RECONNAISSANCE INVESTIGATION OF WATER QUALITY, BOTTOM SEDIMENT, AND BIOTA ASSOCIATED WITH IRRIGATION DRAINAGE IN THE MIDDLE RIO GRANDE VALLEY AND BOSQUE DEL APACHE NATIONAL WILDLIFE REFUGE, NEW MEXICO, 1988-89

By Kim Ong, U.S. Geological Survey;

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CONVERSION FACTORS, VERTICAL DATUM, ABBREVIATED WATER-QUALITY UNITS, AND ACRONYMS

Multiply	By	To obtain
acre	0.4047	square hectometer
acre-foot	0.001233	cubic hectometer
inch	25.40	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
cubic foot per second	28.32	liter per second

Temperatures can be converted by the equations:

$$°F = (1.8 \times °C) + 32$$

$$°C = (°F - 32)/1.8$$

Sea level: In this report sea level refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Data in this report have been collected, analyzed, and reported by several laboratories and governmental agencies; therefore, different reporting units have been used. Assuming that the density of water samples is 1.00 gram per milliliter, the following reporting units are equivalent:

parts per million (ppm) = milligrams per liter (mg/L)
= micrograms per gram (μg/g)
= milligrams per kilogram (mg/kg)
parts per billion (ppb) = micrograms per liter (μg/L)
= micrograms per kilogram (μg/kg)

Concentrations of chemical constituents such as trace elements and pesticides often are smaller than minimum concentrations that can be identified or measured with specified laboratory methods. In those situations, concentrations are reported as less than (<) reporting limits which are the minimum concentrations that can be reported with a high degree of confidence.

Concentrations of chemical constituents in samples are reported on a dry-weight basis for bottom sediment and on a dry-weight or wet-weight basis for biota. The relation between dry-weight concentration and wet-weight concentration with the percent moisture expressed on a wet-weight sample basis is:

$$\text{dry-weight concentration} = \left(\frac{\text{wet-weight concentration}}{1 - \text{percent moisture}/100}\right)$$

Specific conductance is a measure of the capacity of a water solution to conduct an electrical current. It is expressed in μS/cm (microsiemens per centimeter at 25 degrees Celsius) and can be used to estimate dissolved-solids concentrations. A dissolved-solids concentration in water in milligrams per liter in the middle Rio Grande or the Bosque del Apache National Wildlife Refuge is approximately 60 to 75 percent of the specific-conductance value.

Radioactivity in water is expressed in pCi/L (picocuries per liter). A picocurie is one trillionth (1×10^{-12}) of a curie of radioactivity. A curie is the radioactivity of 1 gram of the radium-226 isotope.

Streamflow is reported in ft^3/sec (cubic feet per second). If a flow is estimated from channel hydraulics, the value reported is preceded by the letter "E".

A data-collection site that has data stored in the Water-Quality Storage and Retrieval System (WATSTORE) data base is identified by a unique station number that is either an 8-digit number based on its downstream location on the river system or a 15-digit number based on its latitude-longitude location. These station numbers appear where applicable in some of the data tables in this report.

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ABSTRACT

Laboratory analyses of chemical constituents considered potentially toxic to human health, wildlife, or fish were performed on water, bottom-sediment, and biological samples collected from the Bosque del Apache National Wildlife Refuge in south-central New Mexico for a reconnaissance investigation of irrigation drainage that flows into the Refuge, primarily by way of canals, from the U.S. Bureau of Reclamation's Middle Rio Grande Project area.

Water-quality data from U.S. Geological Survey records indicate that most potentially toxic chemicals in this reach of the Rio Grande were within acceptable limits established for drinking-water supplies and wildlife use. Likewise, data collected for this study from chemical analyses of water in irrigation canals, impoundments, and wells within the Refuge indicate concentrations within safe limits for drinking water and wildlife use. An exception was water from a warm-water supply well that had an arsenic concentration of 53 micrograms per liter. Dissolved cadmium, lead, and mercury concentrations in water either exceeded recommended freshwater criteria at several sites, or exceedance of these criteria was inconclusive because the criteria were smaller than the laboratory reporting limits. All dissolved-selenium concentrations in water samples collected for this study and at Rio Grande stations were less than or were near the analytical reporting limit of 1.0 microgram per liter.

Dissolved-solids concentrations in the Rio Grande increased from a mean of 210 milligrams per liter near the upstream end of the middle Rio Grande Project area to a mean of 649 milligrams per liter near the downstream end. The dissolved-solids concentrations in samples collected within the Bosque del Apache National Wildlife Refuge ranged from 461 milligrams per liter in ponded water to 2,650 milligrams per liter in well water.

Except for lead and manganese, concentrations of all geochemicals in bottom-sediment samples collected from the Rio Grande and the Refuge were within or were less than the geochemical baseline ranges for soils in the Western United States. All selenium concentrations were within the baseline range. Radium-226 in bottom sediment collected from the Refuge may be elevated relative to the uranium in the sediment; however, radium-226 concentrations in water samples were much less than the allowable national drinking-water standard of 5.0 picocuries per liter.

Most concentrations of pesticide residues in water and bottom sediment were less than analytical reporting limits. Exceptions were a few samples in which concentrations were measured at or near the reporting limits for DDT, DDD, DDE, chlordane, aldrin, polychlorinated biphenyls (PCB's), diazinon, and the herbicide 2,4-D.

Biota collected from the Bosque del Apache National Wildlife Refuge included resident birds, bird eggs, fish, aquatic invertebrates, and aquatic plants. Trace elements in most biological samples were less than reporting limits or were less than those in biota from wildlife refuges considered to be uncontaminated. Copper was slightly elevated in some samples but was within safe criteria for wildlife. Trace levels of DDT, DDD, DDE, PCB's, and oxychlordane were detected in 7 of 14 biological composite or single samples collected during 1988. No reproductive abnormalities or deformities were observed during bird nest surveys at the Refuge.

INTRODUCTION

There has been increasing concern about the quality of irrigation-drainage water and its potential harmful effects on human health, fish, and wildlife. Concentrations of selenium greater than water-quality criteria for the protection of aquatic life (U.S. Environmental Protection Agency, 1986) have been detected in subsurface drainage from irrigated land in the western part of the San Joaquin Valley in California. In 1983, incidences of mortality, birth defects, and reproductive failures in waterfowl were documented by the U.S. Fish and Wildlife Service (USFWS) at Kesterson National Wildlife Refuge where irrigation-drainage water was impounded. In addition, potentially toxic trace-element and pesticide residues have been detected in other areas in the Western United States that receive irrigation drainage.

Because of concerns expressed by the U.S. Congress, the U.S. Department of the Interior (DOI) started a program in late 1985 to identify the nature and extent of irrigation-induced water-quality problems that might exist in the Western States. In October 1985, an interbureau group known as the Task Group on Irrigation Drainage was formed within the DOI. The Task Group subsequently prepared a comprehensive plan for reviewing irrigation-drainage concerns for which the DOI may have responsibility.

The DOI developed a management strategy and the Task Group prepared a comprehensive plan for reviewing irrigation-drainage concerns. Initially, the Task Group identified 19 locations in 13 States that warranted reconnaissance-level field investigations. These locations relate to three specific areas of DOI responsibilities: (1) irrigation or drainage facilities constructed or managed by the DOI, (2) national wildlife refuges managed by the DOI, and (3) other migratory-bird or endangered-species management areas that receive water from DOI-funded projects. Nine of the 19 locations were selected for reconnaissance investigations during 1986 and 1987. These nine areas are:

Arizona-California:	Lower Colorado-Gila River valley area
California:	Salton Sea area
	Tulare Lake Bed area
Montana:	Sun River Reclamation Project area
	Milk River Reclamation Project area
Nevada:	Stillwater Wildlife Management area
Texas:	Lower Rio Grande-Laguna Atascosa National Wildlife Refuge area
Utah:	Middle Green River basin area
Wyoming:	Kendrick Reclamation Project area

In 1988, reports for seven of the reconnaissance investigations were published. Reports for the remaining two areas were published in 1990. Based upon results of the first nine reconnaissance investigations, four detailed studies were initiated in 1988: Salton Sea area, Stillwater Wildlife Management area, middle Green River basin area, and the Kendrick Reclamation Project area.

Eleven reconnaissance investigations were initiated in 1988 as follows:

California:	Sacramento Refuge Complex
California-Oregon:	Klamath Basin Refuge Complex
Colorado:	Gunnison and Uncompahgre River basins, and Sweitzer Lake
	Pine River Project
Colorado-Kansas:	Middle Arkansas River basin
Idaho:	American Falls Reservoir
New Mexico:	Middle Rio Grande Project and Bosque del Apache National Wildlife Refuge
Oregon:	Malheur National Wildlife Refuge
South Dakota:	Angostura Reclamation Unit
	Belle Fourche Reclamation Project
Wyoming:	Riverton Reclamation Project

All studies are conducted by interbureau field teams composed of a scientist from the U.S. Geological Survey (USGS) as team leader and additional USGS, U.S. Fish and Wildlife Service (USFWS), and U.S. Bureau of Reclamation (USBR) scientists representing several different disciplines. The investigations are directed toward determining whether irrigation drainage: (1) has caused or has the potential to cause significant harmful effects on human health, fish, and wildlife; or (2) may adversely affect the suitability of water for other beneficial uses.

Purpose and Scope

The Middle Rio Grande Project and Bosque del Apache National Wildlife Refuge (herein referred to as the Refuge or BDANWR) reconnaissance study was selected by the DOI Task Group as one of 10 irrigation-drainage studies to be conducted during water years 1988 and 1989. (A water year is the 12-month period from October 1 to September 30 and designated by the year in which it ends; hence, the 1988 water year was from October 1, 1987, through September 30, 1988.) The USBR manages irrigation projects in the middle Rio Grande valley in New Mexico, and the USFWS manages the irrigated areas within the BDANWR, which is located near the downstream end of the USBR's Middle Rio Grande Project area (fig. 1). The BDANWR receives irrigation-drainage water primarily through irrigation or drainage canals that have been constructed within the middle Rio Grande valley. Although the middle Rio Grande valley extends upstream from the BDANWR for approximately 150 miles, this report focuses on the BDANWR because of its location in the North American central flyway for migratory birds. The Refuge is used as a wintering area by large populations of waterfowl that migrate from the northern part of the continent: the BDANWR provided a habitat for about 60,000 wintering birds during the 1987-88 season. Bald eagles (Haliaeetus leucocephalus), peregrine falcons (Falco peregrinus), and whooping cranes (Grus americana) are among the birds on the Refuge and require protection because these species are on the Federal endangered-species list.

The purpose of this report is to present information for determining if chemical constituents in the water, sediment, and biota associated with irrigation drainage in the USBR's Middle Rio Grande Project area and the BDANWR are potentially harmful to human health, wildlife, and fish, or other beneficial uses.

Middle Rio Grande data from other studies and from the files of the USGS, USBR, and USFWS are included in this report. Reconnaissance water and bottom-sediment samples and resident biota were collected from the BDANWR for laboratory chemical analyses because available data were deemed inadequate for assessing water-quality conditions that may be associated with irrigation drainage at the BDANWR. Selected data are summarized and compared with criteria, standards, or data from other related studies for determining if harmful levels of chemicals are present in the irrigation-drainage water.

Previous Studies

Previous studies of water quality and chemical constituents in wildlife tissues in the middle Rio Grande valley were examined to aid in determining the existence of any irrigation-drainage problems that may be detrimental to wildlife, fish, or human health. These studies provided the background information necessary to plan the field reconnaissance sampling schedule for this study and also provided supplemental data for the middle Rio Grande areas outside of the BDANWR. A USGS network of data-collection stations is operated in the middle Rio Grande valley for gaging streamflow or for obtaining water-quality data. Water-quality data for selected stations on the Rio Grande and the Rio Puerco were retrieved from USGS computer files to develop baseline ranges of water-quality values.

Figure 1

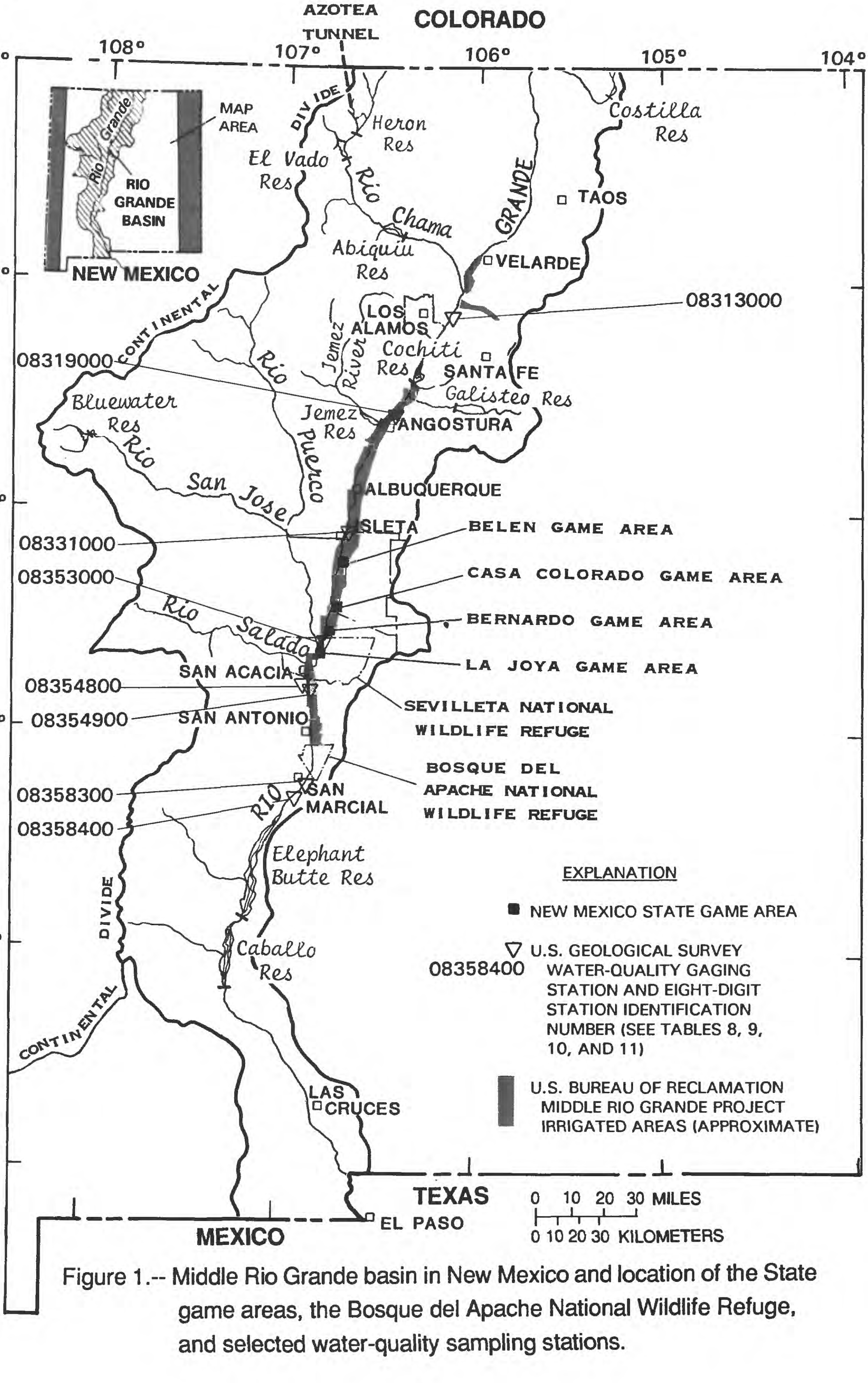

Figure 1.-- Middle Rio Grande basin in New Mexico and location of the State game areas, the Bosque del Apache National Wildlife Refuge, and selected water-quality sampling stations.

The geohydrologic system of the Southwest Alluvial Basins, which include the middle Rio Grande valley, was described in a USGS report (Wilkins, 1986). Part of that report describes the general water-quality characteristics of the alluvial-aquifer system, both shallow and deep, and delineates ground-water-quality zones. Anderholm (1987) described the hydrogeology of Socorro Basin, which includes the BDANWR, and used water-quality characteristics to aid in determining the ground-water sources and the direction of ground-water movement in the aquifer system.

The transport of trace elements in streams and concentrations of pesticides in water, sediment, and biota in the middle Rio Grande valley were investigated by Brandvold and others (1984). This report concludes that a large percentage of trace elements are transported in the streamflow of the Rio Grande in association with suspended sediment. Kidd and others (1974) reported elevated mercury concentrations in the sediment and biota of Elephant Butte Reservoir (fig. 1).

The USBR collected water samples in September 1985 from the four State game management areas and two Federal wildlife refuges in the middle Rio Grande valley (fig. 1). These samples were analyzed for major dissolved constituents, selected trace elements, and selected pesticides. Pesticides and selenium were not detected in the samples, and the USBR concluded that the chemical quality of the water in the areas sampled was suitable for irrigation use (Pridgeon, 1986).

Selenium was investigated on the BDANWR by Persico and Brookins (1988). They found selenium concentrations in sediments that ranged from 0.17 to 0.37 μg/g (microgram per gram), and concentrations in irrigation or impounded water that were less than 1.5 μg/L (micrograms per liter).

The USFWS began monitoring residues of organochlorine compounds and trace elements in birds and fish in 1976 as part of the National Contaminant Biomonitoring Program (NCBP). A collection station for starlings is in Valencia County near the Belen Game Area (fig. 1). A collection station for fish was established in Socorro County at Elephant Butte Reservoir about 25 miles south of the BDANWR. Concentrations of organochlorine compounds in starlings (Sturnus vulgaris) near the Belen Game Area in 1982 were similar to those in starlings from other stations in the contiguous United States according to data in the files of the USFWS. Residues of DDE, PCB's, dieldrin, and trans-nonachlor usually were detected in small concentrations in the starlings. Residue of DDE in a 1987 composite sample was 0.13 μg/g wet-weight, which was less than the geometric mean of DDE in all starling samples (Bunck and others, 1987, p. 71). Residues of DDD, DDE, and PCB's in fish samples collected from the Elephant Butte biomonitoring program station in 1980 and 1981 were less than the nationwide geometric-mean concentrations for these compounds in fish (Schmitt and others, 1985, p. 240). The geometric-mean concentrations for cadmium, copper, mercury, and zinc residues in fish tissue were reported by the 1980 and 1981 NCBP study to be above the 85th percentile of all stations from 1978 through 1981 (Lowe and others, 1985). Popp and others (1983) reported large mercury levels in fish (0.61 μg/g wet-weight) from Elephant Butte Reservoir as well as elevated levels of molybdenum (4.3 μg/g wet-weight) and selenium (2.5 μg/g wet-weight).

In 1986 USFWS personnel collected biological samples at BDANWR as part of the USFWS Environmental Contaminant Program. The types of samples and sampling sites for 1986 were the same as those selected for this reconnaissance study. The data from the 1986 study are used in this report for comparison purposes.

Acknowledgments

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DESCRIPTION OF THE MIDDLE RIO GRANDE VALLEY AND BOSQUE DEL APACHE NATIONAL WILDLIFE REFUGE

The middle Rio Grande valley that includes the USBR's Middle Rio Grande Project area extends from the northern New Mexico community of Velarde to the headwaters of Elephant Butte Reservoir in south-central New Mexico (fig. 1). This part of the middle Rio Grande valley is within the Mexican Highlands section of the Basin and Range province (Hawley, 1986). The Rio Grande is approximately 200 miles long in this reach, and its elevation gradually decreases north to south from 5,580 feet to 4,560 feet above sea level. The BDANWR is located near the downstream end of this reach of the Rio Grande, approximately 40 miles upstream from the Elephant Butte Reservoir Dam (fig. 1).

The 57,191-acre BDANWR, about 85 miles south of Albuquerque, straddles the middle Rio Grande valley in south-central New Mexico (fig. 1). In 1845 the land now occupied by the BDANWR was awarded to Antonio Sandoval as the Bosque del Apache Land Grant. The land grant was purchased by the United States Government in 1936, and on November 22, 1939, the Bosque del Apache National Wildlife Refuge was created by Executive Order 8289. Although land use consisted of livestock grazing and agricultural crop production when the area was under grant status, BDANWR was created as a refuge and breeding ground for migratory birds and other wildlife. The BDANWR owns water rights to about 12,000 acre-feet of water annually for use on 4,139 acres of the Refuge (U.S. Fish and Wildlife Service, 1987, p. 4).

History of Irrigation

The history of irrigation in the middle Rio Grande valley of New Mexico is longer than in any other comparable region of the United States. Many archeologists believe that small-scale irrigation networks formed the basis of Pueblo Indian life along the middle Rio Grande valley as early as 1400 A.D., approximately 150 years prior to the arrival of the first Spanish colonists in the area. The earliest irrigation systems probably consisted only of diversion works and field channeling designed to direct overland runoff onto agricultural fields containing rows of corn, beans, squash, and melons. Ditch irrigation using surface water diverted from the Rio Grande probably was introduced by Spanish colonists who were led to the middle Rio Grande valley by Juan de Oñate in 1598 (Wozniak, 1987, p. 6-15). By the early 18th century, Spanish colonists had developed a self-sufficient subsistence economy based upon native and introduced crops grown on irrigated valley fields.

When this area became a territory of the United States in 1848, an estimated 123,000 acres were under irrigation development (New Mexico State Engineer Office, 1967, p. 156) in the Rio Grande valley between Cochiti Reservoir and San Marcial (fig. 1). This acreage increased slightly to about 125,000 acres by 1925 except that about two-thirds of this acreage experienced crop failure that was partly due to drainage problems. The irrigated acreage in this part of the middle Rio Grande valley in 1988 was about 57,000 acres according to USBR records.

Although the United States acquired this area and its irrigated fields, the associated irrigation technology, community ditch (acequia) organization, and small land-holding pattern remained nearly intact during the late 1800's and early 1900's. The heritages of the vast majority of irrigators early in the 20th century were still Hispanic or Pueblo Indian, and they irrigated crops in a traditional manner. Traditional irrigation systems consisted generally of a main ditch, called the "acequia madre," headed by makeshift rock or brush diversion structures that were easily dismantled by floodwaters. Numerous lateral ditches carried water from the main ditch to individual fields. Water use within each system was regulated by appointed or elected community ditch associations, each acting independently of all others. Problems encountered by these early irrigation systems included depletion of Rio Grande flows by upstream irrigators; aggradation of the bed of the main channel resulting from lower velocity flows; waterlogged lands resulting from a rising water table and the absence of field drains; the absence of organizations to coordinate the activities and water uses of the several dozen independent irrigation systems; and, periodic disastrous flooding that often damaged or destroyed facilities (Wozniak, 1987).

Concern regarding the deterioration of agricultural conditions in the middle Rio Grande valley led to a number of Federal- and State-sponsored studies and to the formation in 1925 of the Middle Rio Grande Conservancy District (MRGCD), the largest irrigation district in the middle Rio Grande valley. The MRGCD began an ambitious program to consolidate, rehabilitate, and modernize agricultural facilities in the middle valley. Using bond revenues, their activities during the 1930's included construction of El Vado Dam to capture unappropriated waters from the upper Rio Chama drainage;

construction of four new major diversion structures at Cochiti, Angostura, Isleta, and San Acacia (fig. 1); construction or rehabilitation of 767 miles of canals; construction of 342 miles of interior and riverside drains; and construction of 180 miles of riverside levees to constrain flood damage. Although the improved irrigation and flood-control systems functioned well initially and increased agricultural acreage, problems with siltation, flooding, channel aggradation, facilities maintenance, and funding continued to plague the middle Rio Grande valley (U.S. Bureau of Reclamation, 1977).

To address these problems, the USBR and the U.S. Army Corps of Engineers jointly prepared a comprehensive plan to rehabilitate and further develop the land and water resources in the middle Rio Grande valley. Sedimentation and flood-control reservoirs would be the responsibility of the Corps of Engineers, rehabilitation of the irrigation facilities of the MRGCD would be the responsibility of the USBR, and levee improvements and channel stabilization would be a joint responsibility of the two Federal agencies. This plan was approved by the Flood Control Act of 1948 and subsequent Federal legislation. In 1951, the USBR assumed the indebtedness and rehabilitation of these dams from the MRGCD, and in 1956 assumed operation and maintenance of its facilities. In 1975, the responsibility for operation and maintenance of the diversion dams, irrigation canals, lateral canals, and riverside drains was returned by the USBR to the MRGCD, except for facilities on the BDANWR that are operated by the USFWS (U.S. Bureau of Reclamation, 1977).

The Corps of Engineers completed flood- and sediment-control dams at Jemez Canyon in 1953, at Abiquiu in 1963, at Galisteo in 1970, and at Cochiti in 1975. The USBR maintains a cleared river channel, also referred to as the Rio Grande Floodway, from Velarde to Elephant Butte Reservoir that safely conveys spring runoff from the upper Rio Grande basin and from localized summer storm runoff with decreased potential for flooding.

In 1959, the USBR completed the Rio Grande Conveyance Channel, which extends for 75 miles from the San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir. The conveyance channel, which runs through the eastern margin of the flood plain within the BDANWR (fig. 2), was designed to convey all river flows of less than 2,000 ft^3/sec (cubic feet per second) to Elephant Butte Reservoir, thus reducing water losses from seepage and evapotranspiration from the wide river channel and its banks. The conveyance channel also acts as a drain to reduce shallow ground-water storage, which alleviates waterlogging of adjacent fields. The total streamflow of the Rio Grande at the San Acacia Diversion Dam is diverted into the conveyance channel about 82 percent of the time (U.S. Bureau of Reclamation, 1977, p. A-30).

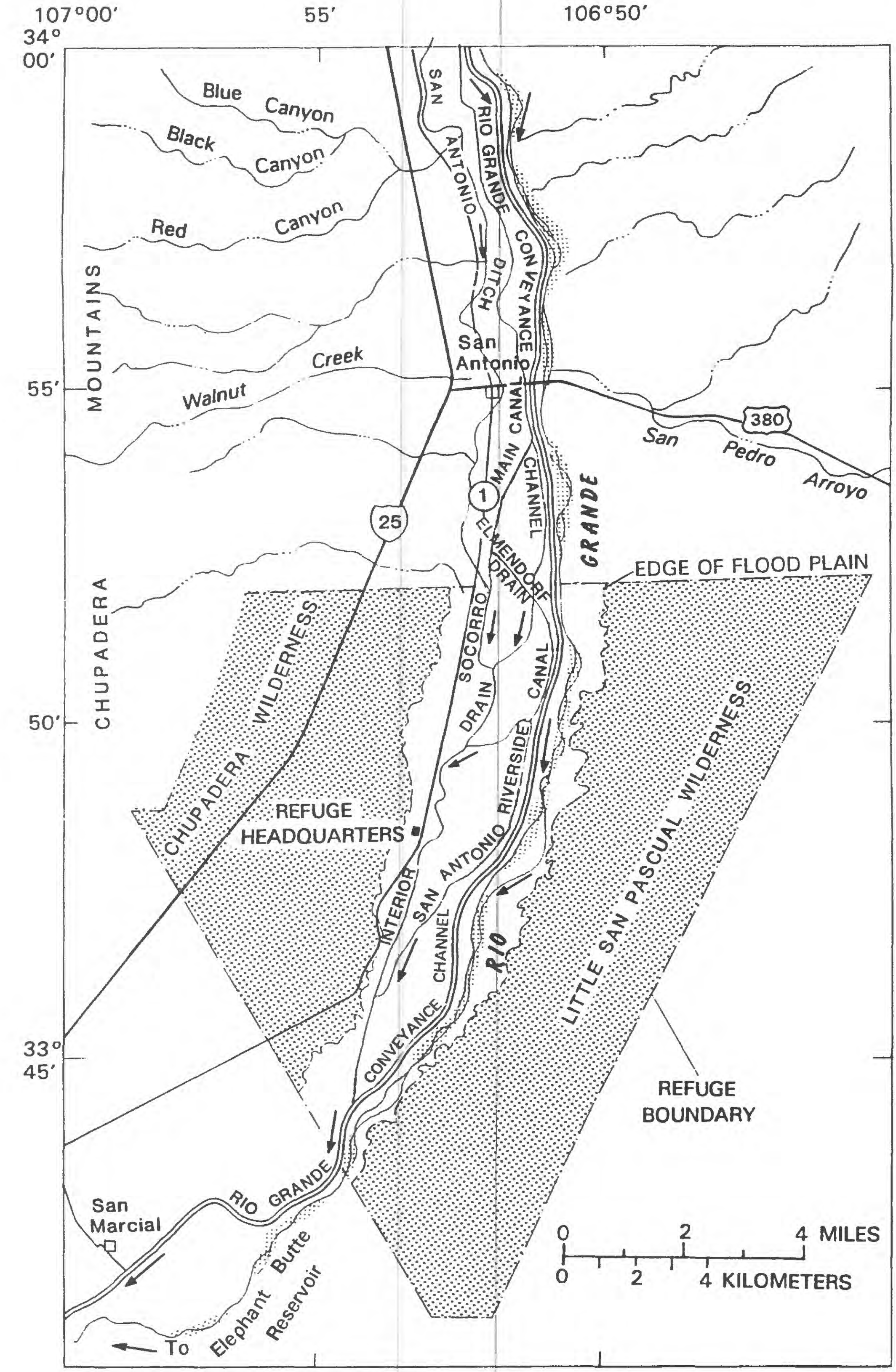

Figure 2.--Flood plain within the Bosque del Apache National Wildlife Refuge.

