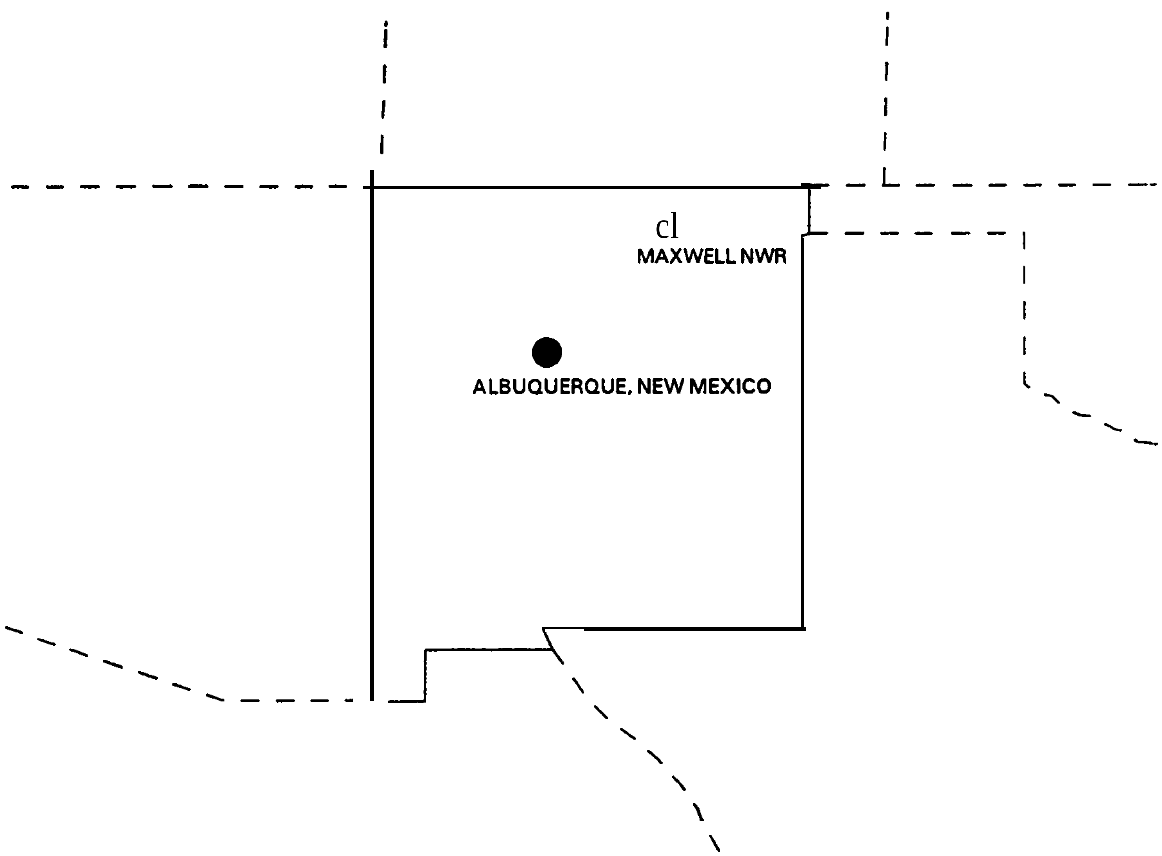
U.S. FISH & WILDLIFE SERVICE

Region 2

ENVIRONMENTAL CONTAMINANTS PROGRAM

AN INVESTIGATION OF SELENIUM, MERCURY, AND LEAD CONCENTRATIONS IN SEDIMENT AND BIOTA FROM MAXWELL NATIONAL WILDLIFE REFUGE, COLFAX COUNTY, NEW MEXICO



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An Investigation of Selenium, Mercury, and Lead Concentrations in Sediment and Biota from Maxwell National Wildlife Refuge, Colfax County, New Mexico

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Abbreviations and Conversion Factors

Abbreviations

parts per million	ppm
parts per billion	ppb
micrograms per gram	ug/g
micrograms per day	ug/day
micrograms per liter	ug/L

Conversions

micrograms per gram	ppm
micrograms per liter	ppb

Dry weight = Wet weight/l - (Moisture % / 100)

Executive Summary

The U.S. Fish and Wildlife Service (Service) conducted this investigation during the summer of 1991 to: (1) determine the nature and extent of selenium, lead, and mercury contamination at Maxwell National Wildlife Refuge (Maxwell NWR), and (2) how such contamination might affect fish and wildlife resources. In 1989, a preliminary investigation revealed that selenium and mercury were present at potentially toxic levels in samples of biological tissue collected from the refuge.

Eighteen sediment and 59 biological samples were collected at six sites on the refuge. Each sample was assayed for selenium, mercury and lead. Samples were assayed for lead because the detection limits in the 1989 study were not low enough to evaluate potential risks that this element might pose to fish and wildlife.

Seven of 11 bird tissue samples collected contained potentially harmful levels of selenium. Embryos of two American avocets and a composite sample of three eared grebe embryos contained between 5.41 and 5.71 ug/g selenium dry weight (dwt). These concentrations of selenium have the potential to cause embryonic teratogenicity in birds nesting at Maxwell NWR. Four of 8 adult migratory bird livers contained concentrations of selenium which may cause nesting migratory birds at Maxwell NWR to experience some degree of adverse biological effects.

Selenium concentrations were consistently higher in all sampled media from Seepage Wetland and Half Playa. All samples of aquatic invertebrates collected at Seepage Wetland and Half Playa contained a mean concentration of 17.7 and 19.0 ug/g dwt of selenium, respectively. Based on studies by Smith and Heinz (1990) and Heinz et al. (1989), the incidence of reproductive impairment significantly increases when avian food sources contain between 4.4 to 7.8 ug/g dwt of selenium as selenomethionine. The selenium concentrations detected in invertebrates in this study were well above this dietary threshold.

Mercury and lead concentrations in all media sampled at Maxwell NWR appeared to be below levels of concern. Mercury was not detected in fillet or whole body portions of game-size fish from Lake No. 13, and was not detected in any of the sediment samples collected. Mercury was detected only in trace amounts in bird tissues. Lead was detected in almost all samples, but at low concentrations below levels of concern.

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Acknowledgments

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Introduction

The U.S. Fish and Wildlife Service (Service) is concerned with organic and inorganic contaminants that may be introduced into national wildlife refuge ecosystems through irrigation drainwater. The Service has documented significant adverse biological effects associated with drainwater contamination in the western United States (Stephens et al. 1988; See et al. 1992; USFWS 1986a). Maxwell NWR in northeastern New Mexico was identified as a site that could potentially be receiving contaminants in irrigation water and from associated water management practices. As a result, sediment and biota samples collected in 1989 from Maxwell NWR were preliminarily screened for the presence of potentially toxic trace elements, residues of organochlorine pesticide compounds, and polychlorinated biphenyls (PCBs). Results indicated that migratory birds and certain species of fish contained elevated concentrations of selenium and mercury Qusk et al. 1991). Migratory bird liver/kidney samples with a mean selenium concentration of 13.98 ug/g dwt and avian embryos containing 3.0 ug/g dwt, indicated that selenium might be bioconcentrating to potentially toxic levels in birds at the refuge. A rainbow trout (*Oncorhynchus mykiss*) sample containing 0.21 ug/g mercury wet weight (wwt) and a black bullhead (*Ameiurus melas*) sample containing 0.08 ug/g mercury wwt suggested that further investigation of mercury was also necessary.

In 1991, the Service conducted a follow-up investigation to determine the extent of selenium and mercury contamination on the refuge and to identify areas of possible selenium accumulation. During the follow-up study, sediment and biota were collected three times at six sites over a three month period. Adults, juveniles, and the eggs of migratory birds were collected when available. Tissue and sediment samples collected for this study were also analyzed for lead because detection limits in the initial study were not low enough to evaluate potential risks that this element poses to fish and wildlife at the refuge.

