10	1	5.01
	2	32.0		2	4.50
SD		***0.0707***	***SD***		***0.3606***
RR-9	1	24.3	BB-11	1	4.03
	2	22.0		2	3.85
SD		***1.6263***	***SD***		***0.1273***
RR-10	1	3.45	MIT-1	1	11.2
	2	3.47		2	10.6
SD		***0.0141***	***SD***		***0.4243***
RR-11	1	4.56	MIT-2	1	6.17
	2	4.44		2	5.85
SD		***0.0849***	***SD***		***0.2263***
RR-12	1	5.09	MIT-3	1	9.26
	2	4.86		2	8.21
SD		***0.1626***	***SD***		***0.7425***
RR-13	1	4.86	MIT-4	1	5.82
	2	4.71		2	5.38
SD		***0.1061***	***SD***		***0.3111***
RR-14	1	4.92	MIT-5	1	5.58
	2	4.87		2	5.43
SD		***0.0354***	***SD***		***0.1061***

ID Number	Replication	Result Selenium	ID Number	Replication	Result Selenium
LHE-1	1	59.2	TLDD-H-3	1	24.0
	2	55.6		2	25.7
SD		***2.5456***	***SD***		***1.2021***
LHE-2	1	63.3	TLDD-H-4	1	8.01
	2	64.5		2	8.21
SD		***0.8485***	***SD***		***0.1414***
LHE-3	1	51.9	TLDD-H-5	1	26.6
	2	47.7		2	26.9
SD		***2.9698***	***SD***		***0.2121***
LHE-4	1	59.6	TLDD-M-1	1	2.53
	2	57.5		2	2.66
SD		***1.4849***	***SD***		***0.0919***
LHE-5	1	50.4	TLDD-M-2	1	1.53
	2	48.8		2	1.58
SD		***1.1314***	***SD***		***0.0354***
LHM-1	1	12.5	TLDD-M-3	1	2.35
	2	13.0		2	2.48
SD		***0.3536***	***SD***		***0.0919***
LHM-2	1	15.7	TLDD-M-4	1	3.28
	2	15.8		2	3.39
SD		***0.0707***	***SD***		***0.0778***
LHM-3	1	20.6	TLDD-M-5	1	3.50
	2	21.8		2	3.66
SD		***0.8485***	***SD***		***0.1131***
LHM-4	1	51.4	TLDD-S-1	1	24.8
	2	52.0		2	25.3
SD		***0.4243***	***SD***		***0.3536***
LHM-5	1	18.0	TLDD-S-2	1	30.9
	2	18.2		2	30.8
SD		***0.1414***	***SD***		***0.0707***
TLDD-H-1	1	5.51	TLDD-S-3	1	30.5
	2	5.46		2	29.5
SD		***0.0354***	***SD***		***0.7071***
TLDD-H-2	1	11.2	TLDD-S-4	1	20.2
	2	11.2		2	20.0
SD		***0.0000***	***SD***		***0.1414***

ID Number	Replication	Result Selenium	ID Number	Replication	Result Selenium
TLDD-S-5	1	27.3	WL-E-03	1	2.54
	2	28.0		2	2.57
SD		***0.4950***	***SD***		***0.0212***
WL-E-01	1	3.03	WL-E-04	1	2.60
	2	3.29		2	2.76
SD		***0.1838***	***SD***		***0.1131***
WL-E-02	1	2.47	WL-E-05	1	9.15
	2	2.73		2	9.70
SD		***0.1838***	***SD***		***0.3889***
Mean SD:	0.3335				
Low SD:	0.0000				
High SD:	2.9698				

SD = Standard Deviation

APPENDIX I.
2010 CONTROL EGGS BORON RESULTS.

Boron Control Spikes.