The total volume of surface water available for delivery through the middle Rio Grande and its diversion systems is approximately 900,000 acre-feet per year. This total includes an annual transmountain diversion of as much as 100,000 acre-feet from the San Juan River basin to the Rio Grande basin through the transmountain Azotea Tunnel, a USBR project completed in 1970 (fig. 1). According to records of the USBR approximately 400,000 acre-feet is diverted annually from the middle Rio Grande to irrigate farmlands along both sides of the river. About 57,000 acres between Cochiti Dam and San Marcial, mostly upstream from BDANWR, currently are irrigated with surface water. The irrigation season usually begins in early March and ends about November 1. The primary crop irrigated in the middle valley is alfalfa hay, followed by grain crops, garden vegetables, chile, and other specialty crops. Irrigation water is supplied to croplands by the complex system of ditches and laterals described earlier. Irrigation drainage is returned to the river or to the irrigation system by numerous drainage canals that also serve to reduce waterlogged fields by capturing shallow ground water and excess overland runoff from local rainstorms.

Climate

The climate within the middle Rio Grande valley is arid or semiarid. As shown in figure 3, the mean annual precipitation from 1931 to 1988 was 9.38 inches (U.S. Department of Commerce, 1988a, b). The middle Rio Grande valley experienced larger than average precipitation from 1983 to 1988; the 1986 precipitation of 15.5 inches was the second largest since 1931 (fig. 3). Commonly more than 50 percent of precipitation occurs during the summer; sudden thunderstorms occasionally cause local heavy runoff and flash floods. Snowfall in the middle Rio Grande valley varies considerably from year to year, but annual snowfall usually is 1 foot or less. The middle Rio Grande valley has a mean annual temperature of 14.3 degrees Celsius (°C) and a mean annual range from 2.4 °C in January to 25.3 °C in July (U.S. Department of Commerce, 1988a, p. 11). The average annual evaporation from shallow reservoirs in the middle Rio Grande valley ranges from 50 to 72 inches per year. About one-third of this evaporation occurs during June and July. The evaporation rate from shallow reservoirs at the BDANWR is about 65 inches per year (Hale and others, 1965, p. 19).

The climate in the vicinity of the BDANWR is semiarid and is characterized by hot summers and relatively mild winters. The mean annual precipitation of 8.32 inches, calculated from 90 years of precipitation records of the U.S. Weather Service station at the BDANWR, is 1.06 inches smaller than the mean annual precipitation of 9.38 inches (fig. 3) for the middle Rio Grande valley (U.S. Department of Commerce, 1988b). Precipitation in 1988 at the BDANWR station was 9.55 inches, or 1.23 inches greater than average for this station. Precipitation for the middle Rio Grande valley in 1988 also was greater than average (fig. 3). The mean annual air temperature for the BDANWR is 15.3 °C; whereas the mean annual air temperature for the middle Rio Grande valley is 14.3 °C (U.S. Department of Commerce, 1988a, p. 11).

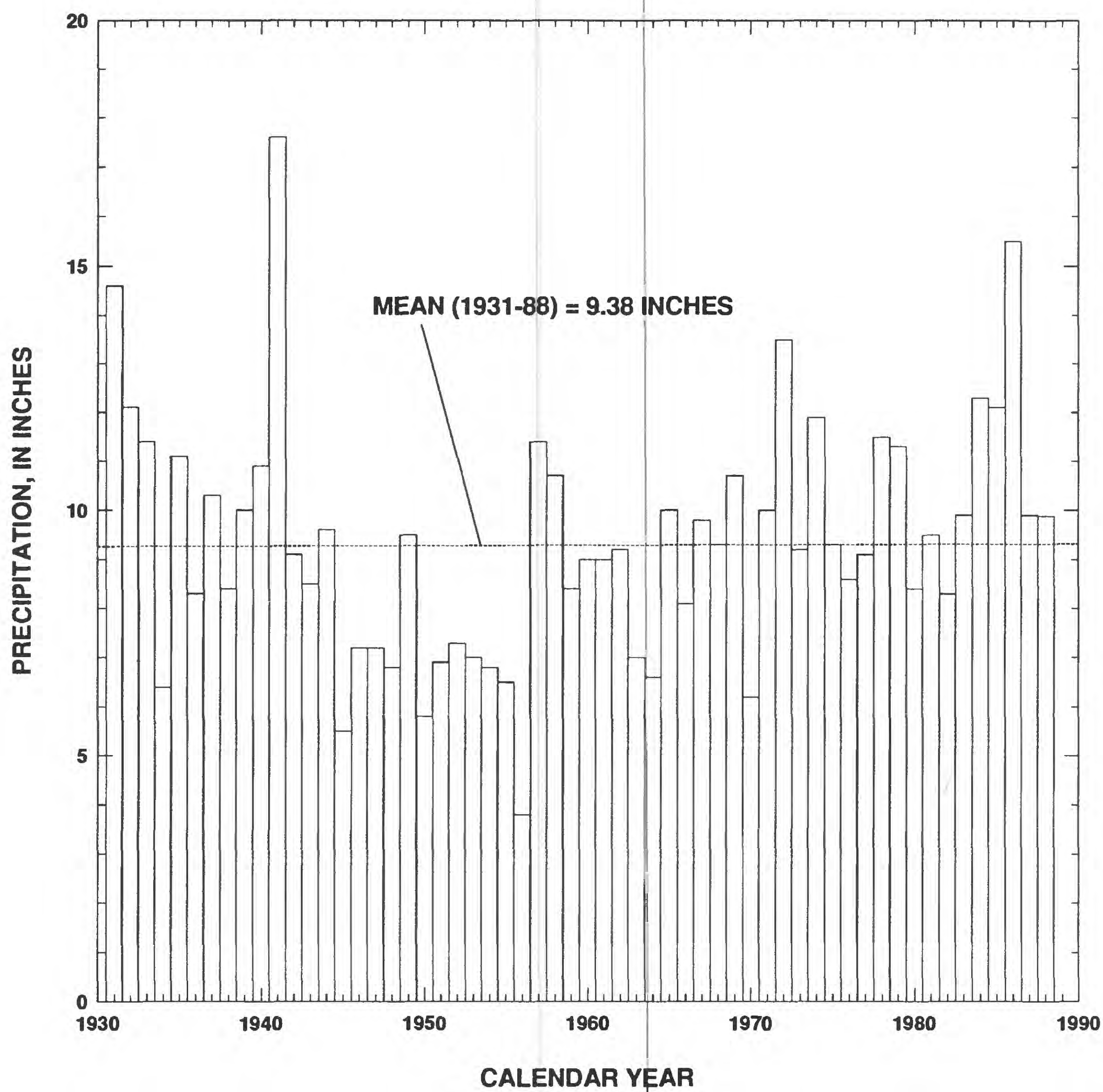

Figure 3.--Mean annual precipitation in the middle Rio Grande valley, New Mexico, 1931-88 (data from U.S. Department of Commerce, 1988a).

Geology and Soils

The middle Rio Grande valley is part of a major geologic feature called the Rio Grande rift. The rift's margins consist of mountain ranges that began forming during Miocene time, about 18 million years ago, from broad regional uplifting generally along a north-south alignment (Wilkins, 1986, p. 7-10). This uplifting is highest east of the rift where Precambrian and Paleozoic rocks predominate along with some Tertiary and Quaternary volcanic rocks. West of the rift, Mesozoic, Tertiary, and Quaternary rocks are present (Wilkins, 1986, p. 10). The uplifted rocks were the source materials for the sediments that have been deposited over downdropped and tilt-faulted blocks that formed the base of a "trough" along the rift. These sedimentary deposits are called the Santa Fe Group and are composed of coarse- and fine-grained sediments of varying proportions, depending on the depositional environment. The deposits may be unconsolidated or moderately consolidated with calcium carbonate as a principal cementing material. The thickness of the Santa Fe Group is estimated to range from 1,000 to 9,000 feet within the middle Rio Grande valley. The younger alluvial sediments in the flood plain are similar in appearance and composition to the older sediments of the underlying Santa Fe Group because they are derived from the same rocks or from erosion of the older sediments (Wilkins, 1986, p. 6).

The geology near the BDANWR is similar to that described for the middle Rio Grande valley. The sedimentary deposits within the Santa Fe Group at the BDANWR may not be as extensive or thick as equivalent deposits in the middle Rio Grande valley north of the BDANWR. The shallow alluvial deposits, usually 100 feet deep or less in the flood plain, may be separated from the deeper deposits of the Santa Fe Group by a confining mudstone unit, designated the Popotosa Formation, that was deposited under playa conditions during Oligocene and Miocene time. Anderholm (1987, p. 12) described the geology and depositional history of the area.

The soils in the middle Rio Grande valley and near the BDANWR are light colored and calcareous, characteristic of soils in warm desert regions (Maker and others, 1978, p. 27-29). The topsoils in the flood plain are mostly sand and clay. Lands nearer the river have a finer texture soil. Subsurface soil layers are moderately coarse to fine grained in texture and drain readily. However, caliche or carbonate cementation may form at shallow depths, particularly on slopes approaching the valley (Maker and others, 1978, p. 29).

Hydrology

The Rio Grande is the principal drainage feature of the middle Rio Grande valley (fig. 1). The 1931-88 average annual streamflow in the Rio Grande entering the USBR's Middle Rio Grande Project area near Velarde is 602,100 acre-feet per year (acre-ft/yr), whereas the 1895-1988 average annual streamflow exiting this project area at San Marcial is 920,800 acre-ft/yr (Borland and Beal, 1989, p. 98, 215). The drainage area within this reach of the Rio Grande is about 17,300 square miles. Average annual inflows to the Rio Grande from major tributaries in this reach are: about 424,600 acre-ft/yr from the Rio Chama (which includes about 100,000 acre-ft/yr of transmountain diversion through Azotea Tunnel); 44,900 acre-ft/yr from the Jemez River; 32,750 acre-ft/yr from the ephemeral Rio Puerco (Borland and Beal, 1989, p. 115, 152, 195); and about 10,500 acre-ft/yr from the ephemeral Rio Salado (Denis and others, 1985, p. 204). From the above figures, the difference of very roughly 200,000 acre-ft/yr between inflow and outflow may be accounted for mostly by evaporation from river and reservoir surfaces, consumptive use by crops on irrigated fields, evapotranspiration by riparian vegetation, and recharge to the alluvial-aquifer system.

There are a number of streamflow-control structures in the middle Rio Grande valley. Large natural lakes are nonexistent. Large surface-water reservoirs were created behind dams constructed primarily for flood control, sediment control, or water-supply impoundment for irrigation. Major water-supply reservoirs on the Rio Grande are the Cochiti Reservoir, which is within the middle Rio Grande valley, and Elephant Butte and Caballo Reservoirs, which are downstream from the middle Rio Grande valley (fig. 1). Major water-supply reservoirs on tributaries are the Heron, El Vado, and Abiquiu Reservoirs on the Rio Chama or tributary; and Bluewater Reservoir on the Rio San Jose (fig. 1). Elephant Butte Reservoir ultimately receives all Rio Grande flow from the middle Rio Grande valley, with irrigation drainage a component of that flow.

Major irrigation diversion structures have been constructed on the Rio Grande at Velarde, Cochiti Dam, Angostura, Isleta, and San Acacia (fig. 1). These diversion structures are connected to complex networks of interlinked supply canals, lateral distribution canals, and drainage canals that together have a length of about 1,100 miles. Local storm runoff also may flow into these canals and combine with irrigation drainage before discharging to the river.

The Rio Grande is a wide, sandy channel in the reach near the BDANWR, and large volumes of water are lost by evaporation especially during shallow streamflows in the summer. On the river banks, dense growths of riparian vegetation, mostly salt cedars, consume large volumes of water through evapotranspiration.

The Rio Grande recharges the shallow valley-fill aquifer and the deeper basin-fill aquifer of the Santa Fe Group. The basin-fill aquifer is a principal aquifer in New Mexico and is the municipal water-supply source for Albuquerque (1980 metropolitan population of 454,000), which is about 90 miles upstream from BDANWR, and for downstream communities along the Rio Grande such as Las Cruces, New Mexico, and El Paso, Texas. Irrigation water also is withdrawn from the shallow valley-fill aquifer or the deep basin-fill aquifer to augment the surface-water supply for irrigation.

The combined streamflows as measured at the USGS gaging stations on the Rio Grande Floodway and Rio Grande Conveyance Channel at San Acacia, both located 20 miles upstream from the BDANWR, indicate that the annual mean daily streamflow from 1979 through 1988 with the exception of 1981 was greater than the 1937-88 annual mean of 1,148 ft^3/s (fig. 4).

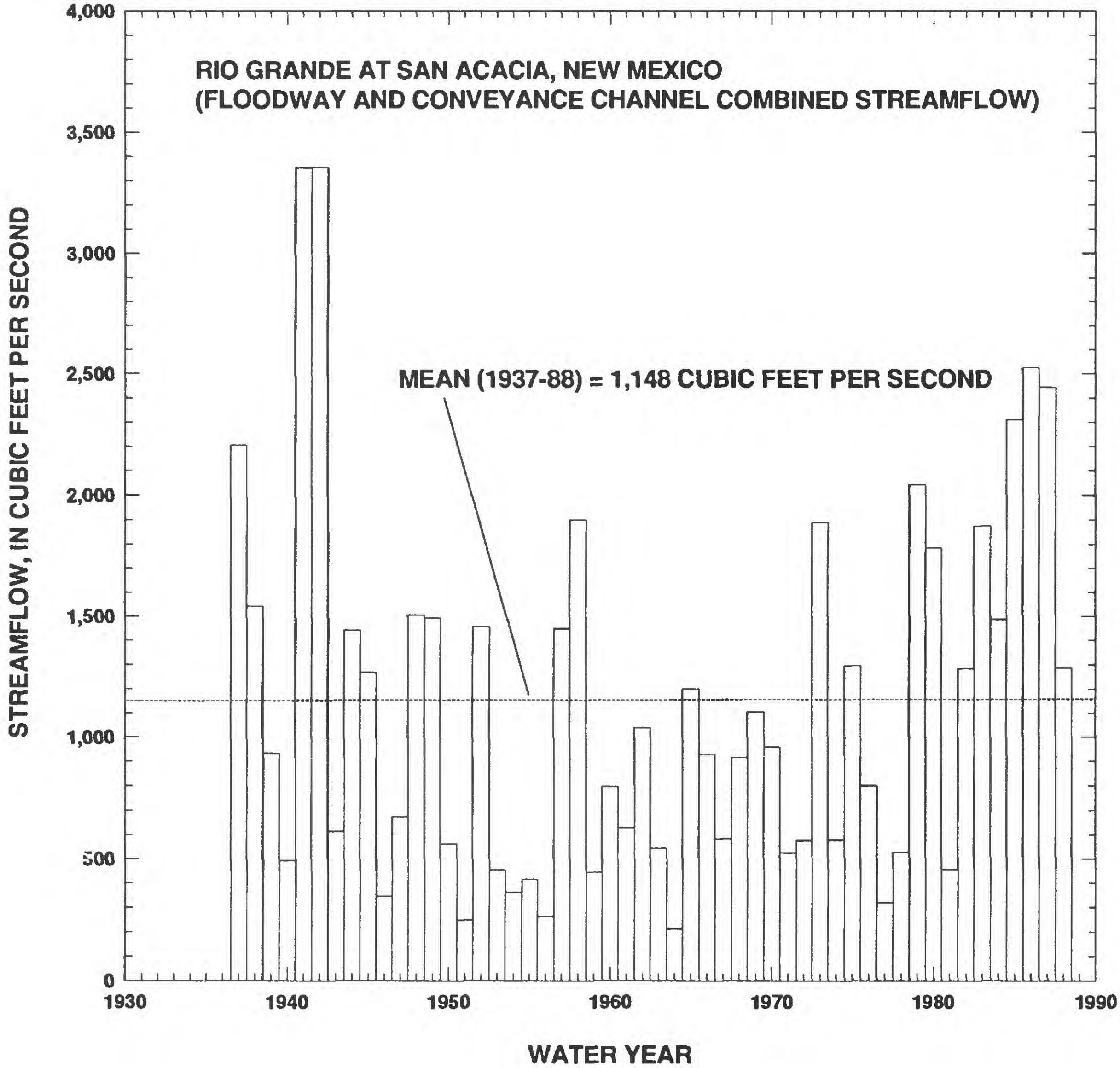

Figure 4.--Annual mean daily streamflow of the Rio Grande at San Acacia, New Mexico, water years 1937-88.

The Rio Grande flows southward through the BDANWR near the eastern edge of the flood plain with the Rio Grande Conveyance Channel paralleling the west bank of the river (fig. 2). The BDANWR receives water for irrigation of croplands and for maintenance of Refuge wetlands from three main canals that enter the BDANWR at the north boundary (fig. 2): Socorro Main Canal, an irrigation-supply canal that begins at the San Acacia Diversion Dam about 20 miles upstream from BDANWR; San Antonio Riverside Canal, a continuation of a series of riverside drains west of the conveyance channel; and Elemendorf Drain, an irrigation drainage ditch and irrigation-supply canal for water diverted from the Socorro Main Canal at a point 1 mile upstream from the Refuge boundary. These canals are interlinked by a network of smaller distribution and drainage canals within the BDANWR (fig. 5). About 65 miles of canals have been constructed within the BDANWR. All the canals eventually discharge into the Interior Drain (fig. 5), a large canal that discharges into the Rio Grande Conveyance Channel near the southern end of the BDANWR. The conveyance channel, in turn, empties into the headwaters of Elephant Butte Reservoir between San Marcial (fig. 1) and the narrow inlet of Elephant Butte Reservoir. Occasionally, overland storm runoff from the mesa west of the flood plain flows into arroyos that empty into the irrigation canals. As a result, flow in the canals on the Refuge is a mixture of Rio Grande diversions, seepage from the Rio Grande or the conveyance channel, surface and subsurface drainage from fields, local storm runoff from arroyos, and ground-water seepage from the shallow or deep aquifers. These flows are augmented during dry periods by irrigation wells located in the BDANWR.

Surface water flowing into the BDANWR is potentially subject to water-quality degradation from a number of sources. In addition to potential irrigation-induced effects such as increased concentrations of dissolved solids, animal wastes, commercial fertilizers, and pesticides, the urbanization upstream adds municipal wastewater, industrial discharges, and urban storm runoff. Upstream tributaries that drain geochemically different areas increase the concentrations of sulfates, chlorides, and trace elements in the Rio Grande. Streamflow in the Rio Puerco, for instance, exhibits generally larger concentrations of these constituents than the Rio Grande (Popp, 1980, p. 89). The dissolved-solids concentration of water in the Rio Grande at San Acacia and downstream from this station is consistently larger than mean values when runoff from the Rio Puerco enters the Rio Grande (U.S. Bureau of Reclamation, 1977, p. B-24). The Rio San Jose basin, a subbasin of the Rio Puerco basin, is the location of uranium milling and mining activities, which can introduce uranium, radium, selenium, and other potentially harmful constituents into the Rio Grande by way of the Rio Puerco.

Within the Refuge the depth to the water table is about 5 to 6 feet. The regional ground-water movement is southward. Deep ground water under artesian conditions may move to the surface through faults or fractures in confining geologic formations. The artesian conditions occur because confined parts of the deep water-yielding layers in the aquifer may be recharged on outcrops of the aquifer on nearby mountains or, possibly, deep geothermal zones may be creating high temperatures and pressures in deeper parts of the aquifer (Anderholm, 1987, p. 18-26).

Figure 5

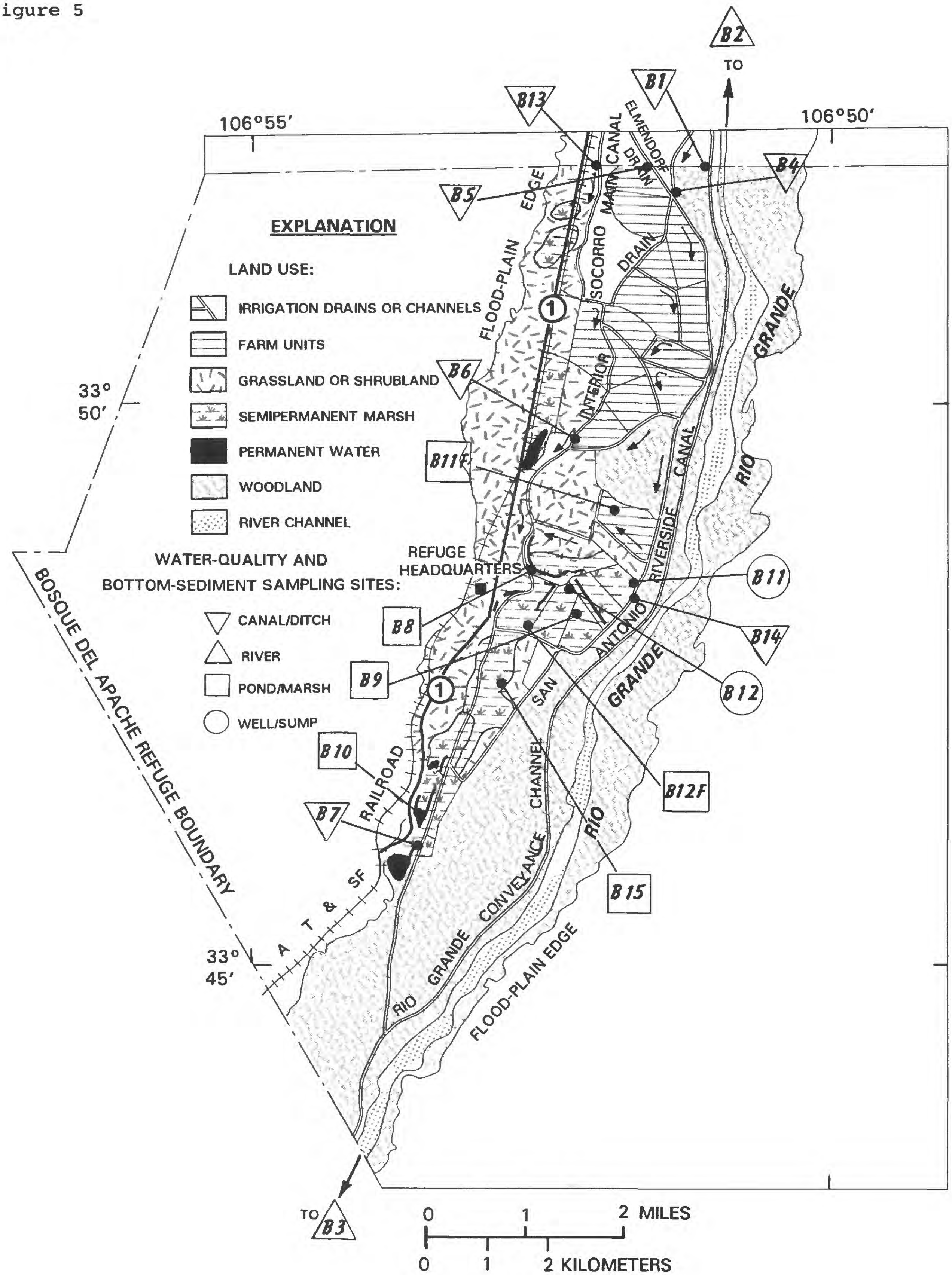

Figure 5.--Flood-plain area of the Bosque del Apache National Wildlife Refuge, land-use designations, and location of water-quality and bottom-sediment sampling sites.

At least 20 water wells have been drilled on the BDANWR to depths ranging from 84 to 252 feet. Most are located in the croplands in the northern part of the BDANWR and are used to augment the surface-water supply during low streamflow periods. The wells have not been used much in the 1980's because the supply from surface-water sources has been greater than average since 1982 (fig. 4). Water levels in the wells recover quickly after pumping because of large hydraulic-conductivity values of the aquifer (Anderholm, 1987, p. 48). One well drilled to a depth of 252 feet produces warm water (33 °C) that is pumped during freezing weather into nearby ponds to keep the ponds partly ice-free for waterfowl.

Wildlife, Habitat, and Management

The USBR's Middle Rio Grande Project area (fig. 1) lies within two major biotic communities: the warm, temperate Chihuahuan Desert and the cold, temperate Great Basin province. The upland areas south of San Acacia support Chihuahuan Desert shrub. North of San Acacia to Isleta, the uplands are semidesert grasslands in a transitional zone between these two biotic communities. North of Isleta, the uplands are classified as Great Basin Grasslands or Great Basin Conifer Woodlands. A riparian forest grows between the river levees of the Middle Rio Grande Project area and the Rio Grande, consisting primarily of Rio Grande cottonwood (*Populus fremontii*), Coyote willow (*Salix exigua*), Russian olive (*Elaeagnus angustifolia*), and salt cedar (*Tamarisk* sp.) (Hink and Ohmart, 1984, p. 4).

A total of 277 species of birds was recorded in the middle Rio Grande valley by Hink and Ohmart (1984, p. 146), and 300 species have been recorded at the BDANWR. About 100 bald eagles winter annually along the Rio Grande and at least 200 peregrine falcons migrate through the State within the migratory corridor of the valley (Hink and Ohmart, 1984, p. 146). These two bird species are on the Federal endangered-species list.

Usually about 50,000 snow geese (*Chen caerulescens*) and 30,000 sandhill cranes (*Grus canadensis*) winter in the middle Rio Grande valley. Twenty endangered whooping cranes were counted in the valley south of Albuquerque during 1987 and more than 44,000 resident waterfowl of various species have been counted in the area. Mallards (*Anas platyrhynchos*) comprise more than 74 percent of the resident waterfowl population (U.S. Fish and Wildlife Service, 1987). In a survey of the middle Rio Grande valley in habitats similar to those on the BDANWR 10 species of amphibians, 38 species of reptiles, and 60 species of mammals were reported (Hink and Ohmart, 1984).

Like the upland areas of the middle Rio Grande valley, wildlife habitat at the BDANWR is classified as Chihuahuan Desert shrub (Hink and Omhart, 1984, p. 4). The BDANWR is characterized by irrigated agricultural fields, riparian and woodland habitat, grasslands, and artificial semipermanent marshes. Most of the natural wetlands on the BDANWR were drained in the early 1900's. Most of the riparian forest lies between the levees and the west bank of the river with a few scattered woodlands outside of the levees. Salt cedars have encroached on a significant part of the riparian forest as well as into the woodlands and grasslands. Rio Grande cottonwood is the predominant vegetation in riparian areas where salt cedar has not encroached (Hink and Ohmart, 1984, p. 43).