Study Area

Maxwell National Wildlife Refuge is located near the center of Colfax County in northeastern New Mexico, approximately 40 miles south of the New Mexico-Colorado border, and 2.5 miles northwest of the town of Maxwell (Figure 1). Geomorphically, the refuge lies within the Canadian River Basin, bordered by the Sangre de Cristo Mountains to the west, the Raton Coal Field to the

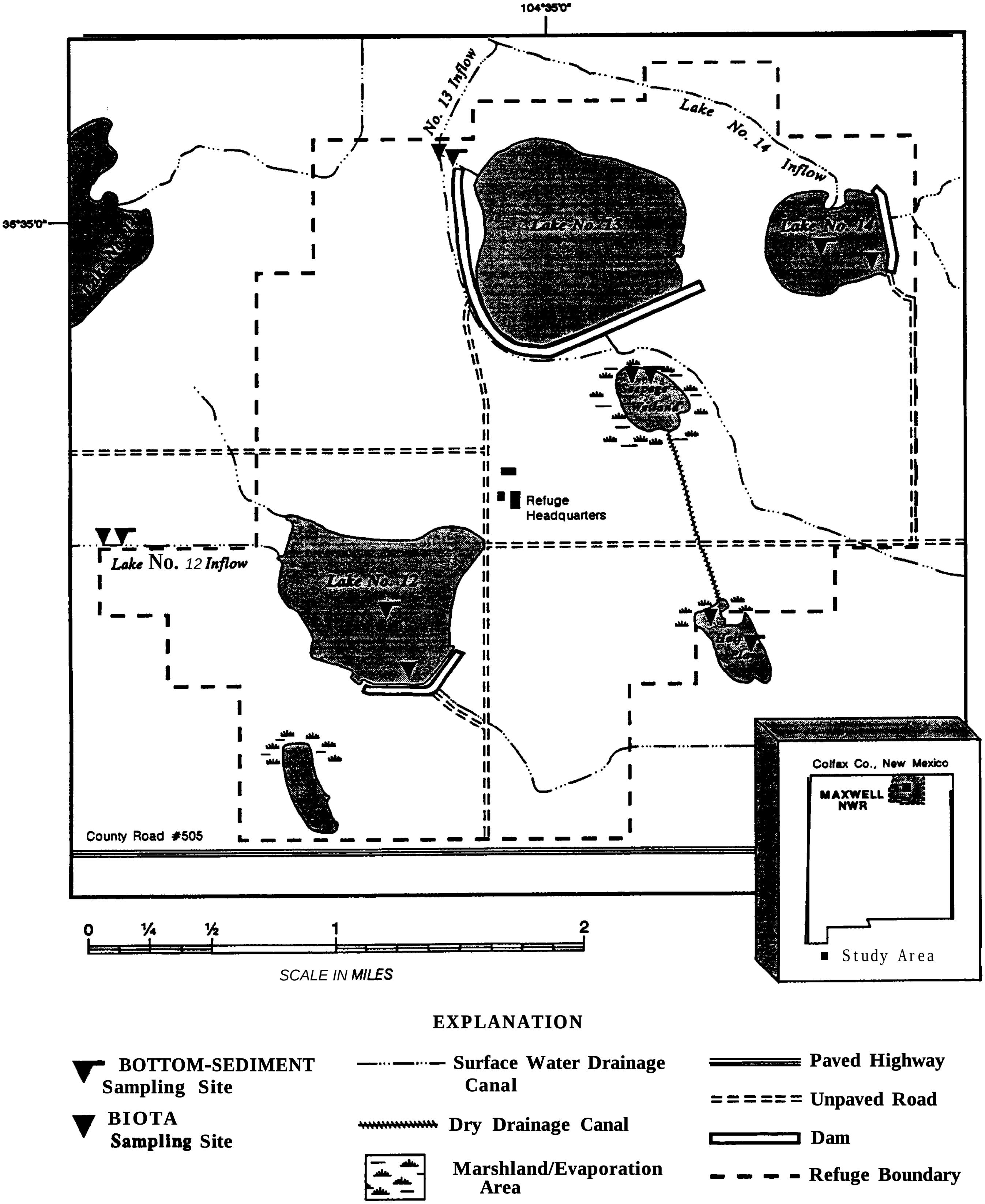

Figure 1.--Sampling locations at the Maxwell National Wildlife Refuge.

north, and Capulin Mountain volcanic range to the east. The refuge boundary encompasses approximately 3,700 acres, including six ponds and lakes totaling approximately 900 surface acres (French, pers. comm.). The elevation of the refuge ranges from 5,980 to 6,090 feet above mean sea level.

The parent materials of soils within the study area are primarily shales and sandstones. These soils generally have a good moisture holding capability, and are consequently good for farming (DOI 1949). A large portion of the refuge is dedicated to farming corn, barley, wheat, and alfalfa (French, pers. comm.).

Six sites (Figure 1) were selected to sample sediment, aquatic invertebrates, and fish, based upon the following criteria: (1) potential contamination problems related to irrigation water and water management practices; (2) area importance in terms of human and land management activities; (3) area importance in terms of migratory bird use. The six sites included Lake No. 12, Lake No. 14, the inflow canals to Lake No. 12 and No. 13, Half Playa and Seepage Wetland. At each of these sites, sediment and biota samples were collected on three separate occasions. Collections of game fish were also made at Lake No. 13. Human health issues were of major concern because the refuge permits angling in Lake No. 13 and No. 14.

Lake No. 12, No. 13, and No. 14 at Maxwell NWR are lacustrine deepwater habitats (water depths greater than 2 meters) and Half Playa and Seepage Wetland are palustrine wetlands (following the classification methods in Cowardin et al. 1979). Irrigation water primarily supplies the three lakes via inflow canals, while irrigation canal seepage and ground-water primarily supply Seepage Wetland and Half Playa. These two playa wetlands usually contain some surface water throughout the year (French, pers. comm.). Two reservoirs northwest of the refuge, Stubblefield Lake and Laguna Madre, may be used to supply water to Lake No. 11, No. 13, and No. 14 via the Stubblefield or Laguna laterals, respectively. Lake No. 12 is filled from Lake No. 11 via the No. 11 lateral and the No. 12 inflow canal. Another supply canal, the Eagle Tail canal, may also be used as an alternate water supply for Lake No. 11, No. 12, and No. 14 and indirectly to Lake No. 12.

Materials and Methods

Sediment, aquatic invertebrates, and fish samples were collected three times at each of the six sites on June 1, July 15, and September 10, 1991. Fish from Lake No. 13 were collected once on August 20, 1991. Migratory bird samples were collected throughout the study period on an as available basis.

Tissue samples collected from birds consisted of individual livers and kidneys from adult killdeer (*Charadrius vociferus*), juvenile teal (*Anas* sp.) and **eared** grebes ***(Podiceps nigricollis)***, and eared grebe and American avocet (***Recurvirostridae americana***) embryos. Fish samples consisted of species specific, whole-fish composites of fathead minnows ***(Pimephales prom&s),*** plains killifish (***Fundulus zebrinus***), channel catfish (***Ictalurus punctatus***), and black bullheads (***Ameiurus melas***). Individual fillet samples of channel catfish and rainbow trout (***Oncorhynchus mykiss***) and individual whole body samples of black bullheads and rainbow trout were collected from Lake No. 13. Each aquatic invertebrate composite sample (at least 3 grams per sample) consisted of various combinations of damselfly nymphs (Order: ***Odonatu),*** dragonfly nymphs, (*Odonata*) crayfish ***(Decopodu),*** water boatmen (***Hemiptera***), mosquito larvae (***Diptera***), and horsefly larvae (***Diptera***).

A stainless steel ***Ekman*** dredge was used to collect sediments from the approximate center of each of the two lakes sampled. A *Wildco* stainless steel hand corer was used at each of the two canal sites and at the two playas. Several five centimeter (approximate) core layers of sediment from the top of the lake or canal bed was sampled from each site. Each sediment sample analyzed was a composite of homogenized individual cores. Sediment was pushed through a 2 millimeter pore diameter sieve to remove pebbles and large pieces of vegetation. Then, the sieved sediment fines were collected in chemically cleaned glass containers and frozen within two hours.