ID Number	Tissue	Spiked Boron (mg)	% Recovery
PDD-P-K-02	egg	0.1	98
PDD-R-R-03	egg	0.1	97
PDD-R-R-07	egg	0.1	98
PDD-R-R-08	egg	0.1	100
		Mean	**98.3**
		Standard deviation	**1.3**

2010 Control Eggs Boron Duplicate Results

ID Number	Replication	Result Boron	ID Number	Replication	Result Boron
PK-1	1	1.36	RK-14	1	1.70
	2	0.879		2	1.62
	3	3.69	***SD***		***0.0566***
	4	1.86	RR-3	1	3.67
SD		***1.2289***		2	3.92
PK-2	1	1.24		3	3.98
	2	0.970	***SD***		***0.1644***
	3	4.62	RR-6	1	3.52
	4	2.19		2	3.43
SD		***1.6612***	***SD***		***0.0636***
RK-4	1	0.470	RR-7	1	5.17
	2	0.970		2	5.76
	3	2.67		3	5.65
SD		***1.1533***		4	5.76
RK-10	1	3.03	***SD***		***0.2815***
	2	3.84	RR-8	1	1.70
	3	3.71		2	1.98
SD		***0.4350***		3	1.52
RK-11	1	1.03		4	1.45
	2	0.957	***SD***		***0.2364***
SD		***0.0516***	RR-10	1	0.830
RK-13	1	0.837		2	0.796
	2	0.833	***SD***		***0.0240***
SD		***0.0028***	RR-11	1	0.946

ID Number	Replication	Result Boron	ID Number	Replication	Result Boron
RR-12	1	1.07	MIT-4	1	1.63
	2	1.61		2	1.32
	3	1.22		3	1.28
	4	1.25	***SD***		***0.1916***
SD		***0.2290***	MIT-5	1	14.8
MIT-1	1	9.21		2	15.1
	2	9.43	***SD***		***0.2121***
	3	9.19			
SD		***0.1332***			
Mean SD	0.3642				
Low SD:	0.0028				
High SD:	1.6612				

SD = Standard Deviation

APPENDIX J.
2010 CONTROL EGGS MERCURY RESULTS.

Mercury Control Spike.

ID Number	Tissue	Spiked Mercury (ng)	% Recovery
PDD-P-R-01	egg	100	98.0

2010 Control Eggs Mercury Duplicate Results

ID Number	Replication	Result Mercury	ID Number	Replication	Result Mercury
RK-4	1	148	PB-9	1	369
	2	170		2	412
SD		***15.56***	***SD***		***30.406***
RK-8	1	175	MIT-1	1	643
	2	133		2	631
SD		***29.70***	***SD***		***8.4853***
RK-12	1	128	MIT-4	1	1290
	3	163		2	1220
SD		***24.75***	***SD***		***49.497***
RR-7	1	711	MIT-5	1	838
	2	643		2	1260
SD		***48.083***	***SD***		***298.399***
Mean SD	63.11				
Low SD:	8.485				
High SD:	298.40				

SD = Standard Deviation

APPENDIX K. KILLDEER AND RECURVIROSTRID NEST SURVEY RESULTS FOR THE SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT EASTERN PROJECT AREA AND PILOT MITIGATION SITES

Killdeer and Black-necked Stilt Nest Survey Results For The San Joaquin River Water Quality Improvement Easter Project Area.

Cell	Strata	Date	No. of Eggs	Date	No. of Eggs	Date	No. of Eggs	Date	No. of Eggs	Comments	Nest Status	Nest Fate	Nest Agent
Killdeer													
Field 17-1	Field edge	05/06	3	05/11	0					tractor	5	5	7
Field 14-3	Field edge	05/18	2	05/21	0					tractor	5	5	7
Field 10-8	Levee	05/25	3	05/27	0					depredated	5	5	4
Field 13-4	Field edge	05/27	1	06/03	0					tractor	5	5	7
Field 18-2	Field edge	06/15	2	06/22	0					depredated	5	5	4
Field 2-8	Field edge	07/07	4	07/18	0					1 egg collected 7/7, PK-1, presume hatch	1	4	1
Field 3-1	Field edge	07/07	4	07/18	0					1 egg collected 7/7, PK-2, presume hatch	1	4	1
Field 10-7	Field edge	07/07	4	07/18	0					1 egg collected 7/7, PK-3, depredated	5	5	4
Field 10-4	Field edge	07/07	4	07/18	0					1 egg collected 7/7, PK-4, presume hatch	1	4	1
Black-necked Stilt													
Field 2-6	Field Edge	05/13	4	05/21	0					1 egg collected 5/13, PR-1, depredated	5	5	4
Field 12-2	Levee	06/01	1	06/08	4	06/15	0			1 egg collected 5/13, PR-2, depredated	5	5	4

Codes for nest status, nest fate, and nest agent.