The total area covered by the major habitat types on the BDANWR are shown below.

Habitat type	Area, in acres
Desert shrub	24,900
Grassland	24,800
Brush	3,000
Marsh	1,600
Forest land	1,300
Cropland	1,300
Stream channel	66

The artificial wetlands are seasonally drained and reflooded to stimulate growth of desired vegetation and aquatic invertebrates for wildlife food (U.S. Fish and Wildlife Service, 1987). The cropland areas consist of irrigated corn and alfalfa fields.

The BDANWR provides habitat for a wide variety of resident species and wintering areas for migratory birds including endangered species. In total, 255 species of birds are regular annual visitors and an additional 40 species are incidental visitors. The visiting birds include 13 species of raptors including the peregrine falcon, 20 species of sandpipers, 9 species of herons, 13 species of flycatchers, 8 species of woodpeckers, and 24 species of sparrows. During the fall of 1987 and winter of 1987-88 the BDANWR was used by one adult and five juvenile bald eagles.

During January 1988 two adult and six juvenile bald eagles were present. Also during January 1988, 16 whooping cranes that migrated from the Grays Lake National Wildlife Refuge in Idaho were present.

Record populations of waterfowl used the Refuge during the fall and winter of 1987-88, including an estimated 10,700 ducks during October 1987. These included cinnamon teal (Anas cyanoptera), blue-winged teal (Anas discors), green-winged teal (Anas crecca), mallard, gadwall (Anas strepera), American widgeon (Anas americana), pintail (Anas acuta), shoveler (Anas clypeata), lesser scaup (Aythya affinis), and ruddy ducks (Oxyura jamaicensis). During March 1988, a record 14,300 ducks were present on the Refuge. Canada goose (Branta canadensis) populations averaged 296 birds on the Refuge, but snow goose and Ross' goose (Chen rossii) populations combined peaked at 39,400 birds during the 1987-88 winter season (U.S. Fish and Wildlife Service, 1987).

Sandhill crane populations at the Refuge reached a peak of 12,900 birds during January 1988, which represented approximately 40 percent of the population wintering in the middle Rio Grande valley. In addition to sandhill cranes, other marsh and shorebirds that were counted on the Refuge include 2,400 American coots (Fulica americana), 90 American white pelicans (Pelecanus erythrorhynchos), 157 double-crested cormorants (Phalacrocorax auritus), and 157 olivaceous cormorants (Phalacrocorax olivaceus).

Other resident wildlife on the BDANWR include cottontail rabbits (Sylvilagus sp.), black-tailed jackrabbits (Lepus californicus), mule deer (Odocoileus hemionus), and coyotes (Canis latrans). The BDANWR provides habitat for more than 100 species of mammals, reptiles, and amphibians.

The BDANWR does not have an established recreation fishery; however, several species of fish, such as brown bullhead (Ictalurus nebulosus), carp (Cyprinus carpio), threadfin shad (Dorosoma petenense), bluegill (Lepomis macrochirus), largemouth bass (Micropterus solmoides), and mosquito fish (Gambusia affinis) are managed for fish-eating birds such as herons, bitterns, egrets, cormorants, and white pelicans; management of fish includes wetland drainage and restocking of the reflooded wetlands. Another source of food for the wildlife is the croplands on the northern part of the Refuge. Crops are grown by local farmers on a cooperative basis. The farmers harvest two-thirds of their share in alfalfa, and the Refuge receives the remaining one-third as unharvested corn for foraging wildlife (U.S. Fish and Wildlife Service, 1987).

The Middle Rio Grande Project area is the location for four New Mexico State Department of Game and Fish refuges that are maintained primarily for wintering waterfowl. These areas are Belen, Casa Colorado, Bernardo, and La Joya State Game Areas. The Sevilleta National Wildlife Refuge also is located in the area (fig. 1).

SAMPLE COLLECTION AND ANALYSIS

The overall approach for the field sampling at the BDANWR was to collect representative samples of water, bottom sediment, and biota associated with irrigation drainage within the Refuge and from the Rio Grande at an upstream station and a downstream station. Because any potential water-quality problems associated with irrigation drainage are likely to enter the Refuge primarily through the irrigation canals, most sampling was done in the canal system. When surface water is unavailable, shallow irrigation wells are used for temporary water-supply sources. Therefore, ground water that is associated with irrigation drainage was collected from two representative ground-water sources.

The DOI's Task Group on Irrigation Drainage designated a standardized list of field measurements and laboratory analyses for water and sediment samples to ensure uniformity of assessment among the 11 reconnaissance investigations initiated during water year 1988. The eight categories of water-quality data and the analyses or measurements for each category are shown in table 1. The pesticide compounds were selected on the basis of their common usage nationally and locally, and on the persistence of pesticide compounds used in the past. Radium-226 also was analyzed because this radioactive element may be transported by tributary streamflow from the Rio Puerco, which receives runoff from uranium mining and milling areas in the Rio San Jose subbasin (fig. 1).

Table 1.--Physical measurements, water-quality properties, and chemical analyses performed on water, bottom-sediment, and biological samples collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

Type of sample	Data category	Analyses or measurements
Water	Physical measurements and water-quality properties	Specific conductance, pH, air temperature, water temperature, dissolved oxygen, barometric pressure, hardness, alkalinity, dissolved solids, streamflow, suspended sediment
Water (filtered)	Major ions and nutrients	Calcium (Ca), magnesium (Mg), sodium (Na), sodium adsorption ratio (SAR), potassium (K), bicarbonate (HCO_3), carbonate (CO_3), sulfate (SO_4), chloride (Cl), fluoride (F), silica (SiO_2), nitrite + nitrate ($NO_2 + NO_3$), phosphorus (P), organic carbon (C), calcium carbonate ($CaCO_3$) saturation index
Water (filtered)	Trace elements and radionuclides	Arsenic (As), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), molybdenum (Mo), selenium (Se), strontium (Sr), vanadium (V), zinc (Zn), uranium (U), radium-226 (Ra-226)
Water (unfiltered)	Pesticides	Chlorophenoxy acid herbicides: 2,4,-D; 2,4,-DP; silvex; 2,4,5-T
		Triazine herbicides: alachlor, ametryn, atrazine, cyanazine, prometon, prometryn, propazine, simazine, simetryn, trifluralin
		Organophosphorous insecticides: chloropyrifos (Dursban), diazinon, ethion, malathion, methyl parathion, methyl trithion, parathion, trithion
Bottom sediment	Major chemicals, trace elements, and radionuclides	Calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), phosphorus (P), aluminum (Al), arsenic (As), barium (Ba), beryllium (Be), bismuth (Bi), boron (B), cadmium (Cd), cerium (Ce), chromium (Cr), cobalt (Co), copper (Cu), europium (Eu), gallium (Ga), gold (Au), holmium (Ho), iron (Fe), lanthanum (La), lead (Pb), lithium (Li), manganese (Mn), mercury (Hg), molybdenum (Mo), neodymium (Nd), nickel (Ni), niobium (Nb), scandium (Sc), selenium (Se), silver (Ag), tantalum (Ta), thorium (Th), tin (Sn), titanium (Ti), vanadium (V), ytterbium (Yb), yttrium (Y), zinc (Zn), radium-226 (Ra-226), uranium (U), strontium (Sr), total carbon, organic carbon

Table 1.—Physical measurements, water-quality properties, and chemical analyses performed on water, bottom-sediment, and biological samples collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988—Concluded

Type of sample	Data category	Analyses or measurements
Bottom sediment	Pesticides	Organochlorine compounds: aldrin, chlordane, DDD, DDE, DDT, dieldrin, endosulfan, endrin, gross polychlorinated biphenyls (PCB's), gross polychlorinated naphthalene (PCN), heptachlor, heptachlor expoxide, lindane, methoxychlor, mirex, perthane, toxaphene
Biological	Trace elements	Aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), magnesium (Mg), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), silver (Ag), strontium (Sr), thallium (Tl), tin (Sn), vanadium (V), zinc (Zn)
Biological	Organic compounds	Aldrin, alpha-chlordane, alpha-HCB, beta-BHC, cis-nonachlor, o,p'DDD, p,p'DDD, o,p'DDE, p,p'DDE, delta-BHC, dieldrin, endrin, gamma-chlordane, HCB, heptachlor, heptachlor epoxide, lindane, mirex, oxychlordane, trans-nonachlor, o,p'DDT, p,p'DDT, CL-2-BIPH (PCB), CL-3-BIPH (PCB), CL-4-BIPH (PCB), CL-5-BIPH (PCB), CL-6-BIPH (PCB), CL-7-BIPH (PCB), CL-8-BIPH (PCB), CL-9-BIPH (PCB), total PCB's, toxaphene

Sampling Sites, Sample Types, and Sampling Schedules

Sampling locations within the BDANWR were chosen to represent inflowing and outflowing irrigation-drainage conditions as well as conditions within the BDANWR. Samples also were collected at nearby Rio Grande Floodway sites for comparison purposes. Water and bottom-sediment samples were collected at the same sites (fig. 5). A brief description of each water and bottom-sediment sampling site is given in table 2.

Sampling times of water and bottom sediment were selected to represent conditions during (September) or after (November) the irrigation season when irrigation drainage is a larger proportion of the streamflow; during the herbicide application season (February to May); during the winter (February) when large populations of migratory birds are present; and during late summer (September) to represent the water available to resident species. The collection schedules for the water and bottom-sediment sampling are shown in table 3.

Biological sampling was initiated on the Refuge during April 1988. Due to construction activities at Sevilleta National Wildlife Refuge and La Joya Game Management Area that caused marsh units to be dry at these areas, all biological samples were collected from the BDANWR, and the sampling schedules were coordinated with the water management schedules on the Refuge. The analyses or measurements performed on biological samples are listed in table 1, and the locations of the biological sampling sites are shown in figure 6. The biological species collected, collection sites, and sampling schedules are shown in table 4.

Common resident fish and wildlife species were collected as biological samples. Not all species occur in abundance in the various wildlife management units on the Refuge, and waterfowl reproduction was observed to be limited. Eggs, immature birds, and adult birds were sampled from mallard, American coot, and black-necked stilt (*Himantopus mexicanus*) species. Fish species sampled were carp, largemouth bass, green sunfish (*Lepomis cyanellus*), bluegill, threadfin shad, mosquitofish, and brown bullhead. Invertebrate species sampled were dragonfly and damselfly, of the order Odonata, and water boatman and backswimmer, of the order Hemiptera, which represent benthic and nektonic organisms. Crayfish (*Palaemonetes kadiakensis*) were collected to represent invertebrate bottom feeders. Plant specimens collected were the species leafy pondweed (*Potamogeton foliosus*) and horned pondweed (*Zannichellia palustris*). Most of the biological samples were collected from units 15B, 18A, 18BW, 18BE, the triangle, 18D, 24B, 24C, and 25A (fig. 6). Field observations for healthy or deformed birds were made during nest searches and during the weekly monitoring of nesting activities. No abnormal growth effects or deformities of birds were observed.

Table 2.--Description of water and bottom-sediment sampling sites for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

[Locations shown in figure 5; BDANWR, Bosque del Apache National Wildlife Refuge]

Study site number	Station number	Description
B1	335213106520210	Rio Grande Conveyance (low-flow) Channel at inflow to BDANWR: River water in this channel will become BDANWR's primary irrigation supply in the future.
B2	08354900	Rio Grande Floodway at San Acacia: Site represents water and bottom sediments in the river upstream from the BDANWR.
B3	08358400	Rio Grande Floodway at San Marcial: Site represents water and bottom sediments in the river near and downstream from the BDANWR. Data collected are supplemented by the data collected for the U.S. Geological Survey's National Stream-Quality Accounting Network.
B4	335211106512710	San Antonio Riverside Canal at inflow to the BDANWR: Canal flow is subsurface seepage and surface irrigation-return flow from irrigated fields upstream from the BDANWR.
B5	335212106514010	Elmendorf Drain at inflow to the BDANWR: Canal flow is surface and subsurface drainage from irrigated fields upstream from and adjacent to the BDANWR.
B6	334928106525010	Interior Drain downstream from BDANWR farm units: Canal flow is a mixture of inflowing water and drainage from farm units at north end of BDANWR.
B7	334612106540510	Interior Drain at downstream end of BDANWR: Canal flow is a mixture of irrigation-supply water, drainage water from within the BDANWR, drainage water originating upstream from the BDANWR, and small volumes of well water.
B8	334832106525720	Permanent pond: Pond is a gravel borrow pit converted to a small pond, which is an impoundment of a mixture of irrigation-supply water, drainage water, and small volumes of well water.

Table 2.--Description of water and bottom-sediment sampling sites for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Continued

Study site number	Station number	Description
B9	334810106522520	Perennial pond on Unit 18BE (referred to as the "triangle"): This triangular-shaped area is a field flooded with a mixture of irrigation-supply water, drainage water, and small volumes of well water.
B10	334616106540720	Permanent marsh: This site is a wetland or permanent marsh formed in narrowed flood plain or oxbow of the Rio Grande near the southern (downstream) end of the BDANWR. The sources of water in the marsh are irrigation-supply canals, irrigation-return flows, runoff, and shallow water-table drainage.
B11	334836106520001	Tiled-drain field at outflow from farm unit 17A: This site is a ground-water sump that collects irrigation-drainage water applied on a typical farm unit in the BDANWR. The site also represents water from shallow irrigation-supply wells that withdraw ground water from the shallow alluvial aquifer into which irrigation water may have infiltrated.
B11F	334907106520520	Farm unit with tiled-drain field: This site is on farmland used to grow forage vegetation for wildlife. The irrigation water that infiltrates the soil moves into the tiled-drainage system that collects at site B11. The sediment (soil) was sampled to determine potential source of solutes that have percolated from irrigated fields through soils on the BDANWR.
B12	334821106523401	Water well: This well yields warm (33 degrees Celsius) water that is withdrawn and discharged into nearby ponds during periods of extreme cold to prevent ice formation so that the ponds can be used by waterfowl.
B12F	334800106530020	Semipermanent marsh: This site is a flooded field with a mixture of irrigation-supply water, drainage water, and well water pumped from site B12. This is a bottom-sediment sampling site for assessing the effects of the warm water applied from the well at site B12.

Table 2.--Description of water and bottom-sediment sampling sites for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Concluded

Study site number	Station number	Description
B13	335213106521510	Socorro Main Canal at inflow to BDANWR: Irrigation-supply water for the BDANWR is transported from the river-diversion point at San Acacia in this canal. The diverted water is mixed with some drainage water because of upstream interflow in a complex network of canals and laterals connected to this supply canal. This canal flows only during irrigation season.
B14	334828106514710	San Antonio Riverside Canal downstream from BDANWR farm units: This is an intermediate site that represents irrigation-supply water with some drainage from within the BDANWR. Water is diverted into impoundments from this canal at downstream gates.
B15	334719106531620	Small pond: Small pond formerly was used as outdoor spa into which warm water from a now-abandoned deep well was pumped. This pond presently traps a pool of water when Unit 24B, a semipermanent marsh, is drained.

Table 3.--Sampling schedules for water and bottom-sediment samples collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

[--, not applicable]

Data category (type of sample)	Sampling sites[1]				
	River (B2, B3)	Canals (B1, B4, B5, B6, B7, B13, B14)	Marshes (B8, B9, B10, B15)	Wells (B11, B12)	Fields (B11F, B12F)
Field measurements and water properties	November	November, September	February, September	February	--
Major dissolved constituents (water)	November	November, September	February, September	February	--
Trace elements and radionuclides (water)	November	November, September	February, September	February	--
Pesticides (water)	--	November, May	February	February	--
Geochemicals (bottom sediments)	March	February	February	--	February
Pesticides (bottom sediments)	--	November	February	--	February

[1]Locations shown in figure 5; descriptions given in table 2.

Figure 6

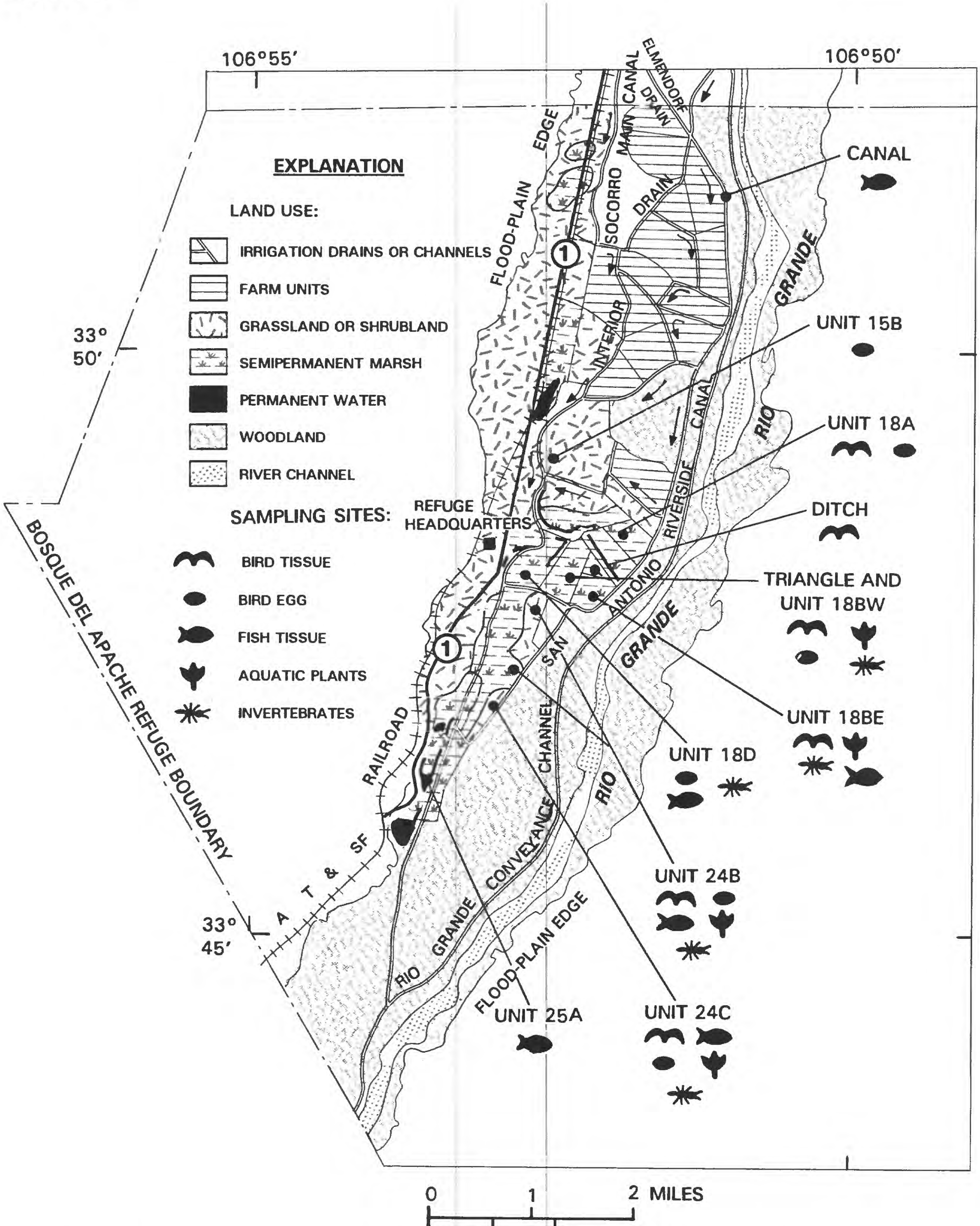

Figure 6.--Flood-plain area of the Bosque del Apache National Wildlife Refuge, land-use designations, and location of biological sampling sites.

Table 4.--Biological species, collection sites, and collection schedules for samples collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, 1988, and the Fish and Wildlife Service Environmental Contaminant Program, 1986

[Locations of BDANWR collection sites shown in figure 6]

Biological species	Scientific name	Reconnaissance study collection sites June-July 1988	U.S. Fish and Wildlife Service Contaminant Program collection and location June-July 1986
Mallard, adult	*Anas platyrhynchos*	18A, triangle, 18BE, 18BW, 24C	
Mallard, immature		18A, 18BE, 18BW	
American coot, adult	*Fulica americana*	18BE, 18BW, 24C	18BE, 18BW, 18D, 24C, Elephant Butte Reservoir
American coot, immature		24B, 24C	
Ruddy duck, adult	*Oxyura jamaicensis*		Sevilleta National Wildlife Refuge
Black-necked stilt, adult	*Himantopus mexicanus*	18A, triangle, 18BE	
Black-necked stilt, immature	*Himantopus mexicanus*	18A, 18BW	
Western kingbird, adult	*Tyrannus verticalls*		Sevilleta National Wildlife Refuge, Elephant Butte Reservoir
Mallard egg		15B, 18A, 18BW	
Coot egg		18D, 24C	
Stilt egg		18A, 18BW	
Carp	*Cyprinus carpio*	18D, 24B, 25A	18BE, 18D, 25A, Riverside Canal, Sevilleta National Wildlife Refuge, Elephant Butte Reservoir

Table 4.--Biological species, collection sites, and collection schedules for samples collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, 1988, and the Fish and Wildlife Service Environmental Contaminant Program, 1986--Concluded

Biological species	Scientific name	Reconnaissance study collection sites June-July 1988	U.S. Fish and Wildlife Service Contaminant Program collection and location June-July 1986
Centrarchidae species			
Green sunfish	Lepomis cyanellus	18BE, 24B, 24C, 25A	25A
Threadfin shad	Dorosoma petenense	18BE, 18D, 25A	Sevilleta National Wildlife Refuge
Mosquito fish	Gambusia affinis	24B, 24C	
Brown bullhead	Ictalurus nebulosus	18D, 24B, 24C, 25A	25A
Catfish	Ictalurus punctatus		Sevilleta National Wildlife Refuge
Odonata species		18BE, 18BW, 24B, 24C	
Hemiptera species		18BE, 18BW, 24B, 24C	
Crayfish	Palaemonetes kadiakensis	18BE, 18D, 24B, 24C	
Leafy pondweed	Potamogeton foliosus	24B	
Horned pondweed	Zannichellia palustris	18BE, 18BW, 24C	
Sedge	Carex sp.		25A
Curly pondweed	Potamogeton crispus		18BE
Coontail	Ceratophyllum sp.		25A
Hardstem bullrush	Scirpus acutus		18BW

Field Methods

The field methods and the laboratory services used were prescribed in the DOI protocol for these studies (U.S. Department of the Interior, 1986). Water and bottom-sediment samples in the river, canals, and ponds were collected using prescribed USGS techniques for depth and cross-sectional integration of a sample in a channel or reservoir (Edwards and Glysson, 1988); water samples from wells were collected using USGS guidelines (Wood, 1976; and Claassen, 1982). Samplers were cleansed and rinsed thoroughly before collecting samples. Precautions were taken to prevent contamination from contacting surfaces. For example, contact with organic compounds such as plastic-ware or plastic bottles was avoided in collecting water or bottom-sediment samples for pesticide analyses. Contact with metal surfaces was avoided when collecting samples for trace-element analyses.

In this reconnaissance study, livers and kidneys of adult and immature mallards, coots, and black-necked stilts were collected and combined. Composite samples of livers and kidneys from at least three individual birds of the same species from several locations were analyzed. Samples of eggs from the three bird species as well as samples of four fish species were collected for analyses. Insects (of the orders Odonata and Hemiptera), crayfish, and aquatic plants also were collected and composited for laboratory analyses.

Biological specimens were collected using approved sampling techniques (U.S. Fish and Wildlife Service, 1985b). Bird specimens were collected using steel shot instead of lead shot that could contaminate the bird tissues. Fish were collected with an electroshocker or with seines. Invertebrate collections were made with hand nets and seines, and plant specimens were hand collected. All specimens initially were chilled and were frozen for shipment to the laboratories for analyses. Special care was taken in handling the samples to avoid contamination with organic compounds or trace elements. Bird specimens were necropsied and skinned. Livers and kidneys were combined and pooled for trace-element analyses. The sample preparation area was thoroughly cleaned and decontaminated before processing each sample. Separate samples of bird eggs, fish, and plants were composited for organic analyses.

Laboratory Support Services

Chemical analyses were performed by the USGS National Water Quality Laboratory in Denver, Colorado, using methods described by Fishman and Friedman (1985) for inorganic constituents in water and methods described by Wershaw and others (1987) for organic compounds in water and bottom sediment. Containers for the samples and reagents for chemically stabilizing the samples were supplied by the laboratory. Water samples were chilled and expedited to the analyzing laboratories after collection.

The USGS Geologic Division Laboratory in Denver analyzed the bottom sediment for geochemical elements using methods described by Severson and others (1987). Analyses were performed on two particle-size ranges for each sample if a sufficient amount of sediment was available for both after laboratory sieving. A coarse range for all sediment particles less than 2.0 millimeters in size and a fine fraction for sediment particles less than 0.0625 millimeter in size were analyzed.

All biological specimens collected for the reconnaissance investigation were analyzed according to USFWS protocol by laboratories under contract to the Patuxent Analytical Control Facility (PACF), Patuxent Wildlife Research Center. Organic analyses were performed by the Geochemical and Environmental Research Group at Texas A & M University in College Station, Texas. Inorganic analyses were performed by Hazleton Laboratories America Inc.[1] in Madison, Wisconsin. The methods that were used by these laboratories are described in the PACF technical memorandum of the USFWS (1985a, b).

Quality Assurance

Water-quality field instruments were calibrated prior to field measurements at each collection site by following applicable procedures described in the analytical manual of the USGS (Fishman and Friedman, 1985). The National Water Quality Laboratory followed the quality assurance practices described in the USGS quality assurance manual for chemical analyses of water and fluvial sediments (Friedman and Erdmann, 1982). A duplicate set of bottom-sediment samples was collected for geochemical analyses for quality-control purposes. Duplicate water samples were not collected because repeat samples at canal sites served as quality-assurance checks by comparing values obtained from these repeat samples.

The Fish and Wildlife Service's PACF provided laboratory quality assurance for biological samples. The precision and accuracy of the laboratory analyses for organic samples were confirmed using spiked blanks and spiked samples. Replicate samples for mallard eggs were analyzed for pesticides and PCB's. All results greater than reporting limits were confirmed by gas chromatography and mass spectrometry. Recovery for spike samples that were greater than reporting limits ranged from 109 to 119 percent. Replicate analyses of mallard eggs differed by 0.01 ppm (part per million).

Trace-element results were confirmed by spike recovery and by duplicate sample analyses. Recovery of compounds analyzed by inductively coupled plasma (ICP) emission spectrometry ranged from 92 to 107 percent for spiked samples. Recovery of trace elements analyzed by atomic absorption spectroscopy varied from 90.8 to 109 percent. Arsenic recovery by hydride generation was 93.5 percent. Duplicate analyses of mallard liver and kidney tissues analyzed by ICP emission spectrometry varied by less than 0.05 percent for 18 trace elements. Duplicate analyses for 16 trace elements on mallard livers and kidneys varied by less than 0.01 percent. Selenium varied by less than 0.08 percent. Arsenic in the duplicate samples indicated no variance.

[1]Use of firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

DISCUSSION OF RESULTS

Results of water analyses for all chemical constituents and sediment analyses for pesticides are discussed relative to the water-quality standards or criteria listed in table 5, parts of which were abstracted from a summary table compiled by the New Mexico State Environmental Improvement Division (McQuillan, 1988). The ground-water standards in table 5 were adopted by the State of New Mexico to protect all ground water containing 10,000 mg/L (milligrams per liter) dissolved solids or less for use as domestic or agricultural water supplies, and to provide water-quality protection for stream segments with ground-water inflows (Goad, 1982). The ground-water standards are referred to because they may have applicability to irrigation-drainage water and because surface-water numerical standards for most chemical constituents were not adopted by the State. Narrative statements rather than numerical limits for most of the chemicals listed in the ground-water standards (table 5) were adopted for another set of water-quality regulations, New Mexico's surface-water-quality standards (New Mexico Water Quality Control Commission, 1988). Numerical limits for most of the inorganic chemicals listed in table 5, however, will replace the narrative statements in revised water-quality standards that are being promulgated for New Mexico streams. The most stringent of the standards or criteria listed in table 5 are the freshwater chronic criteria, which are not enforceable but are recommended limits for the protection of aquatic life (U.S. Environmental Protection Agency, 1986).