Fish samples were collected using seines or gill nets. Individual whole-fish were combined into composite samples of the same species and of similar length and weight. All channel catfish and rainbow trout fillets used for human health risk evaluations were removed from the left side of the fish and analyzed individually. All fish samples were stored in either *Whirl-paks* or *Ziploc* freezer bags and immediately frozen.

Adult and juvenile birds were shot with steel shot, dissected, and their livers and kidneys removed. The liver and kidney from each specimen were analyzed individually. Bird eggs were hand gathered from nests, scored, and the embryonic material was removed from the shell for analysis. All bird samples were stored in either ***Whirl-paks*** or chemically cleaned glass containers and immediately frozen.

Aquatic invertebrates were collected at each site according to availability, using sieves, seines, or plankton nets. When possible, the same invertebrate species were recollected at each location during subsequent sampling efforts. All aquatic invertebrate samples were stored in ***Whirl-paks*** and immediately frozen. For a list of all samples collected at Maxwell NWR during the 1991 contaminants investigation, see appendix A.

Sediment and biota samples were packed in dry ice and shipped to Research Triangle Institute in Research Triangle Park, North Carolina. Each sample was homogenized, freeze dried, and digested with nitric acid. All samples were analyzed for selenium, mercury, and lead using graphite furnace atomic absorption measurements. For a general description of the analytical methods employed to analyze samples in this report, see appendix B.

Results and Discussion

Reproductive success was seemingly poor for shorebird species which attempted to nest at Maxwell NWR during the 1991 breeding season. Only three American avocet and two killdeer nests were found on the refuge. Within two days of discovery, one of the avocet nests and both killdeer nests were destroyed by predators. One egg from each of the two surviving avocet nests was collected for analysis. Both avocet nests which provided egg samples were located on small islands at Seepage Wetland. Since only a small population of American avocets was observed at the refuge and most were suspected to be breeders, no adults were collected for analysis. Whenever Seepage Wetland was frequented by the U.S. Fish and Wildlife field crew, the adult avocets were seen feeding along the shore. No broods of killdeer or American avocets were ever observed. Whether or not any of the avocet eggs at Seepage Wetland ever hatched is unknown. Approximately 50 eared grebe nests were found at Lake No. 14. One egg from each of three different eared grebe nests was collected and submitted as a composite for analysis. Several mallard and teal broods were observed during the summer, although none of their nests was located. A list of the number and species of birds observed at the refuge during the study period are contained in appendix C.

Evaluations of analytical data obtained in this study were based upon comparisons with published scientific findings. Selenium, lead, and mercury values throughout this report are reported in dry weight units unless otherwise noted. This is due to the fact that the analytical laboratory could not provide the moisture content for some samples. When necessary, wet weight values from published scientific findings (that did not report moisture content values) were converted to dry weight values by assuming a 70% moisture content.

Selenium

Selenium is a semimetallic trace element that occurs in both organic and inorganic forms. Selenium is an essential nutrient in trace quantities, but quickly becomes toxic when excessive concentrations are present. In the environment, most selenium originates in seleniferous rocks and soils and is usually introduced into an aquatic system by groundwater processes or by uptake from plant roots (Eisler 1985; Lemly and Smith 1987; Ohlendorf 1989). Sediments and soils may only be a temporary repository for selenium, since biological, chemical and physical processes mobilize selenium both into and out of sediments (Lemly and Smith 1987). Once into plant tissue or dissolved in water, selenium can bioaccumulate directly into biota. When selenium becomes available to fish, birds, and mammals, it can bioconcentrate in tissues to several orders of magnitude higher than that of the food source. For example, fish that have eaten selenium contaminated plankton or benthic fauna may contain 4 times the selenium concentration of their diet, which in turn could contain 500 times the selenium concentration of the water. Even though concentrations of selenium in water may be low, predatory fish, birds, and mammals can still receive toxic levels of selenium from their diet (Lemly and Smith 1987). In body tissues, selenium is quickly accumulated upon exposure (7.8 days in liver), and is also rapidly eliminated (half-time of 18.7 days) once the dietary exposure has ceased (Heinz et al. 1990).

The geochemical baseline range for selenium concentrations in western soils is 0.039 to 1.4 ug/g and the geometric mean is 0.23 ug/g (Shacklette and Boerngen 1984). Five of the sediment samples collected from Maxwell NWR exceeded the upper limit of the geochemical baseline (Table

1). These five samples were from Half Playa and Seepage Wetland (mean concentrations of were 6.3 and 2.13 ug/g selenium, respectively). The highest selenium concentration in sediment was 10.78 ug/g from Half Playa. At these concentrations, benthic organisms could potentially accumulate selenium from sediment to levels that may adversely affect them or other higher trophic level consumers.

Benthic and other aquatic organisms usually receive most of their selenium either by direct contact with seleniferous sediments, or intake of selenium dissolved in water (Lemly and Smith 1987). Under baseline conditions (i.e., those conditions not greatly influenced by human-induced mobilization of selenium), environmental concentrations of selenium rarely exceed 5 ppm in aquatic invertebrates (Hothem and Ohlendorf 1989). Selenium was detected in all 18 aquatic invertebrate samples collected at the refuge (Table 1). Concentrations of selenium in aquatic invertebrates were lowest at Lake No. 12 and No. 14, and at the inflow canals of Lake No. 12 and No. 13. At these four sites, the selenium concentrations ranged from 1.81 to 3.93 ug/g (n= 12). The highest concentrations of selenium in aquatic invertebrates were consistently detected at Seepage Wetland and Half Playa. The mean concentrations of selenium at these two sites were 17.7 ug/g and 19.0 ug/g, respectively, which are well above baseline levels. Three individual invertebrate samples from these two sites were in excess of 20 ug/g selenium.

Based on the studies by Heinz et al. (1989) and Smith and Heinz (1990), the incidence of reproductive impairment significantly increases when avian food sources contain between 4.4 and 7.8 ug/g dwt (between 4 and 7 ug/g wwt with 10% moisture content; Smith and Heinz 1990) selenium as selenomethionine. Food items of migratory birds commonly include aquatic invertebrates, fish and vegetation. Seepage Wetland and Half Playa produced an abundance of aquatic invertebrates, most notably mosquito larvae and damselfly nymphs. Concentrations of selenium in aquatic invertebrates collected from Seepage Wetland and Half Playa were sufficiently high to cause reproductive impairment in migratory birds. Selenium concentrations in aquatic invertebrates collected from the four other sample sites were below levels of concern.

Fish can take up selenium from contaminated food items in addition to intake from sediments and water (Lemly and Smith 1987; Ohlendorf 1989). The mean concentration of selenium in 11 composite samples of small fish ($\leq$ 8 centimeters total length) from four sites was 4.13 ug/g. These

Table l.-**Comparison of selenium concentrations** detected in **biota** and sediments samples collected at Maxwell National Wildlife Refuge on June 1, July 15, and September 10, 1991.