Nest status:
1 Undisturbed/normal
2 Investigator damaged
3 Partially destroyed
4 Some eggs missing
5 Totally destroyed
6 Other (poachers, Etc.)

Nest fate:
1 Lost (not relocated)
2 Fate uncertain
3 Hatched (certain)
4 Presumed hatched
5 Destroyed
6 Abandoned
7 Past term/unviable
8 Terminated

Nest agent:
1 None
2 Unknown
3 Observer
4 Predator
5 Livestock
6 Flooding
7 Vehicle
8 Levee maintenance

Abbreviations used in comment column:
fth = Egg that has failed to hatch
ph = Presumed hatched

Killdeer and Recurvirostrid Nest Survey Results For The San Joaquin River Water Quality Improvement Mitigation Site.

Nest ID	Cell	Strata	Date	No. of Eggs	Date	No. of Eggs	Date	No. of Eggs	Date	No. of Eggs	Comments	Nest Status	Nest Fate	Nest Agent
Killdeer														
001	7	Long Island	05/27	2	06/01	4	06/10	0			depredated	5	5	4
002	9	Long Island	05/27	4	06/01	4	06/10	4	06/17	0	presume hatch	1	4	1
003	7	Long Island	06/01	4	06/10	4	06/17	4	06/24	0	presume hatch	1	4	1
Black-necked stilt														
001	7A	Mound	06/10	4	06/17	0					1 egg collected 10 June, 1 chick next to nest 6/17	1	3	1
002	7	Long Island	06/10	4	06/17	0					depredated	5	5	4
003	7A	Mound	06/17	3	06/24	0					depredated	5	5	4
American avocet														
001	3	Short Island	05/27	1	06/01	4	06/10	3	06/17	3	1 egg collected 1 June, 24 June - 0 eggs	1	4	4
002	3	Short Island	05/27	3	06/01	0					depredated	5	5	4
003	2	Short Island	05/27	2	06/01	0					depredated	5	5	4
004	1	Short Island	05/27	2	06/01	0					depredated	5	5	4
005	4	Short Island	05/27	1	06/01	0					depredated	5	5	4
006	5	Short Island	05/27	3	06/01	0					depredated	5	5	4
007	6	Short Island	05/27	2	06/01	0					depredated	5	5	4
008	7	Long Island	06/01	1	06/01	0					depredated	5	5	4
009	5	Short Island	06/10	4	06/17	3	06/24	3	07/09	0	1 egg collected 10 June	1	4	1
010	3	Short Island	06/10	4	06/17	0					1 egg collected 10 June	5	5	4
011	7	Long Island	06/10	3	06/17	0					depredated	5	5	4
012	7	Long Island	06/10	4	06/17	0					1 egg collected 10 June	5	5	4
013	9	Long Island	06/10	2	06/17	4	06/24	4	07/09	0	2 chicks nearby	1	4	1
014	8	Long Island	06/17	2	06/24	4		0			depredated	5	5	4

Codes for nest status, nest fate, and nest agent.

Nest status:
1 Undisturbed/normal
2 Investigator damaged
3 Partially destroyed
4 Some eggs missing
5 Totally destroyed
6 Other (poachers, Etc.)

Nest fate:
1 Lost (not relocated)
2 Fate uncertain
3 Hatched (certain)
4 Presumed hatched
5 Destroyed
6 Abandoned
7 Past term/unviable
8 Terminated

Nest agent:
1 None
2 Unknown
3 Observer
4 Predator
5 Livestock
6 Flooding
7 Vehicle
8 Levee maintenance

Abbreviations used in comment column:
fth = Egg that has failed to hatch
ph = Presumed hatched