The results of water analyses also are compared to the percentile values for selected water-quality properties and constituents for rivers of the United States in table 6. These percentiles were determined from data collected at 388 stations in the USGS National Stream-Quality Accounting Network (Smith and others, 1987). Mean concentrations for each station were calculated and ranked to obtain the mean concentrations for the 25th, 50th, and 75th percentiles. For this report, the concentration of a chemical constituent in river or canal water is generally considered elevated if it is greater than the 75th-percentile value.

The results of bottom-sediment analyses for geochemicals are discussed relative to geochemical baseline values presented in table 7 that were developed from selected USGS studies of natural soils west of the 97th meridian and within the conterminous United States (R.C. Severson, U.S. Geological Survey, written commun., 1987, based on Shacklette and Boerngen, 1984). The geochemical baselines were determined statistically to include 95 percent of the values for each chemical element that are closest to the geometric mean. Values greater than the upper limits in the baseline ranges generally are considered elevated for bottom sediment; however, the geochemical baselines were developed for soils that may be of finer texture than bottom sediment of aquatic systems such as the Rio Grande and the canals, ponds, and marshes in the BDANWR. Factors to be considered when comparing these baselines to geochemicals in bottom sediment are particle-size percentages in the bottom sediment and corresponding concentrations of the chemical element in water and biological materials.

Table 5.--Comparison of New Mexico Water Quality Control Commission ground-water standards and U.S. Environmental Protection Agency drinking-water standards, health advisories, and freshwater criteria, October 1988

[Modified from McQuillan (1988); NMWQCC, New Mexico Water Quality Control Commission; USEPA, U.S. Environmental Protection Agency; MCL, maximum contaminant level; mg/L, milligrams per liter; μg/L, micrograms per liter; pCi/L, picocuries per liter; PCB's, polychlorinated biphenyls. All standards listed are based on human or aquatic life health concerns except for those followed by "s" for secondary standard or "i" for irrigation standard]

Water-quality property or chemical constituent (unit)	NMWQCC ground-water standards	USEPA primary or secondary MCL for drinking water	USEPA lifetime health advisory[1]	USEPA fresh-water aquatic life chronic criteria[2]
		Inorganics		
pH (units)	6 to 9	6.5 to 8.5(s)		6.5 to 9.0
Dissolved solids (mg/L)	1,000	500(s)		
Arsenic (μg/L)	100	50	50	
Boron (μg/L)	750(i)			
Cadmium (μg/L)	10	10	5	[2]1.1
Chloride mg/L)	250	250(s)		
Chromium, hexavalent (μg/L)	50	50	120	[2]11
Copper (μg/L)	1,000	1,000(s)		[2]12
Fluoride (mg/L)	1.6	4.0		
Lead (μg/L)	50	50	20	[2]3.2
Mercury (μg/L)	2.0	2.0	3.0	0.012
Molybdenum (μg/L)	1,000(i)			
Selenium (μg/L)	50	10		35
Silver (μg/L)	50	50		0.12
Sulfate (mg/L)	600	250(s)		
Zinc (μg/L)	10,000	5,000(s)		[2]110
Nitrate as N (mg/L)	10.0	10.0	10.0	
Nitrite as N (mg/L)		1.0	1.0	
Radium (226 plus 228) (pCi/L)	30	5.0		
Uranium (μg/L)	5,000			
		Pesticides and other organics		
Alachlor (μg/L)			1.5	
Atrazine (μg/L)			3.0	
Chlordane (μg/L)			0.27	0.0043
Chlorpyrifos (μg/L)				0.041
Cyanazine (μg/L)			9.0	

Table 5.--Comparison of New Mexico Water Quality Control Commission ground-water standards and U.S. Environmental Protection Agency drinking-water standards, health advisories, and freshwater criteria, October 1988--Concluded

Water-quality property or chemical constituent (unit)	NMWQCC ground-water standards	USEPA primary or secondary MCL for drinking water	USEPA lifetime health advisory[1]	USEPA freshwater aquatic life chronic criteria[2]
		Pesticides and other organics		
2,4-D (μg/L)		100	70	
DDT (μg/L)				0.001
Diazinon (μg/L)			0.63	
Dieldrin (μg/L)			0.0219	0.0019
Endosulfan (μg/L)				0.056
Endrin (μg/L)		0.2	0.2	0.0023
Heptachlor (μg/L)			0.76	0.0038
Heptachlor epoxide (μg/L)			0.38	
Lindane (μg/L)		4.0	0.2	
Malathion (μg/L)				0.1
Methoxychlor (μg/L)		100	340	0.03
Methyl parathion (μg/L)			2.0	
Metolachlor (μg/L)			10	
Metribuzin (μg/L)			175	
Mirex (μg/L)				0.001
Prometon (μg/L)			100	
Propazine (μg/L)			14.0	
Simazine (μg/L)			35	
2,4,5-T (μg/L)			21	
Toxaphene (μg/L)		5.0	0.31	0.0002
2,4,5-TP (silvex) (μg/L)		10	52	
Trifluralin (μg/L)				2.0
PCB's (μg/L)	1.0		0.79	0.014

[1]Health advisory concentration presents a theoretical additional lifetime cancer risk of 1 per 100,000 persons. USEPA health advisory documents also provide various concentrations posing risks of 1 per 10,000 through 1 per 10,000,000.

[2]Criteria dependent on total hardness as $CaCO_3$; 100 mg/L used while recognizing that total hardness values greater than 100 mg/L may reduce toxicity of certain trace metals to aquatic organisms.

Table 6.--**Baseline values of selected water-quality properties or chemical constituents for rivers of the United States**

[From Smith and others, 1987; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than]

Water-quality property or chemical constituent (unit)	Number of rivers sampled	Sample-mean concentration for indicated percentile		
		25th	50th	75th
pH (standard units)	290	7.3	7.8	8.1
Dissolved oxygen (mg/L)	369	8.7	9.8	10.5
Alkalinity as $CaCO_3$ (mg/L)	289	42.0	104.3	161.8
Calcium (mg/L)	289	15.8	38.2	66.8
Magnesium (mg/L)	289	3.9	11.2	21.7
Sodium (mg/L)	289	6.8	18.3	68.9
Sulfate as $SO_4^=$ (mg/L)	289	10.5	39.9	116.9
Chloride (mg/L)	289	6.7	14.9	53.3
Nitrate total as N (mg/L)	383	0.20	0.41	0.89
Arsenic (µg/L)	293	<1	1	3
Cadmium (µg/L)	285	<2	<2	<2
Chromium (µg/L)	161	9	10	10
Iron (µg/L)	293	36	63	157
Lead (µg/L)	292	3	4	6
Manganese (µg/L)	286	11	24	51
Mercury (µg/L)	199	0.2	0.2	0.3
Selenium (µg/L)	211	<1	<1	1
Zinc (µg/L)	288	12	15	21

Table 7.--Geochemical baselines for soils of the Western United States

[Detection ratio: number of samples in which the element was found in measurable concentrations to number of samples analyzed; baseline, expected 95-percent range; ppm, parts per million; >, greater than; <, less than; *, values preceded by an asterisk are arithmetic means or standard deviations; --, not determined. Data summarized from Shacklette and Boerngen, 1984]

Element (ratio of measure)	Unit	Detection ratio	Geometric mean	Geometric deviation	Baseline	Observed range
Calcium	%	777:777	1.8	3.05	0.19-17	0.06-32
Magnesium	%	777:778	0.74	2.21	0.15-3.6	0.03->10
Sodium	%	744:744	0.97	1.95	0.26-3.7	0.05-10
Potassium	%	777:777	*1.8	*0.71	0.38-3.2	0.19-6.3
Phosphorus	%	524:524	0.032	2.33	0.0059-0.17	0.004-0.45
Aluminum	%	661:770	5.8	2.00	1.5-23	0.5->10
Arsenic	ppm	728:730	5.5	1.98	1.2-22	<0.1-97
Barium	ppm	778:778	580	1.72	200-1,700	70-5,000
Beryllium	ppm	310:778	0.68	2.30	0.13-3.6	<1-15
Boron	ppm	506:778	23	1.99	5.8-91	<20-300
Cadmium	ppm	--	--	--	--	[1]0.020-0.18
Cerium	ppm	81:683	65	1.71	22-190	<150-300
Chromium	ppm	778:778	41	2.19	8.5-200	3-2,000
Cobalt	ppm	698:778	7.1	1.97	1.8-28	<3-50
Copper	ppm	778:778	21	2.07	4.9-90	2-300
Gallium	ppm	767:776	16	1.68	5.7-45	<5-70
Iron	%	776:777	2.1	1.95	0.55-8.0	0.1->10
Lanthanum	ppm	462:777	30	1.89	8.4-110	<30-200
Lead	ppm	712:778	17	1.80	5.2-55	<10-700
Lithium	ppm	731:731	22	1.58	8.8-55	5.0-130
Manganese	ppm	777:777	380	1.98	97-1,500	30-5,000
Mercury	ppm	729:733	0.046	2.33	0.0085-0.25	<0.01-4.6
Molybdenum	ppm	57:774	0.85	2.17	0.18-4.0	<3-7
Neodymium	ppm	120:538	36	1.76	12-110	<70-300
Nickel	ppm	747:778	15	2.10	3.4-66	<5-700
Scandium	ppm	685:778	8.2	1.74	2.7-25	<5.0-50
Selenium	ppm	590:733	0.23	2.43	0.039-1.4	<0.1-4.3
Silver	ppm	--	--	--	--	--
Strontium	ppm	778:778	200	2.16	43-930	10-3,000
Thorium	ppm	195:195	9.1	1.49	4.1-20	2.4-31

Table 7.--Geochemical baselines for soils of the Western United States--Concluded

Element (ratio of measure)	Unit	Detection ratio	Geometric mean	Geometric deviation	Baseline	Observed range
Titanium	%	777:777	0.22	1.78	0.069-0.70	0.05-2.0
Uranium	ppm	224:224	2.5	1.45	1.2-5.3	0.68-7.9
Vanadium	ppm	778:778	70	1.95	18-270	70-500
Ytterbium	ppm	754:764	2.6	1.63	0.98-6.9	<1-20
Yttrium	ppm	759:778	22	1.66	8.0-60	<10-150
Zinc	ppm	766:766	55	1.79	17-180	10-2,100

[1]Average composition range for sandstone, shale, and carbonate rocks as reported in Hem (1985, p. 6).

Water and bottom-sediment samples were not collected in the middle Rio Grande upstream from San Acacia for this study. However, data for eight water-quality stations (fig. 1) were retrieved for water years 1978 through 1988 from the Geological Survey's WATSTORE data system, and baseline ranges were developed for selected water-quality properties and constituents at each station. The range selected for each baseline included the values in the 5th through the 95th percentiles of the ranked values for a property or constituent for each station. The data used were from eight USGS water-quality stations located within the USBR's middle Rio Grande Project area (fig. 1). The baseline values are listed in four tables at the back of the report. The baseline values in these tables are water-quality properties and major dissolved chemical constituents (table 8), dissolved trace elements and radionuclides (table 9), suspended-sediment concentrations and total-extractable trace-element concentrations (table 10), and trace-element concentrations in streambed sediment (table 11). The results of the chemical analyses for water and bottom-sediment samples collected at the BDANWR are considered elevated relative to the middle Rio Grande if the results are larger than the 95th-percentile values in these tables.

The results of the field measurements or laboratory analyses of water and bottom-sediment samples collected at the BDANWR are compiled in six tables at the back of the report. The data in these six tables consist of field measurements, water-quality properties, and suspended sediment analyses (table 12); chemical analyses of major dissolved chemical constituents in water (table 13); chemical analyses of dissolved trace elements in water (table 14); chemical analyses of pesticides in water (table 15); geochemical analyses of bottom sediments (table 16); and chemical analyses of pesticides in bottom sediments (table 17).

Results of chemical analyses performed on biota were compared to results from the USFWS's National Contaminant Biomonitoring Program (NCBP) and to USFWS's Environmental Contaminant Program. Results from this reconnaissance study also were compared to irrigation-drainage studies at Bowdoin National Wildlife Refuge in Montana and the Volta Wildlife Management area in the Tulare Lake Bed area, California because these studies examined species similar to those collected at BDANWR. The Bowdoin National Wildlife Refuge is on the same migratory route used by waterfowl that fly to BDANWR for the winter. No unusual mortality rates or deformities in nesting birds have been observed at the Bowdoin Refuge (Lambing and others, 1988, p. 8). Results of the chemical analyses of biological samples are discussed also in relation to other studies that focused on specific contaminant residues in biota. Biological health criteria for the chemical residues in biological tissues analyzed for this study have not been developed.

The analytical results for biological samples collected during 1986 at BDANWR for the Environmental Contaminant Program are compiled in three tables at the back of the report. The data in these three tables consist of trace elements in birds (table 18), trace elements in fish (table 19), and trace elements in plants (table 20). The analytical results for biological samples collected during 1988 for this reconnaissance study are tabulated for trace elements for all biological samples in table 21. Geometric mean concentrations and concentration ranges for selected trace elements are summarized from the 1988 data for birds in table 22 and for fish, invertebrates, and plants in table 23.

The analytical results for organochlorine residues in birds, fish, and plants collected during 1986 are listed in tables 24 and 25. For the biological samples collected during 1988, organochlorine data are tabulated separately for comparison purposes in table 26. Tables 21 through 26, inclusive, also are located at the back of the report.

Water

The results of water analyses are discussed by the categories of field measurements or chemical analyses performed on the samples (table 1). The results are compared to the standards or criteria in table 5 and to the New Mexico water-quality standards for streams (New Mexico Water Quality Control Commission, 1988). The results also are compared to the baseline values for rivers of the United States (table 6).

Physical Measurements, Water-Quality Properties, and Dissolved-Solids Concentration

The baseline pH ranges (table 8) in the middle Rio Grande were all within the State stream standard range of 6.0 to 8.6 for the upper reach and 6.0 to 9.0 for the lower reach (New Mexico Water Quality Control Commission, 1988, p. 11-15). The range of pH measurements for canals and ponds in the BDANWR was 7.8 to 8.7. The pH for the warm-water supply well (site B12) was 7.22. The State ground-water standard for pH ranges from 6.0 to 9.0 (table 5).

Baseline water temperatures in the middle Rio Grande (table 8) and within the BDANWR did not exceed the State stream standards (New Mexico Water Quality Control Commission, 1988, p. 11-15). The temperature of the warm-water well (site B12) was 33 °C. The State stream standard of 32.2 °C for this segment of the Rio Grande is not applicable to ground water.

The dissolved-oxygen baseline ranges in the middle Rio Grande (table 8) were greater than the State stream lower limit standard of 6.0 mg/L for the upper reach (upstream from Angostura) and 4.0 mg/L for the lower reach (downstream from Angostura) (New Mexico Water Quality Control Commission, 1988, p. 11-15). Dissolved-oxygen concentrations measured in canals and ponds within the BDANWR were all greater than the 4.0-mg/L limit and were near or were greater than saturation levels (table 12).

The baseline alkalinity values in the lower reach of the middle Rio Grande (table 8) and within the BDANWR (table 13) were near or were greater than the 75th percentile of 161.8 mg/L for United States rivers (table 6). These larger alkalinity values impart a greater acid-neutralizing capacity to water supplies. Alkaline waters are characteristic of calcareous soils such as the soils of arid environments (Hem, 1985, p. 109).

The baseline ranges of dissolved-solids concentrations in the middle Rio Grande (table 8) were less than the New Mexico Water Quality Control Commission (1988) limits of 500 mg/L in surface-water standards for the upper reach and 1,500 mg/L for the lower reach except for the 95th-percentile value of 2,790 mg/L for the Rio Puerco near Bernardo. The mean dissolved-solids concentration in the Rio Grande increased from 210 mg/L at Otowi Bridge to 649 mg/L at the conveyance channel at San Marcial, as shown in figure 7. The mean dissolved-solids concentration in the Rio Puerco was 1,547 mg/L. Ephemeral streamflow from the Rio Puerco causes the increase in mean dissolved-solids concentration at downstream Rio Grande stations (fig. 7). Streamflow in the Rio Grande Floodway at San Acacia usually is not diverted into the conveyance channel if the streamflow appears to be mixed with silt-laden runoff from the Rio Puerco. This may be the reason for the smaller range of dissolved-solids concentrations in water from the conveyance channel at San Acacia compared with the floodway (table 8). The increase in mean dissolved-solids concentration in the conveyance channel at San Marcial may be caused by the larger dissolved-solids concentration in drainage water that is discharged into the conveyance channel by way of the BDANWR Interior Drain (fig. 2). The dissolved-solids concentrations in water from canal sites at the BDANWR (table 13) were as much as three times those in water from reconnaissance samples collected from the Rio Grande nearby (fig. 8). The dissolved-solids concentrations in the ponds and marshes were nearly five times larger than concentrations in the nearby Rio Grande. Well water from the tile-field sump (site B11) was similar in dissolved-solids concentration to that in canal or ponded water. The dissolved-solids concentration of 2,650 mg/L in the warm-water well (site B12) was the largest concentration sampled possibly because of geothermal influences to this ground-water supply (Anderholm, 1987, p. 11).

Major Ions and Nutrients

Sodium concentrations in water samples collected from the BDANWR increased with dissolved-solids concentrations, with proportionally larger sodium concentrations in the samples from the Interior Drain (site B7), the ponds (sites B8 and B10), and the wells (sites B11 and B12) (fig. 8). The sodium adsorption ratio (SAR) (table 13) ranged from 1 in river water to 12 in marsh water (site B10). The marsh water's sodium adsorption ratio of 12 and specific conductance of 2,450 μS/cm at 25 °C (microsiemens per centimeter at 25 degrees Celsius) classify the water as medium sodium hazard (SAR's from 10 to 18) and very high salinity hazard (specific conductance greater than 2,250 μS/cm at 25 °C) according to a U.S. Department of Agriculture classification of irrigation water on soils (1954, p. 80). By this classification, the sodium hazard and salinity hazard for the warm-water well (site B12) and the spring pond (site B15) also were elevated. Water samples from all other sites could be placed in low to medium sodium or salinity hazards to soils for irrigation purposes. The samples indicate that these hazards to soils in drainage water increase within the BDANWR. During this reconnaissance study, the field study team observed that the BDANWR with assistance from the USBR is taking measures to prevent salinity buildup in fields and ponds by dredging the Interior Drain for greater drainage efficiency. The BDANWR plans to minimize the use of irrigation-drainage water in the Refuge.

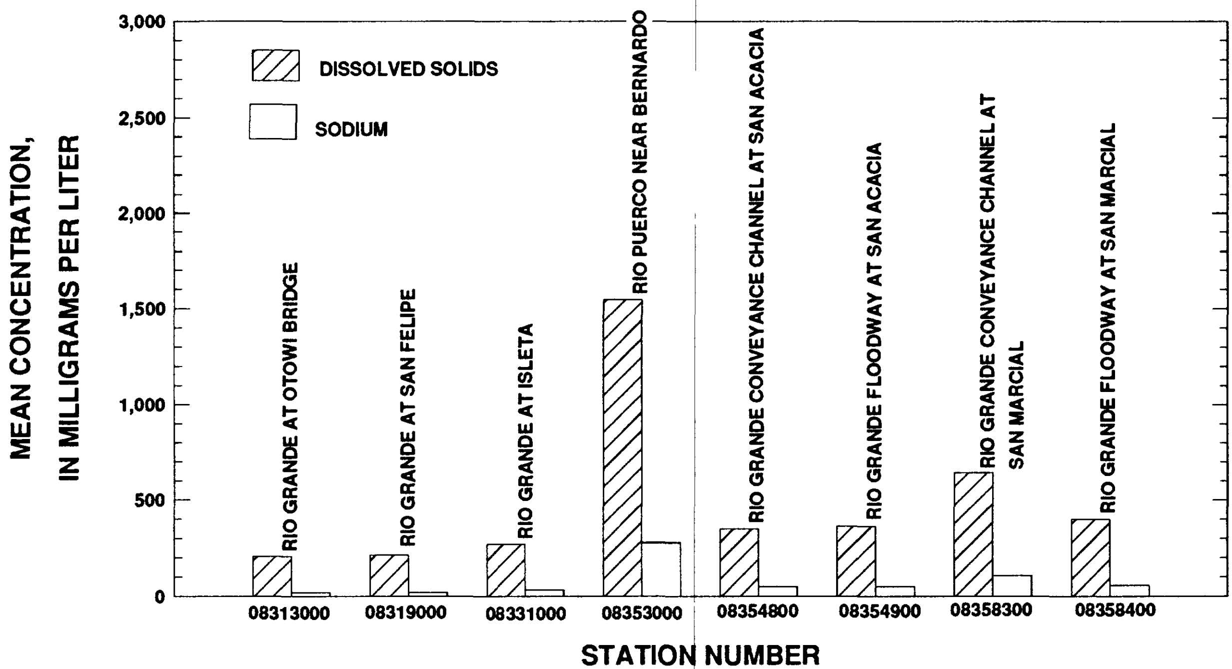

Figure 7.--Mean dissolved-solids (sum of constituents) and sodium concentrations at U.S. Geological Survey water-quality sampling stations within the middle Rio Grande valley, New Mexico, water years 1978-88.

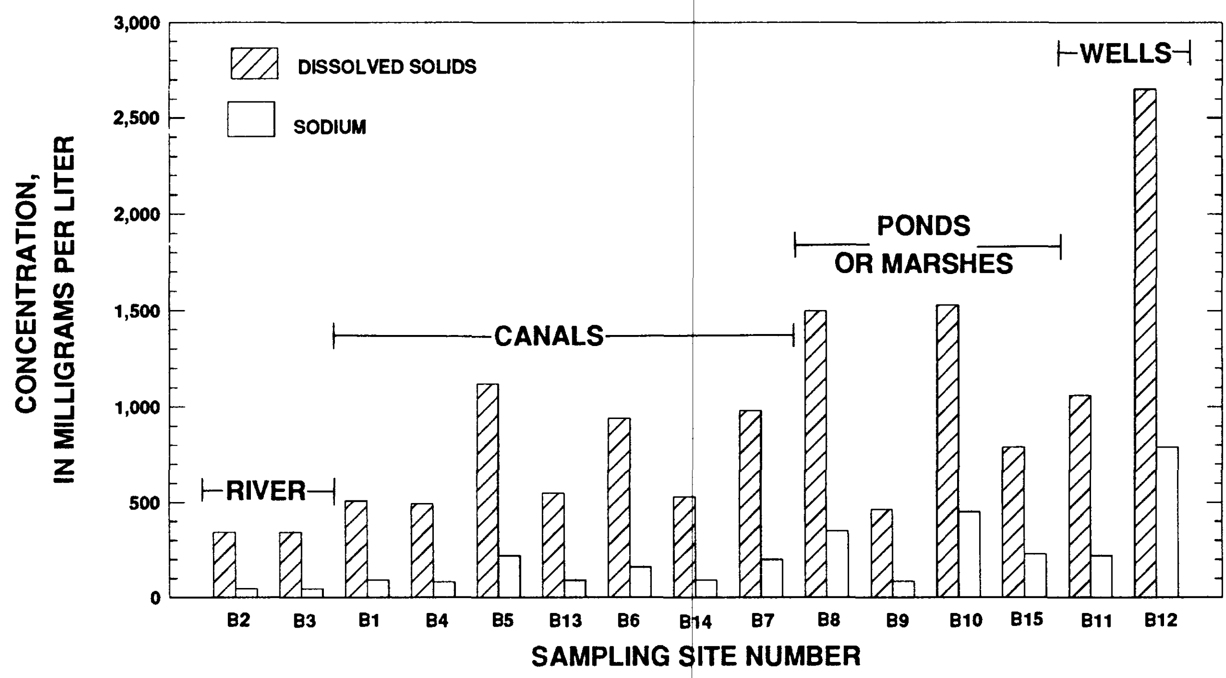

Figure 8.--Dissolved-solids (sum of constituents) and sodium concentrations at water-quality sampling sites for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988.

Total hardness as calcium carbonate in all water samples collected from the BDANWR ranged from 130 to 510 mg/L (table 13). Toxicities to aquatic organisms of the trace elements cadmium, chromium, copper, lead, nickel, and zinc are decreased if these elements are present in freshwater having total hardness concentrations greater than 100 mg/L (U.S. Environmental Protection Agency, 1986). The freshwater criteria for these elements listed in table 5 are based upon a total hardness concentration of 100 mg/L. Larger concentrations of these trace elements may be tolerated by aquatic organisms in contact with waters with larger hardness concentrations.

The calcium, bicarbonate, and carbonate ions in solution that contribute to total hardness, however, were sufficiently small in most of the samples to indicate that calcium carbonate would not precipitate from these waters. Assuming similar chemical conditions at shallow depths, caliche or hardpan layers would not form in shallow depths of the soils. If these layers formed, the drainage of irrigated fields would be impeded. The calcium carbonate saturation indices listed in the last column of table 13 were calculated with the aid of the U.S. Geological Survey's WATEQF computer program (Plummer and others, 1984). These calculated indices were less than 1.0, or less than saturation concentration for calcium carbonate, for all sites except Elmendorf Drain (site B5) and the South Marsh (site B10).

The nitrite plus nitrate (NO_2 + NO_3) baseline concentrations in water samples from the middle Rio Grande were 1.2 mg/L or less (table 8), and in samples from the BDANWR were 1.0 mg/L or less (table 13). These concentrations are smaller than the U.S. Environmental Protection Agency (USEPA) drinking-water maximum contaminant limit of 10 mg/L for nitrate as nitrogen (N) (table 5). Nitrate is usually the predominant ionic form in dissolved oxygen-saturated water (Hem, 1985, p. 124-126). These small concentrations indicate that part of the nitrogen compounds from animal wastes, sewage, and fertilizers that may be introduced are being assimilated by aquatic plants as indicated by algal growth in the canals, ponds, and marshes.

Trace Elements

Results of the analyses for the dissolved trace elements listed in table 1 for water samples collected from the BDANWR are shown in table 14. The results indicate that almost all dissolved concentrations of these elements are less than the New Mexico Water Quality Control Commission ground-water standards, USEPA maximum contaminant limits (MCL) for safe drinking water, USEPA health advisory levels, or USEPA freshwater chronic criteria for trace elements for which standards, limits, goals, or risk levels were established (table 5). Freshwater chronic criteria that were exceeded for cadmium, lead and mercury and USEPA MCL that were exceeded for arsenic were the exceptions.

The dissolved concentration ranges for selected trace elements in the BDANWR or Rio Grande water samples, in micrograms per liter (μg/L) or picocuries per liter (pCi/L), are summarized from table 14 as follows:

Trace element	Range
Arsenic	1 to 53 μg/L
Boron	80 to 890 μg/L
Cadmium	<1 to 4 μg/L
Chromium	<1 to 8 μg/L
Copper	<1 to 11 μg/L
Lead	<5 to 5 μg/L
Mercury	<0.1 to 0.2 μg/L
Molybdenum	<5 to 11 μg/L
Selenium	<1 to 1 μg/L
Vanadium	<1 to 39 μg/L
Zinc	<3 to 27 μg/L
Uranium	<0.4 to 3.2 μg/L
Radium-226	<0.1 to 0.4 pCi/L

Except for arsenic and zinc, the maximum trace-element concentrations are less than the 75th-percentile concentrations reported for U.S. rivers (table 6). The arsenic concentration of 53 μg/L from the warm-water well (site B12) is the only arsenic concentration greater than the 50-μg/L MCL for safe drinking water. All arsenic concentrations in water samples from canals or ponds were 16 μg/L or less. Two zinc concentrations, 27 μg/L for the Rio Grande at San Acacia (site B2) and 22 μg/L for the Rio Grande Conveyance Channel at San Marcial, were greater than the 75th-percentile value of 21 μg/L for U.S. rivers (table 6). The latter sample was collected for another USGS program. These two and all other zinc concentrations in water samples from the BDANWR, however, were much smaller than the 10,000-μg/L New Mexico Water Quality Control Commission ground-water standard, the 5,000-μg/L MCL primary drinking-water standard, and the 110-μg/L USEPA freshwater chronic criteria (table 5).