		Selenium **(ug/g, dry weight)**			
Location ▼	**Sample**	**June 1**	**July 15**	**September 10**	**Mean concentration**
Half Playa	**Sediments**	**6.02**	**10.78**	**2.10**	**6.3 ±3.55**
Half Playa	**Invertebrates**	**20.3**	**16.3**	**20.4**	**19.0 f1.91**
Seepage Wetland	**Sediments**	**3.68**	**1.15**	**1.57**	**2.13 ±1.11**
Seepage Wetland	**Invertebrates**	**20.2**	**19.1**	**13.8**	**17.7 ±2.79**
Lake No. 12	**Sediments**	**0.466**	**0.971**	**0.90**	**0.779 ±0.223**
Lake No. 12	**Invertebrates**	**2.38**	**2.31**	**2.85**	**2.51 ±0.24**
Lake No. 14	**Sediments**	**0.657**	**1.12**	**1.35**	**1.04 ±0.32**
Lake No. 14	**Invertebrates**	**3.93**	**2.84**	**2.26**	**3.01 f0.69**
Lake No. 13 inflow	**Sediments**	**0.765**	**0.863**	**0.88**	**0.836 ±0.051**
Lake No. 13 inflow	**Invertebrates**	**2.45**	**1.81**	**2.86**	**2.37 f0.43**
Lake No. 13 inflow	**Fathead minnows**	**5.18**	**4.68**	**3.80**	**4.55 f0.57**
Lake No. 12 inflow	**Sediments**	**0.60**	**1.09**	**1.35**	**1.01 ±0.31**
Lake No. 12 inflow	**Invertebrates**	**3.21**	**1.95**	**2.10**	**2.42 f0.56**
Lake No. 12 inflow	**Fathead minnows**	**4.14**	**4.25**	**4.56**	**4.31 ±0.18**
Lake No. 12 inflow	**Black bullheads**	**4.72**	**3.77**	******	******

[*, sample type not collected]**

four sites were Lake No. 12 and No. 14, and the two inflow canals; there was no fish life in either Half Playa or Seepage Wetland. Of the 11 samples, the highest concentration was detected in fathead minnows from the No. 13 inflow canal (5.18 ug/g). Most selenium concentrations detected in small fish were within the 4.4 to 7.8 ug/g dietary range that can result in increased incidence of avian reproduction impairment for fish-eating birds.

Skorupa et al. (in review) developed systematic guidelines for interpreting selenium concentrations in livers and eggs of breeding waterbirds. The authors concluded that population mean selenium concentrations in avian livers of breeding birds below 10 ug/g indicated a low risk for selenium-related embryonic deformity, while concentrations in livers in excess of 30 ug/g selenium indicated a high risk for embryonic deformities. Population mean liver selenium concentrations for breeding birds between 10 and 30 ug/g were identified as being in a region of uncertainty of biological risk, and would require further direct studies of avian reproductive performance. The highest individual selenium concentrations in avian livers collected from Maxwell NWR were detected in killdeer (20.0 and 13.0 ug/g), juvenile teal (10.3 ug/g), and eared grebe (10.1 ug/g). Geometric mean (population mean) liver selenium concentrations were calculated for killdeer and juvenile eared grebe only, due to insufficient sample sizes for other avian species collected. The geometric mean concentrations of liver selenium in killdeer and eared grebe were 12.07 (n=3) and 8.04 (n=3) ug/g, respectively. Based on interpretive guidelines developed by Skorupa et al. (in review), the geometric mean liver selenium concentration found in eared grebes is within the low risk threshold for adverse biological effects. The geometric mean liver concentration of selenium observed for killdeer indicates some level of selenium exposure above background levels and a potential risk of embryo deformity, which may warrant further studies of reproductive performance in this species.

Interpretive risk thresholds from avian egg residue data were developed by Skorupa et al. (in review). The authors concluded that individual eggs containing less than 10 ug/g would be at low risk of having a deformed embryo and that individual eggs containing greater than 50 ug/g would be at high risk of having a deformed embryo. Individual selenium egg residues between 10 and 50 ug/g would be in a region of uncertainty for biological risk, and would require further direct studies of avian reproductive performance. Two American avocet embryos and one composite of three eared grebe embryos were collected from Maxwell NWR and analyzed for selenium. All eggs collected showed no embryonic development and may have been abandoned. Selenium concentrations for all avian egg samples were within the range of low biological risk (< 10 ug/g, see Table 2).

The recommended dietary allowance for selenium consumption in humans is 70 ug/day for males and 55 ug/day for females (NRC 1989). The daily exposure of selenium that is not likely to hold significant risk of deleterious effects to humans during a lifetime, based on a 70-kg reference adult, is 350 ug/day (USEPA 1992). The California Department of Health Services issued health advisories against consumption of fish containing greater than 5 ug/g wwt, and recommended a limitation of 4 ounces of fish per 2-week interval for areas where fish were found to contain elevated selenium (2-5 ug/g wwt; Fan et al. 1988). The U.S. geometric mean selenium in whole fish tissue (e.g., background concentration) usually does not exceed 0.5 ug/g wwt (Bauman and May 1984). Geometric mean whole body selenium concentrations for rainbow trout and black bullheads collected from Maxwell NWR were 0.56 and 0.16 ug/g wwt, respectively (Table 3). The mean concentration of selenium in rainbow trout and channel catfish fillets collected from Lake No. 13 was

Table 2.--Concentrations of selenium, lead, and mercury detected in shorebird and waterfowl tissues at Maxwell National Wildlife Refuge, 1991.

Selenium, Lead, and Mercury (ug/g, dry weight)

Location ▼	Sample (Matrix-composite)	Selenium	Lead	Mercury
Seepage Wetland	**American avocet (Embryo)**	**5.56**	**5.50**	**<0.0992**
Seepage Wetland	**American avocet (Embryo)**	**5.71**	**<0.39**	**0.10**
Lake 14	**Eared grebe (Embryo-3)**	**5.41**	**<0.39**	**0.55**
Lake 14	**Juvenile teal (Liver)**	**10.30**	**<1.38**	**1.30**
Lake 12	**Juvenile cinnamon teal (Liver)**	**4.50**	**<0.67**	**0.41**
Lake 14	**Juvenile eared grebe (Liver)**	**5.26**	**2.16**	**<0.37**
Lake 14	**Juvenile eared grebe (Liver)**	**9.80**	**0.23**	**0.145**
Lake 14	**Juvenile eared grebe (Liver)**	**10.10**	**0.23**	**0.339**
Lake 14	**Wdeer (Liver)**	**20.00**	**1.41**	**0.561**
Lake 12	**Killdeer (Liver)**	**6.76**	**co.39**	**0.416**
Lake 12	**Killdeer (Liver)**	**13.00**	**<0.39**	**0.695**

0.348 ±0.098 ug/g wwt (n=4), well within safe concentrations for human consumption. Although only a small number of fillets and whole body fish were analyzed, these data indicate that fish from Lake No. 13 are unlikely to present a selenium-related human health hazard.

Lead

Lead is a ubiquitous trace metal characteristically found in rocks, soils, water, plants, animals, and air. Lead has no beneficial nutritional characteristics to living organisms, and is toxic in most of its chemical forms (Jenkins 1981). Lead concentrations have been found to be highest near areas of lead mining, refining, high motor vehicular traffic, urban zones, and hunting areas (Eisler 1988). Near areas of motor vehicular traffic, lead adsorbs to pavement, rock, and soil particles, after being discharged through automobile exhausts. Once on the road and surrounding areas, rainwater dissolves the lead and from there, it can drain into wildlife habitat where it becomes a potential contaminant (Eisler 1988).

Hunting areas also have a high potential for lead poisoning in wildlife when lead is introduced from spent lead shot (Eisler 1988). In North America alone, approximately 3,000 tons of lead shot

Table 3.--Concentrations of selenium, lead, and mercury detected in whole body and fillet samples of fish collected from Lake No. 13 at Maxwell National Wildlife Refuge, 1991.

Selenium, Lead, and Mercury (ug/g, wet weight)			
Sample (Matrix) ▼	Selenium	Lead	Mercury
Channel catfish (Fillet)	0.44	<0.10	<0.10
Channel catfish (Fillet)	0.45	<0.10	<0.10
Rainbow trout (Fillet)	0.65	<0.10	<0.10
Rainbow trout (Fillet)	0.39	<0.10	<0.10
Rainbow trout (Whole body)	0.71	<0.10	<0.10
Rainbow trout (Whole body)	0.17	<0.10	co.10
Rainbow trout (Whole body)	0.21	co.10	<0.10
Black bullhead (Whole body)	0.12	<0.10	<0.10
Black bullhead (Whole body)	0.18	<0.10	<0.10
Black bullhead (Whole body)	0.26	<0.10	co.10
Black bullhead (Whole body)	0.24	<0.10	<0.10

are expended annually into lakes, marshes, and estuaries by several million waterfowl hunters (USFWS 1986b). Ingestion of spent lead shot and subsequent poisoning accounts for the estimated death of two percent of the continental migratory waterfowl population each year. Spent pellets ingested by waterfowl and other birds are retained in the gizzard where they are ground up into microscopic particles capable of passing through the intestinal wall and being transported by the blood. Lead toxicosis and death may result from the ingestion of as few as two spent pellets (Street 1983).