The largest boron concentration analyzed was 890 μg/L for the sample collected from the warm-water well (site B12). The NMWQCC ground-water standard for boron is 750 μg/L or less for ground water used for irrigation (table 5).

The USEPA freshwater chronic criterion of 1.1 μg/L for cadmium (table 5) was exceeded in water samples collected at river site B2, canal sites B1, B5, B6, B7, B13, B14, and pond sites B10 and B15. Cadmium concentrations at these sites ranged from 1 to 4 μg/L. The cadmium freshwater chronic criterion also was exceeded at the 95th-percentile value, which is the upper limit of the baseline range, for water from three upstream Rio Grande stations (table 9). These 95th-percentile cadmium values ranged from 2.0 to 15 μg/L. At one other station the exceedance of the freshwater criterion for cadmium was inconclusive because the criterion of 1.1 μg/L is less than an earlier analytical reporting limit of less than 3 μg/L. The cadmium baseline values for water from the middle Rio Grande, however, are all less than the safe drinking-water standard of 10 μg/L, except for the 95th-percentile value of 15 μg/L for water from the Rio Grande at San Felipe (table 9). The larger cadmium concentrations in water at the upstream Rio Grande stations may not be related to irrigation drainage because of relatively smaller volumes of irrigation-return flows in the river at these upstream locations.

The usual reporting limit of 5 μg/L for dissolved lead in water is greater than the USEPA freshwater chronic criterion of 3.2 μg/L (table 5). Only one BDANWR reconnaissance water sample (table 14) from an inflowing canal (site B4) contained detectable lead, which was at the usual reporting limit of 5 μg/L. The 95th-percentile value for dissolved lead at all middle Rio Grande stations exceeded the freshwater chronic criterion except for the Rio Grande Floodway at San Acacia (table 9). These 95th-percentile values for lead ranged from 2.0 to 7.5 μg/L. Reporting limits for lead concentrations of less than 5 μg/L were obtained because of less interferences with the analytical method for these samples.

The reporting limit for dissolved mercury, 0.1 μg/L, also is greater than the USEPA freshwater chronic criterion of 0.012 μg/L. Mercury concentrations were at or near this reporting limit in reconnaissance water samples (table 14) collected from the Rio Grande station downstream (site B3), the conveyance channel (site B1), and the warm-water well (site B12). The 95th-percentile value for dissolved mercury in water from all middle Rio Grande water-quality stations exceeded this freshwater criterion except for the Rio Grande Conveyance Channel at San Acacia (table 9) for which samples contained dissolved-mercury concentrations that were less than the reporting limit of 0.1 μg/L. The exceedance of freshwater chronic criteria for mercury is inconclusive for most BDANWR sites because the mercury concentrations are less than the reporting limit.

Dissolved-selenium concentrations in water samples from the Refuge (table 14) were less than the reporting limit of 1.0 μg/L with the exception of a reconnaissance water sample collected from the Rio Grande upstream station at San Acacia (site B2), in which selenium was present at the reporting limit of 1.0 μg/L. All Rio Grande baseline selenium values (table 9) were less than the reporting limit of 1.0 μg/L except for the 95th-percentile values of 1.0 μg/L for water from the Isleta station and 4.5 μg/L for water from the conveyance channel at San Marcial (table 9). Persico and Brookins (1988, p. 213) reported selenium concentrations in water samples from the BDANWR that were less than their selenium analytical method's reporting limit of 1.5 μg/L.

The 5th- to 95th-percentile baseline ranges for dissolved trace-element concentrations in water from the middle Rio Grande in table 9 are comparable to the 25th- to 75th-percentile baseline ranges for the rivers of the United States (table 6), except for larger arsenic baselines in water for each Rio Grande station and potentially larger cadmium baselines, as discussed earlier for water from the upstream Rio Grande stations (table 9). Occasionally arsenic concentrations that are close to USEPA's MCL of 50 μg/L are reported in WATSTORE's ground-water data for the Rio Grande basin in New Mexico. The arsenic data are sparse, but these large concentrations of arsenic in ground water usually are associated with volcanic zones near the western margin of the Rio Grande basin.

A greater proportion of trace elements may be transported in streamflow as trace elements adsorbed to suspended sediment. Popp (1980) investigated trace metals in water and suspended sediments in the middle Rio Grande and concluded that large concentrations of cadmium, lead, mercury, and uranium are transported by the suspended sediment. Total-extractable concentrations are determined from a suspended-sediment and water mixture. The baseline ranges of total-extractable trace-element concentrations (table 10) in water from the middle Rio Grande generally are significantly larger than the corresponding dissolved trace-element ranges (table 9). The suspended-sediment concentration baselines (table 10) indicate large increases in suspended-sediment concentrations in the Rio Grande downstream from the Rio Puerco. A shift from 60 percent to greater than 90 percent of the suspended sediment as finer sized clay or silt particles also is indicated from the 50th-percentile data for the Rio Grande downstream from the Rio Puerco (table 10). The suspended-sediment concentration baseline for the Rio Puerco station near Bernardo ranges from 16,100 to 148,500 mg/L, whereas at the Rio Grande station at Isleta, which is located upstream from the Rio Puerco, the suspended-sediment concentration ranges from 41 to 2,530 mg/L (table 10). Baseline total-extractable trace-element concentrations in water increased in a downstream direction with increasing suspended-sediment concentrations but not proportionally to the large increases in the suspended-sediment concentrations (table 10).

Pesticides

Chlorophenoxy acid herbicides, triazine herbicides, and organophosphorous insecticides (table 1) were analyzed in water samples collected during or after the application season for these compounds (table 15). According to local pesticide-use reports (Bosque del Apache National Wildlife Refuge, written commun., 1988), these types of chemical compounds were applied on fields in the vicinity of the BDANWR. These types of compounds have received approval by the USEPA for use because these compounds are relatively nonpersistent in the environment (Smith and others, 1988, p. 36-42). The specific chemical compounds targeted for analysis in water samples for these three types of pesticides are listed in table 1.

In the water samples collected for this study, the concentrations of almost all pesticide compounds were less than analytical reporting limits (table 15). This is reflected in the reporting ratio, which is the ratio of the number of values greater than the reporting limit to the number of values less than the reporting limit (RL). The pesticide results (table 15) are summarized as follows:

<u>Chlorophenoxy acid herbicides</u>

Samples collected	= 12
Sites sampled	= 8
Target compounds	= 4
Reporting limit (RL)	= 0.01 μg/L
Reporting ratio	= 2:46
Compound (greater than RL)	= 2,4-D at 0.01 μg/L
Site with compound greater than RL	= B2 (fig. 5; table 2)

Triazine herbicides

Samples collected	= 17
Sites sampled	= 14
Target compounds	= 10
Reporting limit (RL)	= 0.1 μg/L
Reporting ratio	= 0:170
Compounds (greater than RL)	= none

Organophosphorous insecticides

Samples collected	= 18
Sites sampled	= 14
Target compounds	= 7
Reporting limit (RL)	= 0.01 μg/L
Reporting ratio	= 5:120
Compound (greater than RL)	= diazinon at 0.01 μg/L
Sites with compounds greater than RL	= B2, B3, B5, B13, and B14 (fig. 5; table 2)

Water-quality standards or criteria are listed in table 5 for 16 of the 22 pesticide compounds that were analyzed in these water samples. The most stringent of the standards or criteria are the USEPA freshwater chronic criteria, and these criteria are from one to three orders of magnitude smaller than reporting limits for the compounds. The results of all of the pesticide analyses were at or near the reporting limits; therefore, it is not known if these criteria were exceeded. Freshwater chronic criteria are not listed for 2,4-D or diazinon.

Although baseline ranges for inorganic and sediment data in WATSTORE were developed for the eight middle Rio Grande water-quality stations (fig. 1), baseline ranges were not developed for pesticide data because the bulk of the reported pesticide concentrations in water were less than reporting limits. The data in WATSTORE include organochlorine insecticide compounds such as DDT. The few pesticide concentrations reported in WATSTORE greater than reporting limits were for 2,4-D, silvex, diazinon, and dieldrin, and these concentrations usually were at or near the reporting limits. The organochlorine insecticide analyses in water samples reported in table 15 were collected for another USGS program, and the results are all less than reporting limits.

Bottom Sediment

Bottom sediment collected for this reconnaissance study was analyzed for 45 geochemicals (table 16) and 17 organochlorine compounds (table 17), including DDT. Although large concentrations of suspended sediment are transported in the streamflow of the middle Rio Grande valley, bottom sediment rather than suspended sediment was analyzed for chemical constituents. The bottom sediment was regarded as an adequate indicator of potentially undesirable chemicals for this reconnaissance investigation because bottom sediment may be the source material for these chemicals, the sediment may adsorb chemicals from streamflow, or the bottom sediment may be a recent deposit of the suspended sediment that transported the adsorbed chemicals from another part of the middle Rio Grande valley. The adsorbed chemicals on bottom sediment may be considered the integrated result of sequences of adsorption, suspension, movement, and re-deposition by streamflow over a long period of time.

Geochemicals

Geochemical analyses were performed on 13 bottom-sediment samples collected from two river sites, five canal sites, three pond or marsh sites, and one field site during February and March 1988. The results are arranged by site number in table 16. Major element analyses are reported in percent of dry-weight, and minor element analyses are reported in parts per million of dry-weight. Results may be summarized as follows when compared with the geochemical baselines listed in table 7 for soils in the Western United States (R.C. Severson, U.S. Geological Survey, written commun., 1987, based on Shacklette and Boerngen, 1984):

1. The concentration ranges for the major elements calcium, magnesium, sodium, potassium, phosphorus, aluminum, barium, iron, strontium, and titanium were within the soil geochemical baseline range for soils in the Western United States.

2. Manganese was the only major element with a concentration range that extended above the soil geochemical baseline's upper limit.

3. The concentration ranges for the minor elements arsenic, beryllium, cerium, chromium, cobalt, copper, gallium, lanthanum, lithium, mercury, molybdenum, neodynium, nickel, niobium, selenium, vanadium, ytterbium, yttrium, and zinc were within the soil geochemical baseline.

4. The concentration ranges for the minor elements boron, scandium, thorium, and uranium were within the soil geochemical baselines or extended below each element's baseline lower limit.

5. Lead was the only minor element having a concentration range that extended above the soil baseline's upper limit.

6. The concentration baselines for soils of the Western United States (table 7) were not established for nine minor elements listed in table 16 (bismuth, cadmium, europium, gold, holmium, silver, tantalum, tin, and radium-226). Because of the analytical methods used, the reporting limits for these elements except for radium-226 were larger than crustal abundance levels (Hem, 1985, p. 5-6). The crustal abundance levels for radium-226 were not determined.

7. A concentration baseline for carbon in soil is not reported in table 7 but total carbon concentrations were less than or were near the crustal abundance levels for sandstone (1.38 percent) and shale (1.53 percent) (Hem, 1985, p. 5-6). Organic carbon content in the fine fraction usually was larger than the organic carbon content in the coarse sample. Organic carbon was

analyzed because organic compounds such as pesticide residues may be selectively concentrated in the organic carbon fraction of sediments (Smith and others, 1988, p. 3-15).

The analytical results for the duplicate bottom-sediment samples collected from the riverbed of the Rio Grande Floodway at San Acacia (site B2) are in close agreement, which indicates good laboratory precision for these data. Although large samples were collected, the amounts of fine material sieved from the duplicate bottom-sediment samples were not sufficient to perform laboratory analyses on the fine-sized fractions for these duplicate samples. This indicated that the riverbed was composed almost entirely of sand-sized particles and that fine sediment was not being deposited on the riverbed at this site.

The surface area of fine-sized sediment for chemical adsorption is greater than an equal weight of coarse-sized sediments, and, as expected, most geochemical element concentrations were larger in the fine fraction. The differences, however, usually were small, and elemental concentrations occasionally were identical for both fractions or were larger in the coarse fraction. A more detailed examination of this large data set (table 16) may produce other findings.

Radium-226, a radioactive-decay product of the uranium isotope U-238, was an additional element that was analyzed in the bottom sediment for this reconnaissance study. Radium is strongly adsorbed to sediment and may be transported on suspended sediment in runoff entering the middle Rio Grande from uranium mining areas by way of the Rio San Jose and the Rio Puerco (fig. 1). A soil geochemical baseline (table 7) for radium-226 was not established; therefore, it is not known if these radium-226 concentrations were elevated in the bottom-sediment samples relative to these soils in the Western United States. The laboratory reports for radium-226 concentrations provided theoretical equilibrium uranium concentrations that were as much as three times larger than the laboratory uranium concentrations reported for these samples in table 16. This indicates that radium-226 in bottom sediment may be elevated in relation to the uranium in bottom sediment. This relation is reversed in water samples from the middle Rio Grande (table 9) and the BDANWR (table 14) because of larger uranium solubility in water compared to radium-226 solubility in water.

Baseline ranges of trace-element concentrations in the bottom sediment of the middle Rio Grande at USGS water-quality stations (fig. 1) are presented in table 11. These baseline ranges were retrieved from USGS WATSTORE data files. The data indicate that most trace-element concentrations in bottom sediment are approximately equal to or are smaller than corresponding baseline trace-element concentrations for soils in the Western United States (table 7). The exceptions are the 95th-percentile concentration of 3.5 $\mu g/g$ for cadmium and the 95th-percentile concentration of 0.47 $\mu g/g$ for mercury, both of which are for the San Felipe station (table 9). Dissolved-cadmium concentrations at the San Felipe station (table 9) also were greater than the observed range for United States rivers (table 6). These elevated cadmium concentrations in water and bottom sediment at the San Felipe station may not be the result of irrigation drainage because this station is located in the upper reach of the middle Rio Grande where proportionally less irrigation drainage is returned to the river.

Pesticides and Polychlorinated Biphenyls (PCB's)

Pesticide compounds selected for analyses in bottom sediment for this study were the organochlorine insecticides because these organochlorine insecticides are strongly sorbed to organic matter in sediment. Organochlorine compounds are characterized as hydrophobic compounds because of small solubilities in water. These types of compounds are environmentally persistent and may be found in association with stream sediment (Smith and others, 1988, p. 25-35). Other types of pesticides, such as those analyzed in water for this study (table 1), are less persistent and are not readily sorbed to sediment. These other pesticides quickly hydrolyze, metabolize, or biochemically degrade into compounds that are difficult to identify. For these reasons, the analysis of pesticides in bottom sediment was limited to organochlorine insecticides.

The 17 organochlorine compounds analyzed in bottom sediment are listed in table 1 and the schedule for collecting these samples is shown in table 3. The compounds include DDT, chlordane, toxaphene, and other environmentally persistent compounds. The compounds DDD and DDE also are on the list because they are metabolized compounds of DDT. Several chemical isomers of DDT are produced in the manufacturing process, the predominant form being p,p'-DDT (Smith and others, 1988, p. 26). This is the isomer usually reported in laboratory analyses. Other organochlorine compounds targeted for analyses in the bottom sediment were polychlorinated biphenyls (PCB's) and polychlorinated naphthalenes (PCN's), both of which are widely used industrial compounds.

Results of organochlorine compounds analyzed in bottom sediment that was collected during November 1987 and February 1988 are summarized as follows (table 17):

Samples collected	= 12
Sites sampled	= 12
Compounds targeted	= 17
Reporting limits (RL)	= 1.0 μg/kg for chlordane, PCB's, PCN's, and perthane; 10 μg/kg for toxaphene; and 0.1 μg/kg for all others
Reporting ratio	= 21:183 (values at or greater than RL: values less than RL)
Compounds detected	= 6 (aldrin, chlordane, DDD, DDE, DDT, and PCB's)

The six compounds with concentrations greater than reporting limits, the concentration ranges above reporting limits, and the sites (fig. 5, table 2) for which the compounds were reported are summarized as follows:

Aldrin	= 0.1 μg/kg for site B9
Chlordane	= from 1.0 to 3.0 μg/kg for sites B4, B5, B10, and B12
DDD	= from 0.1 to 1.7 μg/kg for sites B5, B8, B10, and B12F
DDE	= from 0.1 to 1.3 μg/kg for sites B4, B5, B8, B9, B10, B11F, and B12F
DDT	= 0.1 μg/kg for sites B6 and B7
PCB's	= 2 μg/kg for sites B4, B5, and B10

Organochlorine compounds greater than reporting limits were found in bottom-sediment samples collected from canal, pond, or marsh sites. Bottom-sediment samples collected from the Rio Grande did not contain detectable levels of organochlorine compounds. Samples for pesticide analysis in bottom sediment at the USGS water-quality stations in the middle Rio Grande were not collected; consequently, baseline ranges could not be developed for these compounds.

Water-quality standards or criteria for pesticide residues in bottom sediment were not found; however, if they exist, they probably would apply to very specific conditions. The sorption and release of pesticides from sediment are being studied, and understanding these processes is progressing (Smith and others, 1988). Aquatic organisms bioaccumulate very small concentrations directly from water; however, these concentrations in water may be less than current laboratory reporting limits for water although these concentrations are theoretically in chemical equilibrium with concentrations of the pesticides in the bottom sediment. Theoretical aqueous concentrations of organochlorine compounds in equilibrium with the organochlorine compounds sorbed on sediment can be derived mathematically by using empirical relations of the organochlorine compounds with water, sediment, organic carbon content in sediment, and octanol as a reference organic solvent (Smith and others, 1988, p. 2-11). Equilibrium aqueous organochlorine concentrations, in micrograms per liter, C_e, can be derived from the organochlorine concentrations in bottom sediment in micrograms per gram, C_s, after adjusting for the organic carbon fraction in the sediment, f_{oc}, from the equation:

$$C_e = \frac{C_s}{(K_{oc})\ (f_{oc})} \times 1{,}000 \qquad (1)$$

in which K_{oc} is the distribution coefficient for organic carbon. The organochlorine compound is assumed to be sorbed to the organic carbon fraction of the sediment. The distribution coefficient, K_{oc}, is a function of the distribution coefficient of organic compounds between octanol and water, K_{ow}, which can be obtained experimentally in the laboratory (Smith and others, 1988, p. 7).

For selected bottom-sediment samples collected for this reconnaissance study that contained concentrations greater than reporting limits of organochlorine compounds (table 17) and for which organic carbon was analyzed (table 16), the following equilibrium organochlorine concentrations in water, C_e, were derived using the above equation and the distribution coefficient data in the report by Smith and others (1988, p. 7, 29):

Site	Date	Compound	C_s	f_{oc}	K_{oc}	C_e
B6 (canal)	11-19-87	DDT	0.1 μg/g	0.0012	1,260,000	0.066 μg/L
B10 (marsh)	02-17-88	Chlordane	1.0 μg/g	0.0067	178,000	0.840 μg/L
B10 (marsh)	02-17-88	PCB's	2 μg/g	0.0067	316,000	0.94 μg/L

The theoretical equilibrium organochlorine concentrations in water, C_e, suggest that the freshwater chronic criterion of 0.001 μg/L for DDT (table 5) was exceeded at the BDANWR Interior Drain (site B6), and that the freshwater chronic criterion of 0.0043 ug/L for chlordane was exceeded at the South marsh (site B10). The theoretical concentration for PCB's at site B10 exceeded the freshwater chronic criterion of 0.014 μg/L. These theoretical concentrations would apply only to water in contact with the bottom sediment for a sufficient length of time to arrive at chemical equilibrium. This equilibrium condition is difficult to attain in dynamic hydrologic systems such as the middle Rio Grande and the canals and marshes within the BDANWR. For this reason actual organochlorine concentrations in water are probably much less than the theoretical equilibrium concentrations.

Biota

Because of the potential to cause harmful effects to the biologic community, the chemical elements listed in table 1 were selected for analyses in biological materials for the USFWS 1986 Environmental Contaminant Program study and this irrigation-drainage reconnaissance study. Results of chemical analyses are compared with those of studies conducted at the Bowdoin National Wildlife Refuge in Montana and the Volta Wildlife Management area in California because these studies examined similar species. No unusual wildlife mortalities or deformities have been observed in nesting birds at these wildlife habitats.

Trace Elements

The trace-element results for all of the biological samples collected during 1986 are shown in tables 18 through 20; the analytical results for 1988 samples are shown in table 21. The results are presented for both a wet-weight and a dry-weight basis. In both studies most trace elements in biological materials either were not detected or were at normal background levels. Summary statistics for the elements discussed in the following paragraphs are presented in tables 22 and 23. Arsenic, cadmium, copper, mercury, and selenium will be discussed in relation to irrigation-drainage concerns at the BDANWR. These trace elements were selected because they are the elements with the most significant, although not large, concentrations found in this study. Although lead concentrations in water data examined for this reconnaissance study may potentially exceed freshwater chronic criteria, lead concentrations in biota were less than the reporting limit of 0.2 μg/g wet-weight. Friend (1985, p. 4) stated that lead concentrations greater than 8 μg/g wet-weight in waterfowl liver should be viewed as evidence of contamination.

Arsenic

At BDANWR, arsenic concentrations in all bird livers and kidneys ranged from 0.032 to 0.302 μg/g wet-weight. Arsenic concentrations in eggs from all bird species ranged from 0.022 to 0.098 μg/g wet-weight.

Lambing and others (1988, p. 70) reported arsenic concentrations in coot livers from less than 0.04 to 0.09 μg/g wet-weight at Bowdoin National Wildlife Refuge versus a concentration range of 0.178 to 0.302 μg/g wet-weight at the BDANWR. Eisler (1988, p. 75) reported that arsenic residues in bird liver and kidney tissue in excess of 2 to 10 μg/g wet-weight are considered elevated whereas normal residue levels were less than 0.4 μg/g wet-weight. Concentrations of arsenic in coot eggs ranged from 0.052 to 0.098 μg/g wet-weight at BDANWR (table 21). Analysis of avocet and eared grebe eggs reported by Peterson and others (1988, p. 56) from an area considered a control site for the Kendrick Reclamation Project showed arsenic residues less than the detection limit of 0.079 μg/g wet-weight. Reproductive impairment in birds was not observed at Kendrick or Bowdoin National Wildlife Refuge where arsenic residue levels in bird eggs (0.09-0.28 μg/g wet-weight) were similar to those reported at BDANWR. For the National Contaminant Biomonitoring Program (NCBP), White and others (1977, p. 38) reported arsenic concentrations ranging from less than 0.05 to 1.4 μg/g wet-weight in starlings with an arithmetic mean of 0.156 μg/g wet-weight. White and others (1986, p. 382) reported that kidneys of coots, from a reference site that was considered uncontaminated, had arsenic residues ranging from undetectable to 0.6 μg/g wet-weight.

Arsenic concentrations in fish at BDANWR ranged from 0.078 to 0.598 μg/g wet-weight. Schroeder and others (1988, p. 41) reported that arsenic residues in various species of fish ranged from less than 0.2 to 0.27 μg/g dry-weight at Kern and Pixley National Wildlife Refuges (0.332-2.35 μg/g dry-weight at BDANWR) and that there was little threat to wildlife observed as a result of these concentrations. Data from fish analyses for the NCBP (Lowe and others, 1985, p. 369) indicate that the normal concentration of arsenic in fish tissue would range from 0.05 to 1.69 μg/g wet-weight.

Arsenic concentrations in aquatic invertebrates at BDANWR ranged from 0.24 to 0.725 μg/g wet-weight and in aquatic plants ranged from 0.086 to 0.765 μg/g wet-weight. Arsenic concentrations in invertebrates at Bowdoin ranged from less than 0.05 to 0.09 μg/g wet-weight, and in vascular plants ranged from 0.17 to 0.70 μg/g wet-weight (Lambing and others, 1988, p. 70). These ranges are similar to arsenic-concentration ranges at BDANWR for similar biological specimens. Another study (Lewis and others, 1978, p. 119) indicates that the normal concentration of arsenic in plants would be from 0.1 to 1.0 μg/g dry-weight. Arsenic concentrations in birds, fish, aquatic invertebrates, and plants at BDANWR were similar to minimum concentrations reported in other studies.

Cadmium

For this reconnaissance study, cadmium concentrations in liver and kidney from all bird species ranged from less than 0.1 to 0.84 μg/g wet-weight (less than 0.36 to 3.49 μg/g dry-weight) (table 21). White and Cromartie (1985, p. 298) reported that cadmium concentrations in livers of shorebirds and waterfowl from a reference site ranged from 0.1 to 1.6 μg/g wet-weight. Ohlendorf and others (1986, p. 56) reported a cadmium-concentration range of 0.34 to 1.0 μg/g dry-weight in waterbird livers from the Volta Wildlife Management area in California. Eisler (1985, p. 34) indicated that cadmium concentrations in vertebrate kidney or liver that exceed 10 μg/g wet-weight should be viewed as evidence of probable cadmium contamination. Cadmium was not detected in samples of bird eggs, fish, aquatic invertebrates, or aquatic plants collected for this study.

Copper

Concentrations of copper in bird livers varied among species sampled at BDANWR (table 21) but copper concentrations were similar to those in bird livers examined for other studies. Concentrations of copper in mallards ranged from 3.98 to 60.0 μg/g wet-weight with little difference between adults and immature birds. In coots, copper concentrations in liver tissue varied from 5.48 to 18.1 μg/g wet-weight and in black-necked stilts from 2.54 to 5.3 μg/g wet-weight, again with little difference between adults and immature birds. Lambing and others (1988, p. 70) reported copper concentrations in coot livers that ranged from 9.5 to 30 μg/g wet-weight. A study of the effects of a powerplant (White and others, 1986, p. 381) reported copper concentrations in coot tissue from a reference site that ranged from 2.6 to 12 μg/g wet-weight and indicated that copper concentrations that were less than 9.4 μg/g wet-weight in bird tissue did not produce harmful effects.

Copper concentrations in all bird eggs from BDANWR ranged from 0.52 to 1.52 μg/g wet-weight. This range is similar to the range reported by Lambing and others (1988, p. 71), which was 0.18 to 1.1 μg/g wet-weight for coot tissue. Copper concentrations in great blue heron eggs ranged from 0.29 to 2.71 μg/g wet-weight in another study (Blus and others, 1985, p. 112).

Concentrations of copper also were similar among fish species sampled at BDANWR; however, carp contained the largest copper concentrations. Copper concentrations in carp ranged from 0.56 to 5.36 μg/g wet-weight and copper concentrations in all other species were within this range. Lowe and others (1985, p. 369) in NCBP studies reported copper concentrations in fish during 1978-79 that ranged from 0.29 to 38.75 μg/g wet-weight and during 1980-81 that ranged from 0.25 to 24.1 μg/g wet-weight. The 85th percentiles were 1.14 and 0.90 μg/g wet-weight for these 1978-79 and 1980-81 studies, respectively, with corresponding geometric means of 0.46 and 0.47 μg/g wet-weight in all fish. Copper concentrations in several species of fish at BDANWR exceeded these 85th-percentile baseline values. Schroeder and others (1988, p. 41) reported concentrations of copper ranging from 3.0 to 6.2 μg/g dry-weight in carp from water-supply canals flowing into Kern and Pixley National Wildlife Refuges in California. The dry-weight range in carp examined for this study was 2.8 to 22.2 μg/g dry-weight.

Copper concentrations in aquatic insect specimens collected from the BDANWR varied from 2.32 to 11.3 μg/g wet-weight and in crayfish specimens varied from 10.9 to 33.9 μg/g wet-weight. Copper concentrations in plants from the BDANWR ranged from 1.08 to 2.06 μg/g wet-weight. Lambing and others (1988, p. 71) reported that within the Bowdoin National Wildlife Refuge copper concentrations ranged from 0.18 to 1.4 μg/g wet-weight in invertebrates and from 0.38 to 0.78 μg/g wet-weight in aquatic plants. The maximum copper concentrations in biota collected at the BDANWR were much less than the maximum copper concentrations in biota collected at Volta Wildlife Management area reported by Schroeder and others (1988, p. 53) or reported in the middle Green River basin in Utah by Stephens and others (1988, p. 61). Copper residues in biotic samples from these areas were not identified as being biologically harmful.

Mercury

For this study, mercury concentrations in livers and kidneys of immature and adult mallards ranged from 0.061 to 0.31 μg/g wet-weight. Also, mercury concentrations in all mature and immature coot livers ranged from 0.108 to 0.234 μg/g wet-weight and in all black-necked stilts ranged from 0.055 to 0.44 μg/g wet-weight. In the comparison of mercury residues in mallards, there appeared to be no differences between immature or adult birds. The chemical form of mercury in these analyses was not identified, but most mercury in animal tissue has been determined to exist as methylmercury (Nelson and others, 1971, p. 31), which is the form of mercury most easily retained in animal tissue.

Eisler (1987, p. 17) reported that methylmercury levels in biota usually are less than 1.0 μg/g wet-weight as mercury in locations that are not affected by anthropogenic introductions of mercury. White and Cromartie (1985, p. 299) reported that mercury concentrations in teal livers from a reference site for a dredge-disposal impoundment ranged from undetectable to 0.03 μg/g wet-weight, and in black-necked stilts ranged from 0.1 to 0.2 μg/g wet-weight. Eisler (1987, p. 31) reported that background levels of mercury in wood duck livers ranged from 0.1 to 1.1 μg/g wet-weight. Data from an uncontaminated site in Texas (White and others, 1986, p. 381) indicate that mercury residues in adult coot livers were less than those reported at BDANWR. The concentration ranged from undetectable to 0.09 μg/g wet-weight in the Texas study compared with a range of 0.125 to 0.216 μg/g wet-weight for coot livers in the BDANWR.

The mercury concentrations in bird eggs from the BDANWR (table 22) ranged from 0.034 to 0.096 μg/g wet-weight for mallards, from 0.04 to 0.363 μg/g wet-weight for coots, and from 0.084 to 0.32 μg/g wet-weight for black-necked stilts (table 22). Haseltine and others (1981, p. 94) reported mercury concentrations in mallard eggs that ranged from 0.05 to 0.17 μg/g wet-weight. Lambing and others (1988, p. 71) reported ranges of mercury in coot eggs from 0.09 to 0.28 μg/g wet-weight and in avocet eggs from 0.07 to 0.41 μg/g wet-weight. Mercury concentrations in bird eggs from these studies are comparable to those determined for this study at the BDANWR.

Concentrations of mercury in fish collected from the BDANWR for this study ranged from less than 0.025 to 0.088 μg/g wet-weight. The largest concentration of mercury, detected in a composite carp sample, is less than the geometric mean of 0.11 μg/g wet-weight or the 85th percentile of 0.18 μg/g wet-weight from the NCBP baseline (Lowe and others, 1985, p. 369). Nationwide concentrations of mercury in fish collected during 1978-79 ranged from 0.01 to 1.10 μg/g wet-weight and during 1980-81 ranged from 0.01 to 0.77 μg/g wet-weight (Lowe and others, 1985, p. 369). Geometric mean mercury concentrations in fish from eight sites reported for the San Joaquin River and tributaries in California (Saiki and May, 1988, p. 209) ranged from 0.055 to 0.153 μg/g wet-weight for bluegills and from 0.063 to 0.227 μg/g wet-weight for carp.

At BDANWR, mercury concentrations in aquatic invertebrate samples ranged from less than 0.025 to 0.068 μg/g wet-weight, and in aquatic plant samples ranged from less than 0.025 to 0.056 μg/g wet-weight. These values are comparable to those found at the Bowdoin study site described by Lambing and others (1988, p. 71), in which mercury concentrations in aquatic invertebrates were reported to be less than 0.05 μg/g wet-weight and in aquatic plants to be less than 0.05 μg/g wet-weight. Eisler (1987, p. 71) indicated that an acceptable criterion for mercury concentration in the aquatic food for birds would be less than 0.100 μg/g wet-weight.

Selenium

Selenium concentrations in all bird livers and kidneys collected from BDANWR for this study ranged from 0.20 to 2.40 μg/g wet-weight (table 22), which did not differ significantly from 1986 results (table 18). The range of selenium concentrations reported in 1986 was 0.54 to 2.77 μg/g wet-weight. A study to determine possible causes of embryonic mortalities and deformities in aquatic birds at Kesterson National Wildlife Refuge (Ohlendorf and others, 1986, p. 54) reported selenium concentrations in coot livers that ranged from 21 to 63 μg/g dry-weight, and in ducks that ranged from 19 to 43 μg/g dry-weight. The maximum selenium concentration at BDANWR for ducks in 1988 was 9.1 μg/g dry-weight (table 21). Selenium-concentration ranges reported for the Volta Wildlife Management area (control site) (Ohlendorf and others, 1986) were 3.9 to 4.4 μg/g dry-weight for ducks and 4.4 to 5.6 μg/g dry-weight for coots. Ohlendorf and others (1988, p. 74) reported a mean selenium concentration in bird livers of 94.4 μg/g dry-weight and a maximum value of 97.9 μg/g dry-weight from Kesterson Reservoir. In birds diagnosed as having died from selenium toxicosis, selenium concentrations in coot liver and kidney ranged from 68 to 86.1 μg/g dry-weight.

Selenium concentrations in bird eggs from BDANWR indicated little difference in concentration among the collection sites and the species collected. Selenium concentrations ranged from less than 0.1 to 0.80 μg/g wet-weight. Haseltine and others (1981, p. 94) reported selenium concentrations in mallard eggs collected from islands in Lake Michigan that ranged from 0.28 to 0.81 μg/g wet-weight. Ohlendorf and others (1987, p. 177) discussed selenium concentrations in bird eggs for a selenium-contaminated site and a reference site. At Kesterson Reservoir, a selenium-contaminated site, selenium concentrations in duck eggs ranged from 3.6 to 37 μg/g dry-weight and in stilt eggs from 5.2 to 64 μg/g dry-weight. The Volta Wildlife Management area, used as the reference site, had selenium concentrations in duck eggs that ranged from 1.5 to 2.1 μg/g dry-weight, and in stilts that ranged from 1.6 to 3.4 μg/g dry-weight. At BDANWR the largest reported selenium concentration in eggs was 2.5 μg/g dry-weight in a black-necked stilt egg. Lemly and Smith (1987, p. 4) reported that no apparent problems exist for selenium concentrations that do not exceed 15 to 20 μg/g dry-weight in bird eggs.

Selenium concentrations in fish were comparable among species and among the same species at different sites at the BDANWR. Selenium concentrations ranged from 0.1 to 0.3 μg/g wet-weight with a mean concentration of 0.2 μg/g wet-weight (table 23). Lowe and others (1985, p. 369) reported selenium concentrations nationwide for all fish analyzed in the 1978-79 NCBP study ranging from 0.09 to 3.65 μg/g wet-weight and in the 1980-81 NCBP study ranging from 0.09 to 2.47 μg/g wet-weight. The 85th-percentile baseline for selenium in fish from the 1980-81 study was 0.71 μg/g wet-weight, which is greater than the largest geometric mean concentration of 0.22 μg/g wet-weight for fish samples collected from the BDANWR. Selenium residues in fish at the BDANWR were less than the reported geometric means of 0.46 μg/g and 0.47 μg/g wet-weight for the 1978-79 and the 1980-81 NCBP studies. Lemly and Smith (1987, p. 9) indicated that whole-body residues of selenium that are greater than 12 μg/g dry-weight in fish could result in reproductive failure. The maximum selenium residue reported for the fish in BDANWR was 1.7 μg/g dry-weight. Therefore, selenium is not likely to represent a reproductive hazard to fish in the Refuge.

Similar small concentrations of selenium were analyzed in samples of aquatic invertebrates and aquatic plants collected for this study (table 21). The maximum value in crayfish was 0.2 μg/g wet-weight. Selenium concentrations were less than reporting limits in aquatic plants. The 1986 USFWS study at the BDANWR reported 0.1 μg/g dry-weight of selenium in the plant species analyzed (table 20). Saiki and Lowe (1987, p. 661) compared selenium residues in organisms from an area (Kesterson Reservoir) contaminated with selenium with a reference area (Volta Wildlife Management area). Selenium in aquatic insects collected during August from a Volta pond ranged from 1.3 to 1.7 μg/g dry-weight. Selenium in samples of invertebrates collected from Kesterson ranged from 150 to 290 μg/g dry-weight. Selenium concentrations in rooted plants ranged from 90 to 300 μg/g dry-weight at Kesterson, and selenium concentrations ranged from less than reporting limits to 0.79 μg/g dry-weight at Volta. For the BDANWR the maximum concentration found was 0.78 μg/g dry-weight in crayfish.

Organochlorine Compounds

In the 1986 study at the BDANWR, concentrations of p,p'-DDE, a breakdown product of p,p'-DDT, were detected in all four samples of coot livers and kidneys and one of four samples of whole carp (table 24). Concentrations of p,p'-DDE that were detected in coot tissue ranged from 0.01 to 0.12 μg/g dry-weight, and in the sample of carp was 0.01 μg/g dry-weight.

Oxychlordane; p,p'-DDE; p,p'-DDD; p,p'-DDT; and three isomers of polychlorinated biphenyls (PCB's) (CL-5, CL-7, and CL-8) were detected at concentrations greater than 0.07 μg/g wet-weight in 1988 biological samples for this reconnaissance study (table 26). The samples were either composite or single samples. Bunck and others (1987, p. 73) noted a relative decline nationwide in DDE concentrations in starling samples although the southwestern United States continued to have the largest DDE concentrations in starlings. The DDE concentrations of 2.49 μg/g wet-weight in adult black-necked stilts and 2.29 μg/g wet-weight in black-necked stilt eggs (table 26) at BDANWR are comparable to DDE values observed in the past. Blus (1982, p. 15) reported that DDE concentration in brown pelican eggs in excess of 3 μg/g wet-weight is a critical concentration and could cause reproductive failure. In a study of eggshell thinning due to DDE, Longcore and Stendell (1977, p. 302) noted that many migratory species may nest in areas that are relatively uncontaminated with DDE residues but accumulate DDE residues from other areas along migratory routes. Because the residues of DDE in other samples, particularly in mallards, coots, and fish, are small at BDANWR, it is probable that black-necked stilts are picking up DDE residues from other locations in their migratory route outside of the United States where the use of DDT may continue. Differences in food also may contribute to concentrations of DDE in black-necked stilts. The other compounds that were detected, oxychlordane and the PCB isomers, are at levels similar to those detected in starling samples collected for the NCBP (Bunck and others, 1987).

Organochlorine compounds were not detected in plant samples collected for the 1986 study (table 25). Organochlorine compounds were analyzed in one composite horned pondweed sample for the 1988 study. These data are not presented because organochlorine compounds were not detected in this composite pondweed sample.

SUMMARY

Water, bottom sediment, and biota associated with irrigation drainage were examined for chemical constituents that may be present at concentrations that may cause harmful effects to the health of humans, wildlife, and fish or to other beneficial uses for the water. Sampling sites were established for the river, canals, ponds, marshes, and wells. Sampling times for water and bottom sediment were selected to represent different periods of the irrigation season and to represent the winter period when large populations of migratory birds are present on the Refuge. Biological samples were collected to represent resident species. Analyses were performed for uniform suites of inorganic and organic constituents that were established for the U.S. Department of the Interior reconnaissance investigations of irrigation drainage. The following is a summary of the results of the analyses of water, bottom sediment, and biota from the middle Rio Grande and Bosque del Apache National Wildlife Refuge:

<u>Physical measurements and water-quality properties in water</u>: Water temperatures, dissolved-oxygen concentrations, pH, and dissolved-solids concentrations did not exceed the New Mexico State stream standards for protection of designated uses for the middle Rio Grande, which include wildlife and fish usage. Alkalinity measurements were large in comparison to baseline values for rivers of the United States at all sites, indicating larger pH values and greater acid-neutralizing capacity.

<u>Major dissolved constituents in water</u>: Average dissolved-solids concentrations in the middle Rio Grande increased from 210 mg/L upstream near Velarde to 649 mg/L downstream in the conveyance channel at San Marcial. The larger dissolved-solids concentration in the conveyance channel was caused in part by the larger dissolved-solids concentration in irrigation-drainage water returned from the Refuge's Interior Drain and in runoff from the Rio Puerco, a tributary with large dissolved-solids and suspended-sediment concentrations that occasionally receives

runoff from uranium mining areas. Dissolved-solids concentrations in water samples from the Refuge were as much as five times larger than those from the Rio Grande nearby. Potential salinity and sodium hazards to irrigated soils generally were small in water samples from the Rio Grande and Refuge canals. Total-hardness concentrations in all middle Rio Grande water were larger than 100 mg/L, which reduces potential toxicities of certain trace elements to aquatic organisms. Nitrate concentrations were 1.2 mg/L or less, indicating that nitrogen input from fertilizers or animal wastes is not significant or that some nitrogen is being assimilated by aquatic plants.

Trace elements dissolved in water: Almost all concentrations of potentially toxic trace elements, including selenium, were less than the U.S. Environmental Protection Agency's maximum contaminant limit for safe drinking water. The only safe drinking-water-standard exceedance was an arsenic concentration of 53 μg/L in a representative sample from a warm-water supply well. Arsenic and zinc concentrations were elevated relative to baselines of mean concentrations for United States rivers. The U.S. Environmental Protection Agency's freshwater chronic criteria for cadmium, lead, and mercury may have been exceeded in BDANWR irrigation-drainage water and at U.S. Geological Survey water-quality stations on the Rio Grande; however, this is inconclusive because the freshwater chronic criteria limits for these trace elements are equal to or smaller than the laboratory reporting limits. Trace-element toxicities may be reduced by the hardness of water in the middle Rio Grande. Although the dissolved trace-element concentrations may be small, large suspended-sediment concentrations in the middle Rio Grande and its tributaries may be transporting a larger proportion of these trace elements adsorbed to sediments to downstream locations such as the Bosque del Apache National Wildlife Refuge.

Pesticides in water: Chlorophenoxy acid herbicides, triazine herbicides, and organophosphorous insecticides were analyzed in unfiltered water samples. The laboratory results for analyses of 47 samples for 23 targeted compounds indicated that almost all concentrations of these compounds were less than laboratory reporting limits. The compounds detected were the herbicide 2,4-D at 0.01 μg/L in two river samples and the insecticide diazinon at 0.01 and 0.02 μg/L in two river samples and three canal samples.

Geochemicals in bottom sediment: Bottom-sediment samples were collected from 11 sites to represent river, canal, marsh, or irrigated field conditions. Coarse and fine fractions of these bottom-sediment samples were analyzed for 45 geochemical elements. The results indicated that most geochemical elements were within the concentration baselines for soils in the Western United States; however, cadmium, lead, manganese, and radium-226 concentrations may have been elevated.

Pesticides in bottom sediment: Of 17 organochlorine compounds targeted in the laboratory analyses of 12 bottom-sediment samples collected from canals, ponds, marshes, and fields, only 21 of 204 measurements (7 for DDE, 4 for DDD, 2 for DDT, 4 for chlordane, 1 for aldrin, and 3 for PCB's) were found at or near reporting limits. Although water-quality standards or criteria do not exist for pesticides in sediment, stringent freshwater chronic criteria, which are less than laboratory reporting limits for water, have been established to protect aquatic life. Theoretical concentrations of DDT, chlordane, and PCB's in water that are in chemical equilibrium with concentrations of these compounds detected in bottom sediment were calculated from empirical relations. These theoretical concentrations would exceed stringent freshwater chronic criteria under equilibrium conditions, but these equilibrium conditions are difficult to attain in the dynamic flow systems of the middle Rio Grande and Bosque del Apache National Wildlife Refuge. Actual concentrations may be much less than the theoretical concentrations.

Trace elements in biota: At Bosque del Apache National Wildlife Refuge, most trace-element concentrations in biological samples were either smaller than reporting limits or were in normal background level concentrations. Arsenic was found in all biological samples; however, none of the concentrations were considered to be elevated.

Residues of copper were comparable to those in samples from other refuges; however, one sample of mallard liver and kidney combined contained a copper residue of 60 μg/g wet-weight compared to 12 to 30 μg/g wet-weight in samples from other studies. Copper residues in fish generally were greater than the NCBP baseline of 1.14 μg/g wet-weight in 1978-79 and 0.90 μg/g wet-weight in 1980-81.

Mercury residues in bird tissue from the BDANWR were less than 1.0 μg/g wet-weight, which is the level considered to be indicative of mercury contamination. Concentrations of mercury in fish, aquatic invertebrates, and plants were smaller than concentrations reported in biota from other studies.

Concentrations of selenium at BDANWR were significantly less than levels reported at locations where reproductive impairment to birds has occurred. In samples of mallard kidneys and livers, a maximum selenium concentration of 9.1 μg/g dry-weight (2.4 μg/g wet-weight) was found, which contrasts to selenium concentrations in excess of 94.4 μg/g dry-weight at contaminated sites. Bird eggs collected at the BDANWR also contained relatively small concentrations of selenium--2.5 μg/g dry-weight (0.8 μg/g wet-weight)--which contrasts to a range of 37 to 64 μg/g dry-weight at contaminated sites. Residues of selenium in whole fish were less than the USFWS's NCBP geometric mean value of 0.47 μg/g wet-weight for fish. Selenium concentrations in samples of aquatic invertebrates and plants either were smaller than reporting limits or were near the reporting limits.

Organochlorine compounds in biota: The organochlorine compound p,p'-DDE was found in four coot samples and one carp sample collected for the 1986 study. The largest concentration was 0.04 ug/g wet-weight in a coot sample. Organochlorine compounds were found in 7 of 14 composite or single samples collected during 1988. Concentrations of oxychlordane; p,p'DDE; p,p'DDD; p,p'DDT; and three isomers of PCB's were larger than the reporting limits. The compound p,p'DDE, a breakdown product of p,p'DDT, was found in 6 of the 14 samples analyzed. The maximum concentration reported was 2.49 μg/g wet-weight for an adult black-necked stilt sample. The largest concentration of DDE detected in black-necked stilt eggs was 2.29 μg/g wet-weight. Black-necked stilts may be accumulating DDE residues from other locations along their migratory routes where the use of DDT continues outside of the United States. DDE concentrations of 3 μg/g wet-weight or larger in eggs may cause reproductive defects.

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DATA TABLES

Table 8.—Statistical summary of data for the middle Rio Grande valley—Water-quality properties and major chemical constituents, water years 1978-88

[ft^3/s, cubic feet per second; μS/cm, microsiemens per centimeter at 25 degrees Celsius; deg C, degrees Celsius; mg/L, milligrams per liter; —, no data; *, maximum value; **, minimum value; <, less than]

Property or chemical constituent (unit)	Percentile (less than indicated value)	Sampling site (gaging station number): Rio Grande at Otowi (08313000)	Rio Grande at San Felipe (08319000)	Rio Grande at Isleta (08331000)	Rio Puerco near Bernardo (08353000)	Rio Grande Conveyance Channel at San Acacia (08354800)	Rio Grande Floodway at San Acacia (08354900)	Rio Grande Conveyance Channel at San Marcial (08358300)	Rio Grande Floodway at San Marcial (08358400)	Number of measurements
Streamflow	95th	8,140	5,560	5,800	865	1,665	5,130	1,400	5,275	1,449
(ft^3/s)	5th	426	259	159	0.9	1.1	1.8	0.4	83	
Specific conductance	95th	427	455	575	3,700	1,015	913	1,790	988	813
(μS/cm)	5th	190	210	239	723	292	290	428	348	
pH (standard units)	95th	8.7	8.4	8.2	8.3	8.6	8.6	8.3	8.4	764
	5th	7.7	7.6	7.6	7.1	7.8	7.7	7.5	7.6	
Temperature, water	95th	21.5	22.0	25.5	28.0	27.0	27.0	30.0	25.0	1,479
(deg C)	5th	3.0	2.5	5.0	4.0	4.0	6.5	5.0	2.5	
Dissolved oxygen	95th	12.6	12.4	10.5	—	11.2	12.0	12.9	11.4	465
(mg/L)	5th	7.5	7.6	5.4	—	6.8	6.5	6.4	5.6	
Hardness, total	95th	160	180	205	1,170	240	312	484	285	442
as $CaCO_3$ (mg/L)	5th	70	78	86	203	100	100	131	110	
Dissolved solids, sum	95th	287	302	383	2,790	483	575	1,120	607	361
(mg/L)	5th	125	129	140	470	186	188	271	214	

Table 8.—Statistical summary of data for the middle Rio Grande valley—Water-quality properties and major chemical constituents, water years 1978-88—Concluded

Property or chemical constituent (unit)	Percentile (less than indicated value)	Rio Grande at Otowi (08313000)	Rio Grande at San Felipe (08319000)	Rio Grande at Isleta (08331000)	Rio Puerco near Bernardo (08353000)	Rio Grande Conveyance Channel at San Acacia (08354800)	Rio Grande Floodway at San Acacia (08354900)	Rio Grande Conveyance Channel at San Marcial (08358300)	Rio Grande Floodway at San Marcial (08358400)	Number of measurements
		Sampling site (gaging station number)								
Alkalinity as $CaCO_3$ (mg/L)	95th	127	130	155	255	200*	175	280	190	314
	5th	56	58	68	97	90**	87	120	87	
Calcium (mg/L)	95th	49	52	62	320	66	73	125	86	443
	5th	22	25	28	65	32	32	42	33	
Sodium (mg/L)	95th	29	30	45	505	75	95	160	95	441
	5th	9	10	14	72	19	20	33	22	
Sodium adsorption ratio (SAR)	95th	1.0	1.0	2.0	9.0	2.0	3.0	4.0	3.0	440
	5th	0.5	0.5	0.7	2.0	0.9	0.9	1.0	1.0	
Sulfate (mg/L)	95th	90	96	115	1,650	150	195	360	210	443
	5th	26	33	37	155	46	46	72	53	
Chloride (mg/L)	95th	8.9	8.7	26	320	37	54	120	67	443
	5th	2.6	2.8	4.9	28	7.2	8.1	18	10	
Nitrite plus nitrate as N (mg/L)	95th	0.3	0.2	0.7	1.2	0.9	1.2	0.7	1.1	462
	5th	<0.1	<0.1	0.1	0.05	0.1	0.2	<0.1	0.02	

Table 9.—Statistical summary of data for the middle Rio Grande valley—Dissolved trace elements and radionuclides, water years 1978-88

[NM, not measured; <, less than; µg/L, micrograms per liter; *, maximum value; **, minimum value; —, no data; pCi/L, picocuries per liter]

Chemical constituent (unit)	Percentile (less than indicated value)	Sampling site (gaging station number): Rio Grande at Otowi (08313000)	Rio Grande at San Felipe (08319000)	Rio Grande at Isleta (08331000)	Rio Puerco near Bernardo (08353000)	Rio Grande Conveyance Channel at San Acacia (08354800)	Rio Grande Floodway at San Acacia (08354900)	Rio Grande Conveyance Channel at San Marcial (08358300)	Rio Grande Floodway at San Marcial (08358400)	Number of measurements
Arsenic	95th	3.0	3.5	6.0	NM	7.0	8.0	7.0	7.0	149
(µg/L)	5th	1.0	1.0	2.0	NM	3.0	3.0	<1.0	1.5	
Barium	95th	100	NM	95	NM	NM	NM	82	94	86
(µg/L)	5th	<100	NM	<100	NM	NM	NM	<100	<100	
Boron	95th	70	75	195	735	155	200	240*	195	344
(µg/L)	5th	20	20	30	115	40	35	220**	55	
Cadmium	95th	2.5	15	2.0	NM	<1.0	<3.0	<1.0	1.0	148
(µg/L)	5th	<1.0	<1.0	<1.0	NM	<1.0	<1.0	<1.0	<1.0	
Chromium	95th	2.5	<10	<20	NM	<20	<10	8.0	2.0	150
(µg/L)	5th	<1.0	<5.5	<5.5	NM	<10	<5.5	<1.0	<1.0	
Copper	95th	6.0	10	5.0	NM	4.0	8.5	11	7.5	150
(µg/L)	5th	0.5	1.0	<2.0	NM	<2.0	<1.0	<1.5	<2.0	
Iron	95th	130	52	75	790	23	127	43	79	373
(µg/L)	5th	4.3	<10	<10	<10	<10	<6.5	<10	<10	

Table 9.—Statistical summary of data for the middle Rio Grande valley—Dissolved trace elements and radionuclides, water years 1978-88—Concluded

Chemical constituent (unit)	Percentile (less than indicated value)	Sampling site (gaging station number)								Number of measurements
		Rio Grande at Otowi (08313000)	Rio Grande at San Felipe (08319000)	Rio Grande at Isleta (08331000)	Rio Puerco near Bernardo (08353000)	Rio Grande Conveyance Channel at San Acacia (08354800)	Rio Grande Floodway at San Acacia (08354900)	Rio Grande Conveyance Channel at San Marcial (08358300)	Rio Grande Floodway at San Marcial (08358400)	
Lead (µg/L)	95th	7.0	4.0	4.5	NM	5.0	2.0	7.5	4.0	148
	5th	<1.0	<1.0	<1.0	NM	<1.0	<1.0	<1.0	<1.0	
Mercury (µg/L)	95th	0.6	0.5	0.2	NM	<0.1	0.3	0.2	0.5	144
	5th	<0.1	<0.1	<0.1	NM	<0.1	<0.1	<0.1	<0.1	
Molybdenum (µg/L)	95th	7.5	NM	NM	NM	NM	4.0*	11.5	15	51
	5th	<3.0	NM	NM	NM	NM	—	<5.5	<7.0	
Selenium (µg/L)	95th	<1.0	<1.0	1.0	NM	<1.0*	<1.0	4.5	1.0	165
	5th	<1.0	<1.0	<1.0	NM	<1.0**	<1.0	<1.0	<1.0	
Vanadium (µg/L)	95th	NM	NM	NM	NM	NM	NM	NM	NM	0
	5th	NM	NM	NM	NM	NM	NM	NM	NM	
Zinc (µg/L)	95th	43	22	19	NM	22*	25	41	17	147
	5th	<3.0	<3.0	<3.0	NM	<3.0**	<3.0	<11.5	<3.0	
Uranium (µg/L)	95th	5.0	4.0*	3.5	27*	2.9*	4.6*	3.4*	4.2	72
	5th	0.9	1.5**	1.8	1.8**	1.5**	2.1**	1.3**	2.1	
Radium-226 (pCi/L)	95th	0.15	0.35	0.11	0.15*	0.14*	0.08*	0.10	0.13	71
	5th	0.05	0.07	0.05	0.08**	0.07**	0.07**	0.02	0.06	

Table 10.—Statistical summary of data for the middle Rio Grande valley—Suspended-sediment and total-extractable trace-element concentrations, water years 1978-88

[mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter; NM, not measured; *, maximum value; **, minimum value; —, no data. Total-extractable concentrations are concentrations of the chemical element extracted from the suspended sediment plus the dissolved concentrations]