The geochemical baseline range for lead concentrations in western soils is 5.2 to 55.0 ug/g and the geometric mean is 17.0 ug/g (Shacklette and Boerngen 1984). All 18 sediment samples collected at the refuge were within the geochemical baseline range; four of these samples exceeded the geometric mean concentration (Table 4). These four samples were from Lake No. 14, Lake No. 12, and Seepage Wetland. The highest detected lead concentration in sediments was 20.56 ug/g from Lake No. 14. The International Joint Commission considered ≤27.5 ug/g of selenium in sediments as a background concentration (Ingersoll and Nelson 1989). Based on these results, it appears that sediments at the refuge do not have unusually elevated concentrations of lead.

Lead was detected in all 18 aquatic invertebrate samples collected at the refuge (Table 4). Concentrations of lead in aquatic invertebrates were lowest at Lake No. 14 and the two inflow canals. At these three sites, the concentrations of lead ranged from 0.39 to 2.06 ug/g. The highest concentrations were detected at Half Playa and Lake No. 14. At these two sites, the concentrations ranged from 0.39 to 21.57 ug/g.

Lead is highly toxic to aquatic organisms, especially fish (Rompala et al. 1984). The biological effects in sublethal concentrations of lead include delayed embryonic development, suppressed reproduction, inhibition of growth, increased mucous formation, neurological problems, enzyme inhibition, and kidney disfunction (Rompala et al. 1984; Leland and Kuwabara 1985). The mean concentration of lead in 11 composite samples of small fish was 0.476 ± 0.311 ug/g. The highest concentration was detected in fathead minnows from the No. 12 inflow canal (1.29 ug/g, see Table 4).

Mallards fed diets containing 25 ug/g of lead for 12 consecutive weeks experienced only minor effects as a result. These effects included increased blood lead levels and a decrease in blood ALAD activity (Finley et al. 1976). As a potential food source for migratory birds, all aquatic invertebrates and small fish samples contained concentrations of lead below 25 ug/g. Based on these findings of Finley et al. (1976), it appears that the concentrations of lead in small fish appear to be below the levels which would constitute a hazard to migratory birds residing at Maxwell NWR.

Eisler (1988) recommended that for the protection of natural resources, the concentration of lead in the livers of waterfowl should not exceed 2 ug/g wwt (6.7 ug/g dwt); concentrations in excess of 8 ug/g wwt (26.7 ug/g dwt) can be considered evidence of poisoning. Lead in livers of all birds collected at the refuge ranged from 0.23 to 2.16 ug/g dwt. The highest concentration was detected in a juvenile eared grebe from Lake No. 14. Therefore, it appears that summer resident migratory birds at Maxwell NWR are not accumulating harmful levels of lead.

There is no Food and Drug Administration (FDA) action level for lead concentrations in fish for human consumption, but an edible tissue guideline often cited as an upper limit for lead in foods for human consumption is 0.3 ug/g wwt (Schmitt and Finger 1987; Eisler 1988). All edible portion

Table **4.--Comparison of lead concentrations detected** in biota and sediments samples collected at Maxwell **National Wildlife Refuge on June 1, July 15, and September** 10, 1991.

Lead (ug/g, dry weight)

Location ▾	Sample	June 1	July 15	September 10	Mean concentration
Half Playa	Sediments	14.2	16.17	13.6	14.65 f1.34
Half Playa	Invertebrates	8.02	12.18	0.76	6.98 f4.72
Seepage Wetland	Sediments	12.7	17.19	13.7	14.53 f2.25
Seepage Wetland	Invertebrates	1.93	6.65	0.46	3.01 f2.64
Lake No. 12	Sediments	6.75	20.56	13.2	13.10 f5.14
Lake No. 12	Invertebrates	3.82	1.08	0.20	8.53 f9.34
Lake No. 14	Sediments	16.9	19.35	17.6	18.35 ±1.59
Lake No. 14	Invertebrates	0.754	21.57	0.39	0.74 ±0.28
Lake No. 13 inflow	Sediments	14.7	13.66	14.4	14.25 ±0.44
Lake No. 13 inflow	Invertebrates	0.50	2.06	0.55	1.03 ±0.72
Lake No. 13 inflow	Fathead minnows	0.269	<0.60	0.375	0.31 ±0.04
Lake No. 12 inflow	Sediments	9.55	15.04	13.3	12.63 f2.29
Lake No. 12 inflow	Invertebrates	1.55	0.64	0.63	0.94 f0.43
Lake No. 12 inflow	Fathead minnows	0.248	1.29	0.67	0.736 ±0.428
Lake No. 12 inflow	Black bullheads	<0.197	<0.60	***	***

[***, sample type not collected]

fillets and whole-body fish samples collected at Lake No. 13 were below the detection limit of 0.1 ug/g (Table 3). Although sample numbers were small, these results indicate that edible size rainbow trout, black bullheads, and channel catfish in Lake No. 13 are unlikely to present a lead-related human health hazard.

Mercury

Mercury is a highly toxic heavy metal with no known biological or nutritional function. Methylmercury causes damage to the central nervous system and is carcinogenic, mutagenic, and teratogenic to all animal species (Eisler 1987). Since mercury bioaccumulates and biomagnifies through the food chain, even low concentrations of mercury can still be dangerous to upper trophic level predators. The accumulation of mercury is rapid, but unlike selenium, depuration is slow (Stickel et al. 1977).

The geochemical baseline range for mercury concentrations in western soils is 0.0085 to 0.25 ug/g (Shacklette and Boemgen 1984). All 18 sediment samples collected at the refuge were less than the detection level of 0.01 ug/g (Table 5). Based on our findings, it appears that aquatic sediments at the refuge are generally uncontaminated by mercury. However, this determination does not necessarily rule out potential isolated spots that may have elevated levels of mercury, such as a point source attributable to an unknown dump site.

Mercury was detected in only three of 18 aquatic invertebrate samples. The mercury concentrations in the remaining 15 invertebrate samples were less than the detection levels (Table 5). These results indicate that aquatic invertebrates at the refuge do not appear to contain elevated concentrations of mercury.

Female mallards fed diets containing 0.5 ug/g of mercury throughout their lifetime resulted in liver mercury concentrations ranging from 3.0 to 5.4 ug/g dwt. These females laid a greater percentage of their eggs outside their nest boxes than did control mallards, and also laid fewer eggs and produced fewer ducklings (Heinz 1979). The mean concentration of all eight bird liver samples collected at the refuge was 0.51 $\pm$0.34 ug/g. This mean concentration is well below the liver mercury concentration detected in the test mallards which experienced abnormal behaviors and reduced productivity.

Mercury was detected in two of three embryo samples. One American avocet embryo contained 0.1 ug/g mercury and the composite sample of three eared grebe embryos contained 0.55 ug/g mercury. Eisler (1987) has recommended that avian embryos should contain less than 0.9 ug/g wwt of mercury (3 ug/g dwt). Based upon this recommendation it appears that bird embryos collected from Maxwell NWR do not contain elevated concentrations of mercury.

Eisler (1987) has recommended that the level of mercury in food items for the protection of avian predators should not exceed 0.33 ug/g. Mercury was detected in all 11 composite samples of small fish, but all were below the recommended 0.33 ug/g (Table 5). The highest concentration (0.24 ug/g Hg) was detected in a killifish composite sample from Lake No. 12. The mean concentration of these samples was 0.16 ug/g. Only three out of 18 aquatic invertebrate samples had detectable levels of mercury, and all were below the recommended 0.33 ug/g. Based upon this comparison, migratory

Table S.--Comparison of mercury concentrations detected in biota and sediments samples collected at Maxwell National Wildlife Refuge on June 1, July 15, and September 10, 1991.