Property or chemical constituent (unit)	Percentile (less than indicated value)	Sampling site (gaging station number): Rio Grande at Otowi (08313000)	Rio Grande at San Felipe (08319000)	Rio Grande at Isleta (08331000)	Rio Puerco near Bernardo (08353000)	Rio Grande Conveyance Channel at San Acacia (08354800)	Rio Grande Floodway at San Acacia (08354900)	Rio Grande Conveyance Channel at San Marcial (08358300)	Rio Grande Floodway at San Marcial (08358400)	Number of measurements
Suspended sediment	95th	12,400	515	2,530	148,500	55,800	64,850	24,600	39,300	1,143
(mg/L)	5th	44	11	41	16,100	116	175	129	227	
Silt-clay size, <62.5 microns (percent)	50th	60	66	56	100	97	91	95	96	561
Arsenic	95th	4.0	3.5	9.0	NM	9.5	10.5	6.0*	20	115
(µg/L)	5th	2.0	1.0	2.0	NM	3.0	1.0	6.0**	5.0	
Barium	95th	400	NM	300	NM	NM	NM	10*	2,600	47
(µg/L)	5th	100	NM	<100	NM	NM	NM	<100**	200	
Cadmium	95th	4.5	3.0	1.0	NM	2.5	<1.0	<2.0*	1.0	116
(µg/L)	5th	<1.0	<1.0	<1.0	NM	<1.0	<1.0	<2.0**	<1.0	
Chromium	95th	20	15	20	NM	40	300	10*	110	117
(µg/L)	5th	<10	<10	<10	NM	<15	<10	<20**	<20	

Table 10.—Statistical summary of data for the middle Rio Grande valley—Suspended-sediment and total-extractable trace-element concentrations, water years 1978-88—Concluded

Property or chemical constituent (unit)	Percentile (less than indicated value)	Sampling site (gaging station number)								Number of measurements
		Rio Grande at Otowi (08313000)	Rio Grande at San Felipe (08319000)	Rio Grande at Isleta (08331000)	Rio Puerco near Bernardo (08353000)	Rio Grande Conveyance Channel at San Acacia (08354800)	Rio Grande Floodway at San Acacia (08354900)	Rio Grande Conveyance Channel at San Marcial (08358300)	Rio Grande Floodway at San Marcial (08358400)	
Copper (µg/L)	95th	15	23	30	NM	69	335	9.0*	175	115
	5th	<20	1.0	4.5	NM	4.0	12	5.0**	11	
Iron (µg/L)	95th	6,350	NM	13,800	NM	10,000*	NM	770*	141,500	51
	5th	400	NM	920	NM	—	NM	280**	5,300	
Lead (µg/L)	95th	24	34	51	NM	35	370	14*	67	114
	5th	<200	0.0	<5.0	NM	5.0	2.0	6**	<1.0	
Manganese (µg/L)	95th	325	NM	430	NM	NM	NM	380*	4,000	50
	5th	40	NM	90	NM	NM	NM	140**	300	
Mercury (µg/L)	95th	1.45	0.45	0.30	NM	2.0	0.9	0.2*	1.3	114
	5th	<0.10	<0.10	<0.10	NM	<0.10	<0.10	0.0**	<0.1	
Molybdenum (µg/L)	95th	18.5	NM	NM	NM	NM	NM	14*	9.0	97
	5th	0.0	NM	NM	NM	NM	NM	<1.0**	<1.0	
Selenium (µg/L)	95th	1.0	2.0	1.0	NM	<1.0*	2.0	<1.0*	11.5	98
	5th	<1.0	<1.0	<1.0	NM	<1.0**	<1.0	<1.0**	<1.0	
Zinc (µg/L)	95th	85	385	100	NM	720	1,560	80*	615	100
	5th	<20	<10	<15	NM	20	30	<20**	40	

Table 11.—Statistical summary of bottom-sediment data for the middle Rio Grande valley— Trace-element concentrations, water years 1978-88

[NM, not measured; <, less than; *, maximum value; **, minimum value. All values in micrograms per gram]

Chemical constituent	Percentile (less than indicated value)	Sampling site (gaging station number): Rio Grande at Otowi (08313000)	Rio Grande at San Felipe (08319000)	Rio Grande at Isleta (08331000)	Rio Puerco near Bernardo (08353000)	Rio Grande Conveyance Channel at San Acacia (08354800)	Rio Grande Floodway at San Acacia (08354900)	Rio Grande Conveyance Channel at San Marcial (08358300)	Rio Grande Floodway at San Marcial (08358400)	Number of measurements
Arsenic	95th	3.0	6.0	3.0	NM	2.0*	4.0*	5.0	4.5	50
	5th	0.0	0.0	0.0	NM	<1.0**	1.0**	0.0	1.0	
Cadmium	95th	<1.0	3.5	<1.0	NM	<1.0*	<1.0*	<1.0	<1.0	50
	5th	<1.0	<1.0	<1.0	NM	<1.0**	<1.0**	<1.0	<1.0	
Chromium	95th	7.0	12.0	12.0	NM	6.0	40*	40	3.0	50
	5th<	1.0	<1.0	<1.0	NM	1.0	<1.0**	1.0	<1.0	
Copper	95th	17.5	50.0	7.5	NM	3.0*	10*	4.5	5.0	50
	5th	<1.0	2.0	<1.0	NM	<1.0**	1.0**	<1.0	<1.0	
Iron	95th	1,750	3,200	5,100	NM	6,400*	5,000*	77,100	3,850	46
	5th	10	380	10	NM	510**	650**	410	390	
Lead	95th	15	10	10	NM	10*	<10*	10	15	50
	5th	<10	<10	<10	NM	<10**	<10**	<10	<10	

Table 11.—Statistical summary of bottom-sediment data for the middle Rio Grande valley—Trace-element concentrations, water years 1978-88—Concluded

Chemical constituent	Percentile (less than indicated value)	Sampling site (gaging station number): Rio Grande at Otowi (08313000)	Rio Grande at San Felipe (08319000)	Rio Grande at Isleta (08331000)	Rio Puerco near Bernardo (08353000)	Rio Grande Conveyance Channel at San Acacia (08354800)	Rio Grande Floodway at San Acacia (08354900)	Rio Grande Conveyance Channel at San Marcial (08358300)	Rio Grande Floodway at San Marcial (08358400)	Number of measurements
Manganese	95th	115	240	105	NM	130**	180*	440	120	46
	5th	35	28	28	NM	38*	65**	33	50	
Mercury	95th	0.01	0.47	0.04	NM	0.01*	0.09*	0.01	0.01	50
	5th	<0.06	<0.06	<0.01	NM	<0.1*	<0.01**	<0.01	<0.1	
Selenium	95th	NM	NM	NM	NM	NM	NM	0.00*	0.00*	5
	5th	NM	NM	NM	NM	NM	NM	0.00**	0.00**	
Zinc	95th	9.5	20	15	NM	3.0*	20*	20	25	46
	5th	<10	2.0	1.0	NM	2.0**	3.0**	3.0	3.0	

Table 12.--Summary of physical measurements, water-quality properties, and suspended-sediment data collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

[μS/cm, microsiemens per centimeter at 25 degrees Celsius; mm, millimeters; --, no data; BDANWR, Bosque del Apache National Wildlife Refuge; E, estimated; NA, not applicable]

Station number	Station name (site number, if applicable)	Date	Time	Streamflow (cubic feet per second)	Specific conductance (μS/cm)
08354900	Rio Grande Floodway at San Acacia (B2)	11-06-87	1100	1,320	700
		11-20-87	1345	1,360	495
		03-24-88	1115	1,070	490
		05-04-88	1100	1,500	--
		08-16-88	1000	207	820
08358300	Rio Grande Conveyance Channel at San Marcial	03-25-88	1300	326	900
		05-03-88	1145	399	890
		08-17-88	1045	245	830
08358400	Rio Grande Floodway at San Marcial (B3)	11-05-87	1200	589	710
		11-20-87	1000	900	505
		03-25-88	1000	898	625
335213106520210	Rio Grande Conveyance Channel at inflow to BDANWR (B1)	11-19-87	1000	57	790
		02-18-88	1145	E50	--
		09-01-88	1100	80	750
335211106512710	San Antonio Drain at inflow to BDANWR (B4)	11-18-87	1100	83	790
		02-18-88	1100	E50	--
		05-03-88	1330	E60	1,390
		09-01-88	1330	E150	830
335212106514010	Elmendorf Drain at inflow to BDANWR (B5)	11-18-87	1345	3.0	1,720
		02-18-88	1000	E1.0	--
		05-03-88	1430	E8.0	1,100
		09-01-88	1500	E1.5	1,770
335213106521510	Socorro Main Canal at inflow to BDANWR (B13)	05-03-88	1500	E6.0	700
		09-06-88	1045	E50	860
334928106525010	BDANWR Interior Drain 1.2 miles north of BDANWR HQ (B6)	11-19-87	1450	9.6	1,410
		02-18-88	1300	E5.0	--
		05-03-88	1245	E80	1,010
		09-06-88	1245	E20	980
334828106514710	San Antonio Drain 1.6 miles east of BDANWR (B14)	05-03-88	1130	E30	1,050
		09-06-88	1500	E5.0	860
334612106540510	BDANWR Interior Drain near outflow from BDANWR (B7)	11-19-87	1245	30	1,520
		02-18-88	1400	E10	--
		09-07-88	1030	E65	1,010
334832106525720	Trench pond in field unit 18C at BDANWR (B8)	02-25-88	1300	NA	2,500
		09-06-88	1600	NA	1,070
334810106522520	Field unit 18B-east triangle at BDANWR (B9)	02-24-88	1115	NA	710
334616106540720	South marsh in field unit 25A at BDANWR (B10)	02-25-88	1500	NA	1,590
		09-07-88	1210	NA	2,450
334719106531620	Spring pond in unit 24B at BDANWR (B15)	09-07-88	0900	NA	1,390
334836106520001	06S.01E.05.334 field unit 17A sump at BDANWR (B11)	02-25-88	1030	NA	1,580
334821106523401	06S.01E.07.213 warm-water well at BDANWR (B12)	02-24-88	1500	NA	4,450

pH (standard units)	Temper- ature, air (degrees Celsius)	Temper- ature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Oxygen, dissolved (percent satu- ration)	Baro- metric pressure (mm of mercury)	Sediment, suspended (milligrams per liter)	Sediment, suspended (percent finer than 0.062 mm)
7.60	19.0	13.0	9.0	100	654	3,940	--
8.25	15.0	10.0	9.6	101	645	--	--
8.00	20.0	13.5	13.0	145	657	--	--
8.60	26.0	19.5	7.9	101	652	99	98
8.00	32.0	21.0	7.1	95	641	31,900	--
7.85	19.5	14.0	9.7	109	662	--	--
8.30	24.0	17.0	8.5	108	625	144	--
8.15	24.5	22.0	6.8	92	649	641	--
7.90	21.0	12.0	9.2	99	663	3,030	--
8.35	12.5	4.0	11.4	102	652	--	--
8.20	18.0	10.5	9.7	100	662	--	--
8.20	12.5	12.5	7.5	83	652	--	--
--	--	--	--	--	--	--	--
8.00	23.0	17.0	7.8	97	635	--	--
8.25	10.0	13.0	7.7	86	650	--	--
--	--	--	--	--	--	--	--
8.10	23.5	16.0	--	--	--	--	--
8.30	24.0	18.0	7.9	101	635	--	--
8.15	11.0	10.5	10.8	115	648	--	--
--	--	--	--	--	--	--	--
7.80	31.0	19.0	--	--	--	--	--
8.30	23.0	20.0	7.7	103	635	--	--
8.32	27.0	16.0	--	--	--	--	--
8.40	22.5	19.5	7.8	103	635	--	--
8.20	14.5	13.5	8.2	--	--	--	--
--	--	--	--	--	--	--	--
8.10	26.0	15.5	--	--	--	--	--
8.30	29.0	19.5	7.6	100	635	--	--
8.20	22.0	18.5	--	--	--	--	--
8.20	27.0	21.0	7.3	99	634	--	--
8.20	9.0	8.5	9.8	99	652	--	--
--	--	--	--	--	--	--	--
8.20	24.5	18.0	7.5	96	635	--	--
8.05	16.0	12.0	7.8	86	650	--	--
8.50	30.0	25.0	7.9	116	634	--	--
7.94	10.0	9.0	7.2	73	650	--	--
8.42	19.0	12.5	9.0	100	648	--	--
8.70	28.0	23.5	7.4	106	634	--	--
8.40	25.0	19.0	7.8	102	634	--	--
7.48	14.5	10.0	4.0	42	651	--	--
7.22	19.0	33.0	0.7	12	640	--	--

Table 13.--Summary of data for major dissolved chemical constituents in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

[mg/L, milligrams per liter; deg C, degrees Celsius; --, no data; * data from other U.S. Geological Survey data collection program; BDANWR, Bosque del Apache National Wildlife Refuge; mi, miles; <, less than]

Station number	Station name (site number, if applicable)	Date	Time	Hardness, total (mg/L as $CaCO_3$)	Hardness noncarbonate whole water total, field (mg/L as $CaCO_3$)
08354900	Rio Grande Floodway at San Acacia (B2)	11-06-87	1100	210	62
		11-20-87*	1345	170	31
		03-24-88	1115	160	19
		05-04-88*	1100	150	24
		08-16-88*	1000	240	44
08358300	Rio Grande Conveyance Channel at San Marcial	03-25-88	1300	220	44
		05-03-88*	1145	210	30
		08-17-88*	1045	230	53
08358400	Rio Grande Floodway at San Marcial (B3)	11-05-87	1200	190	42
		11-20-87*	1000	180	40
		03-25-88	1000	170	28
335213106520210	Rio Grande Conv Channel at inflow to BDANWR (B1)	11-19-87	1000	200	34
		09-01-88*	1100	210	50
335211106512710	San Antonio Drain at inflow to BDANWR (B4)	11-18-87	1100	220	47
		09-01-88	1330	230	55
335212106514010	Elmendorf Drain at inflow to BDANWR (B5)	11-18-87	1345	450	140
		09-01-88	1500	460	110
335213106521510	Socorro Main Canal at inflow to BDANWR (B13)	09-06-88	1045	260	87
334928106525010	BDANWR Interior Drain 1.2 mi north of BDANWR HQ (B6)	11-19-87	1450	400	140
		09-06-88	1245	280	89
334828106514710	San Antonio Drain 1.6 mi east of BDANWR (B14)	09-06-88	1500	240	69
334612106540510	BDANWR Interior Drain near outflow from BDANWR (B7)	11-19-87	1245	380	120
		09-07-88	1030	280	86
334832106525720	Trench pond in field unit 18C at BDANWR (B8)	02-25-88	1300	510	240
		09-06-88	1600	270	77
334810106522520	Field unit 18B-east triangle at BDANWR (B9)	02-24-88	1115	190	23
334616106540720	South marsh in field unit 25A at BDANWR (B10)	02-25-88	1500	310	0
		09-07-88	1210	270	0
334719106531620	Spring pond in unit 24B at BDANWR (B15)	09-07-88	0900	130	0
334836106520001	06S.01E.05.334 field unit 17A sump at BDANWR (B11)	02-25-88	1030	400	80
334821106523401	06S.01E.07.213 warm-water well at BDANWR (B12)	02-24-88	1500	470	130

Table 13.--Summary of data for major dissolved chemical constituents in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Continued

Station number	Date	Alkalinity (mg/L as $CaCO_3$)	Solids, residue at 180 deg C, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium adsorption ratio	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)
08354900	11-06-87	210	--	435	65	11	65	2	4.8	256
	11-20-87	142	332	341	53	9.6	44	2	3.7	173
	03-24-88	136	--	323	48	9.0	41	1	12	166
	05-04-88	120	--	306	47	9.0	41	1	2.7	98
	08-16-88	155	--	577	74	14	89	3	5.4	189
08358300	03-25-88	168	528	527	65	13	92	3	5.2	205
	05-03-88	183	503	490	62	12	85	3	2.2	223
	08-17-88	174	543	540	70	13	93	3	6.0	212
08358400	11-05-87	138	397	387	59	11	55	2	4.7	168
	11-20-87	--	344	343	55	9.9	44	1	3.7	--
	03-25-88	--	344	344	52	9.8	47	2	3.7	--
335213106520210	11-19-87	--	510	507	62	11	93	3	5.1	--
	09-01-88	160	479	457	64	12	80	3	4.8	195
335211106512710	11-18-87	--	504	493	68	12	83	3	4.9	--
	09-01-88	174	564	518	70	13	86	3	5.0	198
335212106514010	11-18-87	--	1,130	1,120	140	25	220	5	7.2	--
	09-01-88	368	1,190	1,140	140	28	220	5	7.3	449
335213106521510	09-06-88	178	582	548	79	16	90	3	5.0	203
334928106525010	11-19-87	--	963	940	120	25	160	4	7.0	--
	09-06-88	195	647	609	85	17	100	3	5.4	238
334828106514710	09-06-88	174	562	528	74	14	91	3	5.1	212
334612106540510	11-19-87	--	995	979	110	24	200	5	11	--
	09-07-88	198	671	639	85	17	110	3	5.6	242
334832106525720	02-25-88	262	1,620	1,500	140	40	350	7	9.5	320
	09-06-88	194	689	672	79	18	130	4	8.0	222
334810106522520	02-24-88	154	465	461	58	12	85	3	5.2	188
334616106540720	02-25-88	176	1,000	1,000	78	27	230	6	14	210
	09-07-88	284	1,560	1,530	47	36	450	12	14	298
334719106531620	09-07-88	180	859	789	35	9.4	230	9	5.6	210
334836106520001	02-25-88	320	1,110	1,060	110	30	220	5	8.4	390
334821106523401	02-24-88	328	2,870	2,650	120	41	790	16	35	400

Table 13.--Summary of data for major dissolved chemical constituents in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Concluded

Station number	Date	Carbonate (mg/L as CO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Nitrogen, $NO_2 + NO_3$, dissolved (mg/L as N)	Phosphorus ortho, dissolved (mg/L as P)	Carbon, organic total (mg/L as C)	Saturation index, calcium carbonate ($CaCO_3$)
08354900	11-06-87	0	140	32	0.50	24	0.760	0.310	32	--
	11-20-87	0	94	25	0.50	22	0.720	--	--	0.494
	03-24-88	0	85	18	0.50	22	0.970	0.280	4.8	--
	05-04-88	24	85	18	0.50	21	0.600	0.220	3.8	--
	08-16-88	0	200	49	0.60	21	0.860	0.080	410	--
08358300	03-25-88	0	160	64	0.50	22	0.220	0.080	--	--
	05-03-88	0	140	60	0.50	21	0.210	0.070	--	--
	08-17-88	0	160	65	0.40	24	0.300	0.090	--	--
08358400	11-05-87	0	110	28	0.50	23	0.770	0.260	--	--
	11-20-87	--	97	24	0.50	22	0.680	--	--	0.551
	03-25-88	--	95	22	0.50	23	0.910	0.290	--	0.573
335213106520210	11-19-87	--	140	69	0.60	25	<0.100	--	--	--
	09-01-88	0	150	50	--	--	<0.100	--	--	--
335211106512710	11-18-87	--	140	56	0.60	24	<0.100	--	--	0.709
	09-01-88	7	180	59	--	--	0.170	--	--	--
335212106514010	11-18-87	--	370	130	0.60	32	0.170	--	--	1.063
	09-01-88	0	400	130	--	--	0.140	--	--	--
335213106521510	09-06-88	7	190	60	--	--	0.360	--	--	0.967
334928106525010	11-19-87	--	290	140	0.60	38	<0.100	--	--	0.983
	09-06-88	0	210	74	--	--	0.310	--	--	--
334828106514710	09-06-88	0	180	59	--	--	0.170	--	--	0.769
334612106540510	11-19-87	--	260	190	0.80	26	<0.100	--	--	0.875
	09-07-88	0	220	81	--	--	0.470	--	--	--
334832106525720	02-25-88	0	410	390	--	--	<0.100	--	--	0.820
	09-06-88	7	210	110	--	--	<0.100	--	--	--
334810106522520	02-24-88	0	140	57	--	--	<0.100	--	--	0.216
334616106540720	02-25-88	2	280	190	--	--	<0.100	--	--	--
	09-07-88	24	480	330	--	--	<0.100	--	--	1.114
334719106531620	09-07-88	5	190	210	--	--	<0.100	--	--	--
334836106520001	02-25-88	0	360	140	--	--	0.110	--	--	0.250
334821106523401	02-24-88	0	550	910	--	--	1.00	--	--	0.246

Table 14.--Summary of data for dissolved trace elements in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

[µg/L, micrograms per liter; --, no data; <, less than; BDANWR, Bosque del Apache National Wildlife Refuge; pCi/L, picocuries per liter]

Station number	Station name (site number, if applicable)	Date	Time	Aluminum, dis-solved (µg/L as Al)
08354900	Rio Grande Floodway at San Acacia (B2)	11-06-87	1100	--
	:	11-20-87	1345	--
		03-24-88	1115	--
		05-04-88	1100	--
		08-16-88	1000	--
08358300	Rio Grande Conveyance Channel at San Marcial	03-25-88	1300	<10
		05-03-88	1145	10
		08-17-88	1045	10
08358400	Rio Grande Floodway at San Marcial (B3)	11-05-87	1200	30
		11-20-87	1000	--
		03-25-88	1000	20
335213106520210	Rio Grande Conveyance Channel at inflow to BDANWR (B1)	11-19-87	1000	--
		09-01-88	1100	--
335211106512710	San Antonio Drain at inflow to BDANWR (B4)	11-18-87	1100	--
		09-01-88	1330	--
335212106514010	Elmendorf Drain at inflow to BDANWR (B5)	11-18-87	1345	--
		09-01-88	1500	--
335213106521510	Socorro Main Canal at inflow to BDANWR (B13)	09-06-88	1045	--
334928106525010	BDANWR Interior Drain 1.2 miles north of BDANWR (B6)	11-19-87	1450	--
		09-06-88	1245	--
334828106514710	San Antonio Drain 1.6 miles east of BDANWR (B14)	09-06-88	1500	--
334612106540510	BDANWR Interior Drain near outflow from BDANWR (B7)	11-19-87	1245	--
		09-07-88	1030	--
334832106525720	Trench pond in field unit 18C at BDANWR (B8)	02-25-88	1300	--
		09-06-88	1600	--
334810106522520	Field unit 18B-east triangle at BDANWR (B9)	02-24-88	1115	--
334616106540720	South marsh in field unit 25A at BDANWR (B10)	02-25-88	1500	--
		09-07-88	1210	--
334719106531620	Spring pond in unit 24B at BDANWR (B15)	09-07-88	0900	--
334836106520001	06S.01E.05.334 field unit 17A sump at BDANWR (B11)	02-25-88	1030	--
334821106523401	06S.01E.07.213 warm-water well at BDANWR (B12)	02-24-88	1500	--

Table 14.--Summary of data for dissolved trace elements in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Continued

Station number	Date	Arsenic, dis-solved (µg/L as As)	Barium, dis-solved (µg/L as Ba)	Beryl-lium, dis-solved (µg/L as Be)	Boron, dis-solved (µg/L as B)	Cadmium, dis-solved (µg/L as Cd)	Chro-mium, dis-solved (µg/L as Cr)	Cobalt, dis-solved (µg/L as Co)	Copper, dis-solved (µg/L as Cu)
08354900	11-06-87	7	--	--	130	1	<10	--	11
	11-20-87	4	--	--	90	<1	1	--	1
	03-24-88	--	--	--	90	--	--	--	--
	05-04-88	--	--	--	80	--	--	--	--
	08-16-88	4	--	--	130	<1	<1	--	3
08358300	03-25-88	6	64	<0.5	--	<1	1	<3	1
	05-03-88	5	69	<0.5	--	<1	<1	<3	3
	08-17-88	7	69	<0.5	--	<1	<1	<3	<1
08358400	11-05-87	5	66	<0.5	--	<1	<1	<3	4
	11-20-87	4	--	--	90	<1	2	--	2
	03-25-88	5	66	<0.5	--	<1	2	<1	1
335213106520210	11-19-87	6	--	--	150	<1	1	--	2
	09-01-88	6	--	--	120	2	1	--	1
335211106512710	11-18-87	6	--	--	140	<1	1	--	7
	09-01-88	6	--	--	140	1	1	--	1
335212106514010	11-18-87	1	--	--	290	<1	1	--	3
	09-01-88	2	--	--	270	3	2	--	1
335213106521510	09-06-88	4	--	--	140	1	1	--	2
334928106525010	11-19-87	3	--	--	210	<1	<1	--	1
	09-06-88	4	--	--	160	4	1	--	1
334828106514710	09-06-88	6	--	--	140	3	1	--	1
334612106540510	11-19-87	5	--	--	250	<1	8	--	2
	09-07-88	5	--	--	160	4	2	--	1
334832106525720	02-25-88	5	--	--	290	<1	1	--	4
	09-06-88	6	--	--	170	3	1	--	2
334810106522520	02-24-88	3	--	--	150	<1	1	--	2
334616106540720	02-25-88	<1	--	--	230	3	1	--	4
	09-07-88	5	--	--	510	1	1	--	1
334719106531620	09-07-88	16	--	--	250	2	1	--	<1
334836106520001	02-25-88	<1	--	--	250	<1	1	--	<1
334821106523401	02-24-88	53	--	--	890	<1	1	--	<1

Table 14.--Summary of data for dissolved trace elements in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Continued

Station number	Date	Iron, dis- solved (µg/L as Fe)	Lead, dis- solved (µg/L as Pb)	Lithium, dis- solved (µg/L as Li)	Manga- nese, dis- solved (µg/L as Mn)	Mercury, dis- solved (µg/L as Hg)	Molyb- denum, dis- solved (µg/L as Mo)	Nickel, dis- solved (µg/L as Ni)	Sele- nium, dis- solved (µg/L as Se)
08354900	11-06-87	200	<5	--	--	<0.1	--	--	1
	11-20-87	--	<5	--	--	<0.1	4	--	<1
	03-24-88	8	--	--	--	--	--	--	--
	05-04-88	5	--	--	--	--	--	--	--
	08-16-88	14	<5	--	--	<0.1	--	--	<1
08358300	03-25-88	8	<5	95	11	0.2	<5	2	<1
	05-03-88	10	<5	78	15	<0.1	<6	2	<1
	08-17-88	8	<5	86	2	<0.1	<10	<1	<1
08358400	11-05-87	18	<5	49	2	0.2	<10	3	<1
	11-20-87	--	<5	--	--	<0.1	4	--	<1
	03-25-88	10	<5	64	3	0.1	--	4	<1
335213106520210	11-19-87	--	<5	--	--	0.1	5	--	<1
	09-01-88	--	<5	--	--	<0.1	4	--	<1
335211106512710	11-18-87	--	<5	--	--	<0.1	5	--	<1
	09-01-88	--	5	--	--	<0.1	4	--	<1
335212106514010	11-18-87	--	<5	--	--	<0.1	6	--	<1
	09-01-88	--	<5	--	--	<0.1	6	--	<1
335213106521510	09-06-88	--	<5	--	--	<0.1	5	--	<1
334928106525010	11-19-87	--	<5	--	--	<0.1	5	--	<1
	09-06-88	--	<5	--	--	<0.1	4	--	<1
334828106514710	09-06-88	--	<5	--	--	<0.1	5	--	<1
334612106540510	11-19-87	--	<5	--	--	<0.1	7	--	<1
	09-07-88	--	<5	--	--	<0.1	4	--	<1
334832106525720	02-25-88	--	<5	--	--	<0.1	6	--	<1
	09-06-88	--	<5	--	--	<0.1	8	--	<1
334810106522520	02-24-88	--	<5	--	--	<0.1	7	--	<1
334616106540720	02-25-88	--	<5	--	--	<0.1	7	--	<1
	09-07-88	--	<5	--	--	<0.1	8	--	<1
334719106531620	09-07-88	--	<5	--	--	<0.1	4	--	<1
334836106520001	02-25-88	--	<5	--	--	<0.1	9	--	<1
334821106523401	02-24-88	--	<5	--	--	0.2	11	--	<1

Table 14.--Summary of data for dissolved trace elements in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Concluded