		Mercury (ug/g, dry weight)		
Location ▼	Sample	June 1	July 15	September 10
Half Playa	Sediments	<0.099	<0.097	<0.09
Half Playa	Invertebrates	<0.111	<0.097	<0.11
Seepage Wetland	Sediments	<0.099	CO.099	<0.09
Seepage Wetland	Invertebrates	<0.099	<0.098	<0.09
Lake No. 12	Sediments	<0.099	<0.098	CO.09
Lake No. 12	Invertebrates	<0.10	0.111	0.216
Lake No. 14	Sediments	<0.098	<0.097	<0.09
Lake No. 14	Invertebrates	<0.175	<0.18	<0.09
Lake No. 13 inflow	Sediments	< 0.099	<0.099	CO.10
Lake No. 13 inflow	Invertebrates	<0.10	<0.097	<0.09
Lake No. 13 inflow	Fathead minnows	0.11	0.211	0.228
Lake No. 12 inflow	Sediments	<0.10	<0.098	<0.09
Lake No. 12 inflow	Invertebrates	<0.10	<0.099	0.161
Lake No. 12 inflow	Fathead minnows	0.137	0.165	0.171
Lake No. 12 inflow	Black bullheads	0.1385	0.111	***

[***, sample type not collected]

birds feeding on aquatic invertebrates and fish at Maxwell NWR are unlikely to receive harmful levels of mercury.

The FDA (1984) action level for mercury in fish for human consumption is 1.0 ug/g wwt. All edible portion (n=4) fish samples collected at Lake No. 13 were less than the detection limit. Whole-body portion (n=7) collected at Lake No. 13 were also less than the detection limit (Table 5). These results indicate that game size rainbow trout, black bullheads, and channel catfish in Lake No. 13 are unlikely to pose a mercury-related health risk to humans.

Conclusion

Selenium contamination is harmful to aquatic ecosystems because it can be cycled back into the biota and remain at elevated concentrations for years after waterborne inputs of selenium have stopped (Lemly and Smith 1987). This study indicates that selenium contamination may be a problem at Maxwell National Wildlife Refuge and that further definitive studies are necessary to evaluate the magnitude and scope of any selenium-related adverse impacts to biota residing at the refuge.

Mean concentrations of selenium were highest in all matrices collected at Seepage Wetland and Half Playa. Selenium may be leeching out of the soils by seep water from leaky canals, and then entering the surface water of the two playa lakes. Following this study, several ground-water monitoring wells were installed by the US. Geological Survey around Half Playa and Seepage Wetland to test this hypothesis. Elevated concentrations of selenium *were* detected in seepage water entering Half Playa at separate positions (91.2 and 3.95 ug/L). The concentrations of dissolved selenium detected in the seep water, in addition to that detected in biota during this investigation, support a hypothesis that: (1) selenium is entering Half Playa; (2) probably evapoconcentrating in water and sediment; and, (3) is bioconcentrating in biota. Although selenium was not detected in seep water at the Seepage Wetland groundwater well, the same process may be occurring at this site a8 well.

The mean concentrations of selenium in aquatic invertebrates and sediments at Seepage Wetland were 17.7 ug/g and 2.13 ug/g respectively. The mean concentration of selenium in aquatic invertebrates and sediments at Half Playa were 19.0 ug/g and 6.3 ug/g, respectively. These data indicate that migratory birds feeding at Seepage Wetland and Half Playa on Maxwell NWR are being exposed to elevated concentrations of selenium.

Mean concentrations of selenium were lower in all matrices at the two lake sites than at the two playas, probably because any selenium entering the lakes via groundwater mobilization is continually being diluted by large amounts of inflow water with low concentrations of selenium. Since these lakes are flow through systems with inflow and outflow canals, they do not act as evaporation basins like Seepage Wetland or Half Playa. Also, the volume of water in all three lakes at Maxwell NWR is probably sufficient to dilute selenium concentrations to safe levels.

Lead was detected in almost all biotic samples collected, but their concentrations were below a level for concern. Sediments at Lake No. 12, No. 14 and at Seepage Wetland contained lead concentrations above the geometric mean for lead in soils of the western United States, but these concentrations are apparently not contaminating biota. Therefore, no further study of lead contamination at Maxwell NWR appears necessary at this time.

Out of the 77 samples of sediment and biota collected from Maxwell NWR, only 26 samples contained detectible levels of mercury; the majority of these samples were small fish and bird tissues. However, the detected concentrations of mercury were below a level for concern for these samples. No further study of mercury contamination at Maxwell NWR appears necessary at this time.

Neither lead nor mercury were detected in fish fillets of rainbow trout and black bullhead collected from Lake No. 13, and selenium concentrations were near background levels. Although only a small number of fillets were sampled, selenium, lead, and mercury in the three game-size fish species collected were within ranges considered safe for human consumption.

As a result of identifying site-specific selenium contamination on the refuge, the Maxwell National Wildlife Refuge/Vermejo Irrigation Project has been nominated for inclusion in the Department of the Interior's irrigation drainwater program. However, we recommend that any subsequent studies of drainwater-related problems on the refuge be limited to hydrologic studies that focus on determining the most feasible methods for remediation of the two selenium contaminated areas, Seepage Wetland and Half Playa. A reconnaissance investigation should also be conducted on the remainder of the Vermejo Irrigation Project to identify sources and extent of selenium contamination.

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Appendix A.--Sample matrix, weight, location, and date of collection for all samples collected during the Maxwell National Wildlife Refuge 1991 investigation.

Sample catalog

Sample (Sample Number)▼	Matrix (Composite amount)	Sample Weight (g)	Location	Date
American avocet (69)	Embryo	23.3	Seepage Wetland	6/12/91
American avocet (82)	Embryo	17.6	Seepage Wetland	6/12/91
Eared grebe (70)	Embryo (3)	53.8	Lake No. 14	7/16/91
Juvenile eared grebe (133)	Liver	2.0	Lake No. 14	8/15/91
Juvenile eared grebe (134)	Kidney	1.0	Lake No. 14	8/15/91
Juvenile eared grebe (135)	Liver	6.0	Lake No. 14	8/15/91
Juvenile eared grebe (136)	Kidney	2.0	Lake No. 14	8/15/91
Juvenile eared grebe (137)	Liver	12.0	Lake No. 14	8/15/91
Juvenile eared grebe (138)	Kidney	4.0	Lake No. 14	8/15/91
Juvenile teal (72)	Liver	0.9	Lake No. 14	7/16/91
Juvenile teal (73)	Kidney	0.3	Lake No. 14	7/16/91
Juvenile cinnamon teal (74)	Liver	1.8	Borrow pit at Lake 12	7/16/91
Juvenile cinnamon teal (75)	Kidney	0.5	Borrow pit at Lake 12	7/16/91
Killdeer (76)	Liver	7.6	Lake No. 14	7/10/91
Killdeer (77)	Kidney	1.0	Lake No. 14	7/10/91
Killdeer (78)	Liver	5.6	Lake No. 12	7/10/91
Killdeer (79)	Kidney	1.6	Lake No. 12	7/10/91
Killdeer (80)	Liver	3.7	Lake No. 12	7/10/91
Killdeer (81)	Kidney	1.0	Lake No. 12	7/10/91
Channel catfish (10)	Fillet	155.9	Lake No. 13	8/20/91
Channel catfish (11)	Fiiet	99.2	Lake No. 13	8/20/91
Rainbow trout (01)	Fillet	80.0	Lake No. 13	8/20/91
Rainbow trout (02)	Fiiet	198.4	Lake No. 13	8/20/91
Rainbow trout (03)	Whole body	652.0	Lake No. 13	8/20/9 1
Rainbow trout (04)	Whole body	510.3	Lake No. 13	8/20/91
Rainbow trout (OS)	Whole body	396.9	Lake No. 13	8/20/9 1
Black bullhead (06)	Whole body	269.3	Lake No. 13	8/20/91
Black bullhead (07)	Whole body	368.5	Lake No. 13	8/20/9 1
Black bullhead (08)	Whole body	340.2	Lake No. 13	8/20/9 1
Black bullhead (09)	Whole body	255.1	Lake No. 13	8/20/91
Black bullhead (37)	Whole body (10)	385.6	Lake No. 12 inflow	6/01/91
Black bullhead (67)	Whole body (10)	133.5	Lake No. 12 inflow	7/15/91
Black bullhead (123)	Whole body (> 5)	67.0	Lake No. 14	9/11/91
Fathead minnow (36)	Whole body (45)	110.0	Lake No. 13 inflow	6/01/91
Fathead minnow (38)	Whole body (20)	72.5	Lake No. 12 inflow	6/01/91
Fathead minnow (65)	Whole body (14)	50.2	Lake No. 13 inflow	7/15/91
Fathead minnow (66)	Whole body (10)	36.7	Lake No. 12 inflow	7/15/91

Appendix *A.-Continued.* Sample matrix, weight, location, and date for all samples collected during the Maxwell National Wildlife Refuge 1991 investigation.

Sample catalog

Sample (Sample Number)	Matrix (Composite-amount)	Sample Weight (g)	Location	Date
Fathead minnow (119)	Whole body (> 5)	16.0	Lake No. 13 inflow	9/10/91
Fathead minnow (121)	Whole body (> 10)	42.0	Lake No. 12 inflow	9/11/91
Plains killifish (120)	Whole body (> 15)	41.0	Lake No. 12	9/11/91
Plains killifish (122)	Whole body (10)	8.0	Lake No. 14	9/11/91
Damselfly nymphs (31)	Whole body (> 100)	5.2	Lake No. 12 inflow	6/04/91
Damselfly nymphs (32)	Whole body (> 100)	5.5	Lake No. 12	6/04/91
Damselfly nymphs (33)	Whole body (> 100)	4.4	Lake No. 14	6/04/91
Damselfly nymphs (61)	Whole body (> 100)	6.5	Lake No. 12	7/15/91
Damselfly nymphs (115)	Whole body (> 100)	4.0	Half Playa	9/10/91
Crayfish (30)	Whole body (8)	77.0	Lake No. 13 inflow	6/01/91
Crayfish (59)	Whole body (> 10)	115.9	Lake No. 13 inflow	7/15/91
Crayfish (60)	Whole body (> 5)	68.0	Lake No. 12 inflow	7/15/91
Crayfish (114)	Whole body (> 5)	60.0	Lake No. 13 inflow	9/10/91
Crayfish (117)	Whole body (> 5)	68.0	Lake No. 12 inflow	9/11/91
Dragonfly nymphs (113)	Whole body (> SO)	7.0	Seepage Wetland	9/10/91
Dragonfly nymphs (118)	Whole body (> 25)	3.0	Lake No. 14	9/11/91
Water boatmen (62)	Whole body (> SO)	6.1	Lake No. 14	7/15/91
Water boatmen (116)	Whole body (> 25)	3.5	Lake No. 12	9/11/91
Mosquito larva (34)	whole body (> 1000)	4.1	Seepage Wetland	6/05/91
Mosquito larva (63)	Whole body (> 1000)	12.6	Seepage Wetland	7/15/91
Mosquito larva (64)	Whole body (> 1000)	7.8	Half Playa	7/15/91
Horsefly larva (35)	Whole body (> 100)	3.8	Half Playa	6/05/91
Sediments (13)	Whole sediment	201.4	Lake No. 13 inflow	5/30/91
Sediments (14)	Whole sediment	209.0	Lake No. 12 inflow	6/01/91
Sediments (15)	Whole sediment	226.3	Lake No. 12	6/04/91
Sediments (16)	Whole sediment	286.0	Lake No. 14	6/04/91
Sediments (17)	Whole sediment	260.8	Seepage Wetland	6/05/91
Sediments (18)	Whole sediment	387.3	Half Playa	6/05/91
Sediments (53)	Whole sediment	407.5	Lake No. 13 inflow	7/15/91
Sediments (54)	Whole sediment	336.0	Lake No. 12 inflow	7/15/91
Sediments (55)	Whole sediment	299.4	Lake No. 12	7/15/91
Sediments (56)	Whole sediment	343.5	Lake No. 14	7/15/91
Sediments (57)	Whole sediment	386.1	Seepage Wetland	7/15/91
Sediments (58)	Whole sediment	407.3	Half Playa	7/15/91
Sediments (107)	Whole sediment	297.7	Seepage Wetland	9/10/91
Sediments (108)	Whole sediment	331.8	Lake No. 13 inflow	9/10/91
Sediments (109)	Whole sediment	285.0	Half Playa	9/10/91

Appendix **A.--*Continued.*** Sample matrix, weight, location, and date for all samples collected during the Maxwell National Wildlife Refuge 1991 investigation.

Sample catalog

Sample (Sample Number) ▼	Matrix (Composite-amount)	Sample Weight (g)	Location	Date
Sediments (110)	Whole sediment	269.3	Lake No. 12	9/10/91
Sediments (111)	Whole sediment	290.6	Lake No. 12 inflow	9/11/91
Sediments (112)	Whole sediment	262.2	Lake No. 14	9/11/91

Appendix B.--Analytical methods employed to analyze samples for the Maxwell NWR 1991 investigation.

(*Note:* Not all samples received each of these treatments. Individual methods are specifically designed for specific samples).

1. **Homogenization A.** All samples were homogenized. Homogenization was preformed using a ***Kitchen Aid*** food processor. Portions were then freeze dried for determination of moisture content and subsequent acid digestion.

2. **Homogenization B.** Following freeze drying, samples were ground to approximately 100 mesh using a glass mortar and pestle.

3. **Digestion for Graphite Furnace Atomic Absorption (GFAA) Measurement.** Using a CEM microwave oven, 0.25 to 0.5 grams of freeze dried tissue were heated in a capped 120 **mL** ***Teflon*** vessel in the presence of ***5*** **mL** of ***Baker Instra-Analyzed*** nitric acid for three minutes at 120 watts. The residue was then diluted to 50 **mL** with laboratory pure water.

4. **GFAA.** GFAA measurements were made using a ***Perkin-Elmer Zeeman*** 3030 atomic absorption spectrophotometer with a ***HGA-600*** graphite furnace and an ***AS-60*** autosampler.

5. **Digestion for Inductively Coupled Plasma Emission (ICP) Measurement.** Some 0.25 to 0.5 grams of sediment were placed in a 120 **mL** ***Teflon*** microwave vessel. One **mL** each of **HCl,** HF, and $HClO_4$, and 10 **mL** HNO_3 were added to the vessel. The vessel was then capped according to the manufacturer's instructions and was heated in a CEM microwave oven for two minutes at 120 watts, three minutes at 180 watts, and ten minutes at 600 watts. The resulting residue is diluted to 100 **mL** with 5% HCI. This solution was then filtered through ***Whatman 41*** filter paper prior to ICP measurement. An HF resistance torch tip was used for these digests during the ICP measurement.

Appendix C.-Identified species and numbers of birds sighted on five occasions during the Maxwell National Wildlife Refuge 1991 investigation.

Bird Survey

Bird Species ▼	Number Observed	Bird Species ▼	Number Observed
Bank swallow	2	Lesser scaup	4
Vesper sparrow	25	Grackle	2
Song sparrow	3	Killdeer	5
American robin	1	American avocet	15
Western kingbird	35	Long billed curlew	1
Easternkingbird	14	Western grebe	1
Meadow lark	37	Bared grebe	75
Lark bunting	13	Cinnamon teal	6
Magpie	9	Blue-winged teal	3
Mocking bird	1	Readhead	5
Kestrel	6	Mallard	7
Kestrel (juvenile)	2	Gadwall	16
Mourning dove	33	Canada goose	6
Red-winged blackbird	25	Great blue heron	2
Read-headed woodpecker	2	Burrowing owl	1
Bullock's northern oriole	12	Burrowing owl (juvenile)	1
Blue grosbeak	1	Great homed owl	5
Brown-headed cowbird	1	Swainson's hawk	5
Canvasback	2	Double crested cormerant	3

▸ Total number of birds recorded: 404

Appendix D.-Contaminant concentrations detected in sediment and biota samples collected at Maxwell National Wildlife Refuge, June-September, 1991.

[Trace-element concentrations are in micrograms per gram. A-avocet, American avocet; B-bullhead, black **bullhead;** C-teal, cinnamon teal; **E-grebe,** eared **grebe; FH-minnow,** fathead minnow; **P-killifish,** plains **killifish;** R-trout, rainbow trout; **ug/g,** micrograms Per gram; g, grams; **<,** less tban detection limit; **N/A, not assertained]**

Trace-elements (ug/g, dry weight)

Sample (Sample Number)▾	Percent **Moisture**	Sample **Weight (g)**	**Selenium**	**Mercury**	**Lead**
A-avocet embryo (69)	**69.8**	23.3	5.56	**<0.0992**	5.5
A-avocet embryo (82)	**70.9**	17.6	5.71	0.1	**CO.3914**
E-grebe embryo composite (70)	78.0	53.8	5.41	0.55	**<0.3914**
Juvenile E-grebe liver (133)	**NIA**	2.0	5.26	CO.365	2.16
Juvenile E-grebe kidney (134)	**N/A**	1.0	5.3	**<1.0**	**<2.0**
Juvenile E-grebe liver (135)	**N/A**	6.0	9.8	0.145	0.23
Juvenile E-grebe kidney (136)	**NIA**	2.0	9.54	**<0.1558**	**<0.3115**
Juvenile E-grebe liver (137)	**N/A**	12.0	**10.1**	**0.339**	0.23
Juvenile E-grebe kidney (138)	**N/A**	4.0	**9.76**	0.383	**<0.1984**
Juvenile teal *liver (72)*	72.7	0.9	**10.3**	1.3	**<1.3761**
Juvenile teal kidney (73)	70.0	0.3	**12.0**	**<1.7241**	**<6.8966**
Juvenile C-teal liver (74)	74.52	1.8	4.5	0.41	**<0.6726**
Juvenile C-teal kidney (75)	72.7	0.5	**<4.0323**	**<0.8065**	**<3.2258**
Killdeer liver (76)	67.2	7.6	20.0	0.561	1.41
Killdeer kidney (77)	74.4	**1.0**	10.6	0.674	< 0.885
Killdeer liver (78)	70.7	5.6	6.76	0.416	< 0.3906
Killdeer kidney (79)	39.9	1.6	**11.1**	**0.591**	0.69
Killdeer liver (80)	68.4	3.7	**13.0**	**0.695**	< 0.3945
Killdeer kidney (81)	75.9	**1.0**	16.0	0.687	**Cl.9048**
Channel cattish fillet (10)	**NIA**	**155.9**	0.26	**<0.1**	**<0.1**
Channel catfish fillet (11)	NIA	**99.2**	0.24	**CO.1**	**<0.1**
R-trout fillet (01)	**N/A**	**80.0**	0.44	**<0.1**	**<0.1**
R-trout fillet (02)	**NIA**	**198.4**	0.45	**co.1**	**<0.1**
R-trout whole body **(03)**	**NIA**	652.0	0.65	**<0.1**	**<0.1**
R-trout whole body (04)	**NIA**	510.3	0.39	**<0.1**	**<0.1**
R-trout whole body (OS)	**N/A**	396.9	0.71	**<0.1**	**<0.1**
B-bullhead whole body (06)	**N/A**	269.3	0.17	**<0.1**	**<0.1**
B-bullhead whole body (07)	**N/A**	368.5	0.21	**<0.1**	**<0.1**
B-bullhead whole body (08)	**N/A**	340.2	0.12	**<0.1**	**CO.1**
B-bullhead whole body (09)	**N/A**	255.1	0.18	**<0.1**	**<0.1**
B-bullhead whole body (37)	**74.1**	385.6	4.72	**0.1385**	**CO.1969**
B-bullhead whole body (67)	**79.4**	133.5	3.77	**0.111**	**<0.6**
B-bullhead whole body (123)	75.5	67.0	3.97	**0.132**	0.49
FH-minnow whole body (36)	70.1	**110.0**	5.18	**0.11**	0.269

Appendix **D.--*Continued.* Contaminant concentrations detected in sediment and biota samples collected at Maxwell National Wildlife Refuge, June-September,** 1991.

Trace-elements **(ug/g, dry weight)**

Sample (Sample Number)▼	Percent Moisture	Sample Weight (g)	Selenium	Mercury	Lead
FH-minnow whole body (38)	72.4	72.5	4.14	0.137	0.248
FH-minnow whole body (65)	77.1	50.2	4.68	0.211	<0.6
FH-minnow whole body (66)	78.6	36.7	4.25	0.165	• 1.29
FH-minnow whole body (119)	N/A	16.0	3.8	0.228	0.375
FH-minnow whole body (121)	N/A	42.0	4.56	0.171	0.67
P-killifish whole body (120)	N/A	41.0	3.01	0.24	0.71
P-killifish whole body (122)	N/A	8.0	3.36	0.152	0.49
Damselfly nymphs (31)	21.2	5.2	3.21	< 0.0998	1.55
Damselfly nymphs (32)	21.7	5.5	2.38	<0.1	3.82
Damselfly nymphs (33)	15.0	4.4	3.93	co.1754	0.754
Damselfly nymphs (61)	85.2	6.5	2.31	0.111	1.08
Damselfly nymphs (115)	N/A	4.0	20.4	<0.1121	0.76
Crayfish (30)	68.5	77.0	2.45	<0.1	0.5
Crayfish (59)	84.89	115.9	1.81	<0.0965	2.06
Crayfish (60)	73.0	68.0	1.95	<0.0992	0.64
Crayfish (114)	66.7	60.0	2.86	<0.0996	0.55
Crayfish (117)	67.5	68.0	2.1	0.161	0.63
Dragonfly nymphs (113)	N/A	7.0	13.8	<0.099	0.46
Dragonfly nymphs (118)	N/A	3.0	2.26	< 0.0994	0.39
Water boatmen (62)	94.08	6.1	2.84	co.1799	21.57
Water boatmen (116)	N/A	3.5	2.85	0.216	0.2
Mosquito larva (34)	21.7	4.1	20.2	<0.0992	1.93
Mosquito larva (63)	90.0	12.6	19.1	<0.0984	6.65
Mosquito larva (64)	84.89	7.8	16.3	< 0.0969	12.18
Horsefly larva (35)	39.7	3.8	20.3	<0.1111	8.02
Sediments (13)	22.1	201.4	0.765	< 0.0994	14.7
Sediments (14)	34.4	209.0	0.6	co.1	9.55
Sediments (15)	28.3	226.3	0.466	< 0.0992	6.75
Sediments (16)	25.6	286.0	0.657	<0.0977	16.9
Sediments (17)	45.6	260.8	3.68	<0.0998	12.7
Sediments (18)	31.7	387.3	6.02	< 0.0994	14.2
Sediments (53)	27.77	407.5	0.863	< 0.0992	13.66
Sediments (54)	47.32	336.0	1.09	<0.0984	15.04
Sediments (55)	64.9	299.4	0.971	< 0.098	20.56
Sediments (56)	60.6	343.5	1.12	<0.0971	19.35
Sediments (57)	34.7	386.1	1.15	< 0.0996	17.19
Sediments (58)	34.9	407.3	10.78	< 0.0969	16.17

Appendix D.--*Continued.* Contaminant concentrations detected in sediment and biota samples collected at Maxwell National Wildlife Refuge, June-September, 1991.

Trace-elements (ug/g, dry weight)

Sample (Sample Number)▼	Percent Moisture	Sample Weight (g)	Selenium	Mercury	Lead
Sediments (107)	26.8	297.7	1.57	< 0.0971	13.7
Sediments (108)	22.9	311.8	0.88	<0.1	14.4
Sediments (109)	34.3	285.0	2.1	< 0.0969	13.6
Sediients (110)	51.9	269.3	0.9	<0.099	13.2
Sediments (111)	33.3	290.6	1.35	<0.0977	13.3
Sediments (112)	56.4	262.2	1.35	< 0.0986	17.6