Station number	Date	Silver, dis-solved (µg/L as Ag)	Stron-tium, dis-solved (µg/L as Sr)	Vana-dium, dis-solved (µg/L as V)	Zinc, dis-solved (µg/L as Zn)	Radium-226, dis-solved, plan-chet count (pCi/L)	Radium-226, dis-solved, radon method (pCi/L)	Uranium, natural dis-solved (µg/L as U)
08354900	11-06-87	--	--	--	27	--	--	--
	11-20-87	--	440	3	<3	<0.1	--	2.5
	03-24-88	--	--	--	--	--	--	--
	05-04-88	--	--	--	--	--	--	--
	08-16-88	--	--	--	5	--	--	--
08358300	03-25-88	<1.0	700	<6	4	--	--	--
	05-03-88	<1.0	660	<6	22	--	0.04	1.3
	08-17-88	<1.0	810	<6	3	--	--	--
08358400	11-05-87	<1.0	580	<6	7	--	0.08	2.1
	11-20-87	--	480	3	3	<0.1	--	2.8
	03-25-88	<1.0	450	5	4	--	0.10	3.2
335213106520210	11-19-87	--	680	<1	<3	<0.1	--	1.2
	09-01-88	--	--	1	21	--	--	--
335211106512710	11-18-87	--	660	<1	9	<0.1	--	1.9
	09-01-88	--	--	2	6	--	--	--
335212106514010	11-18-87	--	1,200	<1	6	<0.1	--	2.6
	09-01-88	--	--	2	12	--	--	--
335213106521510	09-06-88	--	--	3	4	--	--	--
334928106525010	11-19-87	--	1,400	<1	7	0.1	--	1.2
	09-06-88	--	--	3	5	--	--	--
334828106514710	09-06-88	--	--	2	<3	--	--	--
334612106540510	11-19-87	--	1,300	2	20	<0.1	--	1.7
	09-07-88	--	--	3	4	--	--	--
334832106525720	02-25-88	--	--	6	10	0.2	--	1.4
	09-06-88	--	--	2	14	--	--	--
334810106522520	02-24-88	--	--	<1	9	<0.1	--	1.6
334616106540720	02-25-88	--	--	3	7	0.1	--	2.0
	09-07-88	--	--	11	<10	--	--	--
334719106531620	09-07-88	--	--	39	20	--	--	--
334836106520001	02-25-88	--	--	1	8	<0.1	--	0.90
334821106523401	02-24-88	--	--	18	20	0.4	--	<0.40

Table 15.--Summary of data for pesticides in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

[μg/L, micrograms per liter; <, less than; --, no data; BDANWR, Bosque del Apache National Wildlife Refuge; analyzed on unfiltered water]

Station number	Station name (site number, if applicable)			2,4-D, total (μg/L)	2,4-DP, total (μg/L)	Silvex, total (μg/L)
08354900	Rio Grande Floodway at San Acacia (B2)	11-20-87	1345	0.01	<0.01	<0.01
		03-24-88	1115	0.01	<0.01	<0.01
		08-16-88	1000	--	--	--
08358400	Rio Grande Floodway at San Marcial (B3)	11-20-87	1000	<0.01	<0.01	<0.01
335213106520210	Rio Grande Conveyance Channel at inflow to BDANWR (B1)	11-19-87	1000	--	--	--
335211106512710	San Antonio Drain at inflow to BDANWR (B4)	11-18-87	1100	<0.01	<0.01	<0.01
		05-03-88	1330	<0.01	<0.01	<0.01
335212106514010	Elmendorf Drain at inflow to BDANWR (B5)	11-18-87	1345	<0.01	<0.01	<0.01
		05-03-88	1430	<0.01	<0.01	<0.01
335213106521510	Socorro Main Canal at inflow to BDANWR (B13)	05-03-88	1500	<0.01	<0.01	<0.01
334928106525010	BDANWR Interior Drain 1.2 miles north of BDANWR HQ (B6)	11-19-87	1450	<0.01	<0.01	<0.01
		05-03-88	1245	<0.01	<0.01	<0.01
334828106514710	San Antonio Drain 1.6 miles east of BDANWR (B14)	05-03-88	1130	<0.01	<0.01	<0.01
334612106540510	BDANWR Interior Drain near outflow, BDANWR (B7)	11-19-87	1245	<0.01	<0.01	<0.01
334832106525720	Trench pond in field unit 18C at BDANWR (B8)	02-25-88	1300	--	--	--
334810106522520	Field unit 18B-east triangle at BDANWR (B9)	02-24-88	1115	--	--	--
334616106540720	South marsh in field unit 25A at BDANWR (B10)	02-25-88	1500	--	--	--
334836106520001	06S.01E.05.334 field 17A sump at BDANWR (B11)	02-25-88	1030	--	--	--
334821106523401	06S.01E.07.213 warm-water well at BDANWR (B12)	02-24-88	1500	--	--	--

Table 15.--Summary of data for pesticides in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Continued

Station number	Date	2,4,5-T, total (µg/L)	Ala-chlor, total recover (µg/L)	Ame-tryne, total (µg/L)	Atra-zine, total (µg/L)	Cyan-azine, total (µg/L)	Prome-ton, total (µg/L)	Prome-tryn, total (µg/L)	Pro-pazine, total (µg/L)	Sima-zine, total (µg/L)
08354900	11-20-87	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
	03-24-88	<0.01	--	--	--	--	--	--	--	--
	08-16-88	--	--	--	--	--	--	--	--	--
08358400	11-20-87	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
335213106520210	11-19-87	--	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
335211106512710	11-18-87	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
	05-03-88	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
335212106514010	11-18-87	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
	05-03-88	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
335213106521510	05-03-88	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
334928106525010	11-19-87	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
	05-03-88	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
334828106514710	05-03-88	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
334612106540510	11-19-87	<0.01	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
334832106525720	02-25-88	--	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
334810106522520	02-24-88	--	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
334616106540720	02-25-88	--	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
334836106520001	02-25-88	--	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10
334821106523401	02-24-88	--	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10

Table 15.--Summary of data for pesticides in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Continued

Station number	Date	Sime-tryn, total (µg/L)	Tri-flura-lin, total recover (µg/L)	Aldrin, total (µg/L)	Chlor-dane, total (µg/L)	DDD, total (µg/L)	DDE, total (µg/L)	DDT, total (µg/L)	Di-eldrin, total (µg/L)	Endo-sulfan, total (µg/L)
08354900	11-20-87	<0.1	<0.10	--	--	--	--	--	--	--
	03-24-88	--	--	--	--	--	--	--	--	--
	08-16-88	--	--	<0.010	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
08358400	11-20-87	<0.1	<0.10	--	--	--	--	--	--	--
335213106520210	11-19-87	<0.1	<0.10	--	--	--	--	--	--	--
335211106512710	11-18-87	<0.1	<0.10	--	--	--	--	--	--	--
	05-03-88	<0.1	<0.10	--	--	--	--	--	--	--
335212106514010	11-18-87	<0.1	<0.10	--	--	--	--	--	--	--
	05-03-88	<0.1	<0.10	--	--	--	--	--	--	--
335213106521510	05-03-88	<0.1	<0.10	--	--	--	--	--	--	--
334928106525010	11-19-87	<0.1	<0.10	--	--	--	--	--	--	--
	05-03-88	<0.1	<0.10	--	--	--	--	--	--	--
334828106514710	05-03-88	<0.1	<0.10	--	--	--	--	--	--	--
334612106540510	11-19-87	<0.1	<0.10	--	--	--	--	--	--	--
334832106525720	02-25-88	<0.1	<0.10	--	--	--	--	--	--	--
334810106522520	02-24-88	<0.1	<0.10	--	--	--	--	--	--	--
334616106540720	02-25-88	<0.1	<0.10	--	--	--	--	--	--	--
334836106520001	02-25-88	<0.1	<0.10	--	--	--	--	--	--	--
334821106523401	02-24-88	<0.1	<0.10	--	--	--	--	--	--	--

Table 15.--Summary of data for pesticides in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Continued

Station number	Date	Endrin, total (μg/L)	PCB, total (μg/L)	Naphthalenes, polychlor, total (μg/L)	Heptachlor, total (μg/L)	Heptachlor epoxide, total (μg/L)	Lindane, total (μg/L)	Methoxychlor, total (μg/L)	Mirex, total (μg/L)	Perthane, total (μg/L)
08354900	11-20-87	--	--	--	--	--	--	--	--	--
	03-24-88	--	--	--	--	--	--	--	--	--
	08-16-88	<0.010	<0.1	<0.10	<0.010	<0.010	<0.010	<0.01	<0.01	<0.1
08358400	11-20-87	--	--	--	--	--	--	--	--	--
335213106520210	11-19-87	--	--	--	--	--	--	--	--	--
335211106512710	11-18-87	--	--	--	--	--	--	--	--	--
	05-03-88	--	--	--	--	--	--	--	--	--
335212106514010	11-18-87	--	--	--	--	--	--	--	--	--
	05-03-88	--	--	--	--	--	--	--	--	--
335213106521510	05-03-88	--	--	--	--	--	--	--	--	--
334928106525010	11-19-87	--	--	--	--	--	--	--	--	--
	05-03-88	--	--	--	--	--	--	--	--	--
334828106514710	05-03-88	--	--	--	--	--	--	--	--	--
334612106540510	11-19-87	--	--	--	--	--	--	--	--	--
334832106525720	02-25-88	--	--	--	--	--	--	--	--	--
334810106522520	02-24-88	--	--	--	--	--	--	--	--	--
334616106540720	02-25-88	--	--	--	--	--	--	--	--	--
334836106520001	02-25-88	--	--	--	--	--	--	--	--	--
334821106523401	02-24-88	--	--	--	--	--	--	--	--	--

Table 15.--Summary of data for pesticides in water collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Concluded

Station number	Date	Toxa-phene, total (μg/L)	Chloro-pyrifos (Dursban), total (μg/L)	Di-azinon, total (μg/L)	Ethion, total (μg/L)	Mala-thion, total (μg/L)	Methyl para-thion, total (μg/L)	Methyl tri-thion, total (μg/L)	Para-thion, total (μg/L)	Tri-thion, total (μg/L)
08354900	11-20-87	--	--	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	03-24-88	--	--	--	--	--	--	--	--	--
	08-16-88	<1	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
08358400	11-20-87	--	--	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
335213106520210	11-19-87	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
335211106512710	11-18-87	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	05-03-88	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
335212106514010	11-18-87	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	05-03-88	--	--	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
335213106521510	05-03-88	--	--	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
334928106525010	11-19-87	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	05-03-88	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
334828106514710	05-03-88	--	--	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
334612106540510	11-19-87	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
334832106525720	02-25-88	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
334810106522520	02-24-88	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
334616106540720	02-25-88	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
334836106520001	02-25-88	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
334821106523401	02-24-88	--	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 16.--Summary of data for major chemicals, trace elements, and radionuclides in bottom sediment collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

[*, duplicate sample; coarse, all sizes in sample less than 2.0 millimeters; fine, sample fraction passing through 62.5-micron sieve; %, percent dry-weight; ppm, parts per million dry-weight; <, less than; --, no data; pCi/g, picocuries per gram]

		Site number (see figure 5 for site locations)							
Chemical constituent	Unit	B2* Coarse	B2* Coarse	B3 Coarse	B3 Fine	B1 Coarse	B1 Fine	B4 Coarse	B4 Fine
Calcium	%	1.4	1.5	1.5	3.4	1.4	4.3	3.5	3.5
Magnesium	%	0.22	0.22	0.39	0.93	0.20	0.72	1.2	1.1
Sodium	%	1.4	1.4	1.1	1.0	1.2	1.3	0.77	0.94
Potassium	%	1.8	1.8	1.4	1.7	1.6	1.8	1.9	1.9
Phosphorus	%	0.03	0.03	0.04	0.09	0	0.05	0.07	0.07
Aluminum	%	3.9	3.9	3.8	5.2	4.0	4.6	7.7	7.0
Arsenic	ppm	2.0	2.0	2.2	4.9	2.0	4.4	6.4	6.6
Barium	ppm	690	700	620	1,100	640	930	600	630
Beryllium	ppm	<1	<1	<1	1	<1	1	2	2
Bismuth	ppm	<10	<10	<10	<10	<10	<10	<10	<10
Boron	ppm	0.5	<0.4	0.7	3.6	<0.41	1	0.8	1.0
Cadmium	ppm	<2	<2	<2	<2	<2	<2	<2	<2
Cerium	ppm	32	30	31	100	25	81	73	67
Chromium	ppm	17	16	24	85	18	49	57	53
Cobalt	ppm	6	6	6	15	5	13	14	13
Copper	ppm	5	5	7	18	9	16	28	27
Europium	ppm	<2	<2	<2	<2	<2	<2	<2	<2
Gallium	ppm	8	9	8	12	8	11	18	15
Gold	ppm	<8	<8	<8	<8	<8	<8	<8	<8
Holmium	ppm	<4	<4	<4	<4	<4	<4	<4	<4
Iron	%	1.7	1.4	1.4	3.9	1.0	2.7	3.2	2.8
Lanthanum	ppm	22	21	20	58	17	47	42	39
Lead	ppm	12	10	11	21	10	17	23	21
Lithium	ppm	10	10	11	26	10	20	42	36
Manganese	ppm	310	280	300	680	330	1,700	830	740
Mercury	ppm	<0.02	<0.02	<0.02	0.04	<0.02	0.02	0.04	0.04
Molybdenum	ppm	<2	<2	<2	<2	<2	<2	<2	<2
Neodynium	ppm	16	17	16	49	12	39	35	33
Nickel	ppm	6	6	7	19	6	15	22	19
Niobium	ppm	5	<4	6	13	<4	5	11	10
Scandium	ppm	2	2	4	8	2	6	11	9
Selenium	ppm	<0.1	0.1	0.1	0.2	<0.1	0.2	0.4	0.4
Silver	ppm	<2	<2	<2	<2	<2	<2	<2	<2
Tin	ppm	<10	<10	<10	<10	<10	<10	<10	<10
Titanium	%	0.19	0.16	0.23	0.65	0.13	0.39	0.39	0.39
Strontium	ppm	290	300	230	240	280	320	260	260
Tantalum	ppm	<40	<40	<40	<40	<40	<40	<40	<40
Thorium	ppm	4	5	4	18	4	14	12	12
Vanadium	ppm	43	35	39	120	28	80	86	74
Yttrium	ppm	10	10	12	29	9	24	23	23
Ytterbium	ppm	1	1	1	4	1	3	3	3
Zinc	ppm	27	23	24	75	18	52	75	66
Uranium	ppm	0.4	0.4	0.4	1.3	0.65	1.3	1.6	1.6
Radium-226	pCi/g	0.539	0.461	0.655	--	0.550	--	1.28	--
Total carbon	%	0.23	0.26	0.34	1.45	0.32	1.88	1.75	1.72
Organic carbon	%	0.04	0.06	0.12	0.55	0.09	0.78	0.96	0.88

Table 16.--Summary of data for major chemicals, trace elements, and radionuclides in bottom sediment collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Continued

	Site number (see figure 5 for site locations)							
Chemical constituent	B5 Coarse	B5 Fine	B6 Coarse	B6 Fine	B7 Coarse	B7 Fine	B8 Coarse	B8 Fine
Calcium	2.7	2.6	1.3	3.4	1.3	3.3	4.2	6.8
Magnesium	0.76	0.73	0.28	0.83	0.26	0.84	0.57	0.85
Sodium	1.0	0.71	1.2	1.2	1.2	1.2	0.97	0.57
Potassium	2.0	1.4	1.8	1.9	1.9	1.9	1.7	1.3
Phosphorus	0.05	0.04	0.04	0.05	0.03	0.07	0.05	0.06
Aluminum	6.1	4.9	4.2	5.1	4.3	5.3	4.5	4.7
Arsenic	7.4	6.8	2.4	4.2	3.7	6.3	6.7	12.0
Barium	990	630	690	820	730	920	560	390
Beryllium	2	1	<1	1	1	2	1	1
Bismuth	<10	<10	<10	<10	<10	<10	<10	<10
Boron	1.4	1.3	0.5	1.7	0.6	2.4	1.3	1.8
Cadmium	<2	<2	<2	<2	<2	<2	<2	<2
Cerium	56	52	59	71	35	74	38	48
Chromium	40	35	28	45	19	54	22	37
Cobalt	12	10	8	11	7	14	8	9
Copper	21	21	8	16	9	17	13	17
Europium	<2	<2	<2	<2	<2	<2	<2	<2
Gallium	14	11	10	11	9	14	10	11
Gold	<8	<8	<8	<8	<8	<8	<8	<8
Holmium	<4	<4	<4	<4	<4	<4	<4	<4
Iron	2.2	1.9	2.3	2.6	1.1	2.7	1.4	2.0
Lanthanum	34	30	37	41	22	42	25	29
Lead	130	50	13	23	14	27	13	15
Lithium	29	25	12	25	13	28	24	32
Manganese	1,900	880	820	1,100	2,100	4,500	850	1,300
Mercury	0.02	0.04	<0.02	0.02	<0.02	0.02	<0.02	0.02
Molybdenum	<2	<2	<2	<2	<2	<2	<2	<2
Neodymium	26	24	27	34	18	37	18	23
Nickel	14	13	8	14	6	15	9	12
Niobium	7	5	7	4	4	8	5	5
Scandium	7	5	3	7	3	7	5	7
Selenium	0.2	0.3	<0.1	0.2	0.1	0.3	0.2	0.3
Silver	<2	<2	<2	<2	<2	<2	<2	<2
Tin	<10	<10	<10	<10	<10	<10	<10	<10
Titanium	0.29	0.24	0.31	0.37	0.15	0.39	0.18	0.24
Strontium	240	180	230	280	240	280	390	500
Tantalum	<40	<40	<40	<40	<40	<40	<40	<40
Thorium	10	9	9	11	5	15	6	9
Vanadium	60	52	61	71	29	72	36	51
Yttrium	19	17	14	24	13	24	13	17
Ytterbium	2	2	2	3	1	3	2	2
Zinc	67	55	37	54	32	60	36	50
Uranium	1.1	1.3	0.65	1.0	0.70	0.85	0.80	1.2
Radium-226	1.08	--	0.862	--	1.01	--	0.712	--
Total carbon	1.54	2.00	0.29	1.33	0.50	1.72	2.23	4.46
Organic carbon	0.92	1.11	0.12	0.49	0.30	0.91	1.21	2.15

Table 16.--Summary of data for major chemicals, trace elements, and radionuclides in bottom sediment collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988--Concluded

Chemical constituent	Site number (see figure 5 for site locations)							
	B9 Unsieved	B9 Fine	B10 Unsieved	B10 Fine	B11F Unsieved	B11F Fine	B12F Unsieved	B12F Fine
Calcium	3.8	3.9	3.3	4.9	3.1	3.6	2.4	1.9
Magnesium	0.90	0.91	0.64	1.0	0.95	1.1	1.3	0.97
Sodium	1.0	1.1	2.1	1.1	0.91	0.91	0.49	0.35
Potassium	1.9	1.9	2.2	1.9	1.9	1.9	1.9	1.4
Phosphorous	0.06	0.07	0.05	0.07	0.06	0.07	0.07	0.05
Aluminum	5.5	6.6	7.2	6.2	5.8	6.8	9.2	6.7
Arsenic	4.5	3.6	3.3	6.2	5.0	6.8	5.8	7.7
Barium	660	650	750	710	630	660	530	470
Beryllium	2	1	2	2	2	2	2	2
Bismuth	<10	<10	<10	<10	<10	<10	<10	<10
Boron	1.6	1.6	1.1	2.0	1.2	1.4	1.3	1.6
Cadmium	<2	<2	<2	<2	<2	<2	<2	<2
Cerium	59	59	56	65	60	70	79	60
Chromium	37	53	30	44	48	52	58	47
Cobalt	10	10	8	13	11	12	14	11
Copper	20	25	17	22	21	24	29	22
Europium	<2	<2	<2	<2	<2	<2	<2	<2
Gallium	12	12	16	15	15	15	22	16
Gold	<8	<8	<8	<8	<8	<8	<8	<8
Holmium	<4	<4	<4	<4	<4	<4	<4	<4
Iron	2.1	2.0	1.9	2.7	2.4	2.7	3.7	2.8
Lanthanum	34	35	34	39	35	41	45	35
Lead	19	18	18	23	20	21	27	30
Lithium	34	32	28	42	34	37	53	41
Manganese	380	380	430	720	440	470	460	360
Mercury	<0.02	0.02	<0.02	0.04	0.02	0.02	0.04	0.06
Molybdenum	<2	<2	<2	<2	<2	<2	<2	<2
Neodynium	29	29	26	31	30	34	36	28
Nickel	14	14	10	16	15	18	21	17
Niobium	7	8	7	8	8	9	11	9
Scandium	7	7	6	9	8	9	13	10
Selenium	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.4
Silver	<2	<2	<2	<2	<2	<2	<2	<2
Tin	<10	<10	<10	<10	<10	<10	<10	10
Titanium	0.28	0.31	0.23	0.34	0.31	0.37	0.39	0.33
Strontium	280	270	630	400	250	260	240	180
Tantalum	<40	<40	<40	<40	<40	<40	<40	<40
Thorium	10	10	9	11	11	13	14	11
Vanadium	57	57	51	72	67	74	110	81
Yttrium	19	20	20	22	20	23	22	20
Ytterbium	2	2	2	3	2	3	2	2
Zinc	55	52	45	67	60	67	94	70
Uranium	1.1	0.65	0.90	1.5	0.80	1.0	1.2	1.5
Radium-226	1.11	--	0.82	--	1.01	--	1.18	--
Total carbon	2.44	2.19	1.21	2.52	1.71	1.94	2.09	2.41
Organic carbon	1.46	1.17	0.67	1.32	0.94	1.03	1.65	1.92

Table 17.--Summary of data for pesticides in bottom sediment collected for the Bosque del Apache National Wildlife Refuge reconnaissance study, water year 1988

[BDANWR, Bosque del Apache National Wildlife Refuge; <, less than. All values in micrograms per kilogram dry-weight]

Station number	Station name (site number, if applicable)	Date	Time	Aldrin, total in bottom material
08354900	Rio Grande Floodway at San Acacia (B2)	11-20-87	1345	<0.1
08358400	Rio Grande Floodway at San Marcial (B3)	11-20-87	1000	<0.1
335213106520210	Rio Grande Conveyance Channel at inflow to BDANWR (B1)	11-19-87	1000	<0.1
335211106512710	San Antonio Drain at inflow to BDANWR (B4)	11-18-87	1100	<0.1
335212106514010	Elmendorf Drain at inflow to BDANWR (B5)	11-18-87	1345	<0.1
334928106525010	BDANWR Interior Drain 1.2 miles north of BDANWR HQ (B6)	11-19-87	1450	<0.1
334612106540510	BDANWR Interior Drain near outflow, BDANWR (B7)	11-19-87	1245	<0.1
334832106525720	Trench pond in field unit 18C at BDANWR (B8)	02-18-88	1330	<0.1
334810106522520	Field unit 18B-east triangle at BDANWR (B9)	02-17-88	1330	0.1
334616106540720	South marsh in field unit 25A at BDANWR (B10)	02-17-88	1500	<0.1
334907106520520	Field unit 17A in NW section at BDANWR (B11F)	02-17-88	1400	<0.1
334800106530020	Field unit 18D in SE section at BDANWR B12F)	02-17-88	1115	<0.1

Station number	Date	Chlordane, total in bottom material	DDD, total in bottom material	DDE, total in bottom material	DDT, total in bottom material	Dieldrin, total in bottom material	Endosulfan, total in bottom material	Endrin, total in bottom material	PCB, total in bottom material
08354900	11-20-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1
08358400	11-20-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1
335213106520210	11-19-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1
335211106512710	11-18-87	3.0	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	2
335212106514010	11-18-87	3.0	1.7	1.3	<0.1	<0.1	<0.1	<0.1	2
334928106525010	11-19-87	<1.0	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<1
334612106540510	11-19-87	<1.0	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<1
334832106525720	02-18-88	<1.0	0.1	0.2	<0.1	<0.1	<0.1	<0.1	<1
334810106522520	02-17-88	<1.0	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<1
334616106540720	02-17-88	1.0	0.2	0.6	<0.1	<0.1	<0.1	<0.1	2
334907106520520	02-17-88	<1.0	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<1
334800106530020	02-17-88	1.0	0.1	0.5	<0.1	<0.1	<0.1	<0.1	<1

Station number	Date	PCN, total in bottom material	Heptachlor, total in bottom material	Heptachlor epoxide, total in bottom material	Lindane, total in bottom material	Methoxychlor, total in bottom material	Mirex, total in bottom material	Perthane, total in bottom material	Toxaphene, total in bottom material
08354900	11-20-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
08358400	11-20-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
335213106520210	11-19-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
335211106512710	11-18-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
335212106514010	11-18-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
334928106525010	11-19-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
334612106540510	11-19-87	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
334832106525720	02-18-88	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
334810106522520	02-17-88	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
334616106540720	02-17-88	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
334907106520520	02-17-88	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
334800106530020	02-17-88	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10

Table 18.—Trace-element residues in liver and kidney combined from birds collected from the Bosque del Apache National Wildlife Refuge, La Joya State Game Management Area, and Elephant Butte Reservoir, 1986

[Results in micrograms per gram wet-weight and dry-weight; <, less than]

Trace element	Collection site[1] (biological sample)											
	Bosque del Apache National Wildlife Refuge								La Joya State Game Management Area (ruddy duck)		Elephant Butte Reservoir (coot)	
	18BE (coot)		18BW (coot)		18D (coot)		24C (coot)					
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Aluminum	2.87	11.0	1.24	4.5	2.32	9.0	1.93	7.0	0.84	3.0	3.79	8.9
Arsenic	<0.05	<0.2	0.16	0.61	0.05	0.2	0.14	0.5	<0.06	<0.2	0.09	0.2
Barium	0.12	0.46	0.16	0.63	0.18	0.67	0.11	0.4	0.06	0.2	0.09	0.2
Beryllium	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.02	<0.03	<0.1	0.01	0.02
Boron	<0.52	<2	<0.32	<2	0.53	2	0.55	<2	0.84	3	<0.85	<2
Cadmium	0.21	0.79	0.13	0.52	0.13	0.49	0.44	1.6	0.03	0.09	0.35	0.83
Chromium	0.05	0.2	0.12	0.46	0.08	0.3	0.06	0.2	0.08	0.3	0.13	0.3
Copper	6.76	25.9	7.64	29.6	10.11	39.3	9.54	34.7	8.60	30.7	26.50	62.2
Iron	1,041.39	3,990.0	1,986.00	7,700.0	2,888.50	10,900.0	987.75	3,590.0	1,367.38	4,880	1,256.70	2,950.0
Lead	<0.13	<0.5	0.13	<0.5	<0.19	<0.7	<0.14	<0.5	<0.14	<0.5	<0.21	<0.5
Magnesium	204.36	783.0	169.51	657.0	182.32	688.0	207.90	756	212.11	757	311.83	732
Manganese	6.73	25.8	4.39	17.0	3.98	15.0	4.95	18	2.07	7.4	5.54	13
Mercury	0.13	0.49	0.17	0.67	0.05	0.19	0.52	1.9	0.06	0.2	1.15	2.7
Molybdenum	1.25	4.8	1.21	4.7	1.06	4.0	1.10	4.0	0.84	3	1.28	3.0
Nickel	0.05	0.2	0.08	0.3	0.29	1.1	0.06	0.2	<0.03	<1	0.21	0.49
Selenium	0.91	3.5	0.54	2.1	0.64	2.4	1.29	4.7	1.60	5.7	2.77	6.5
Silver	<0.52	<2	<0.52	<2	0.53	<2	0.55	<2	<0.06	<2	<0.85	<2
Strontium	0.55	2.1	0.41	1.6	0.32	1.2	0.50	1.8	0.48	1.7	0.51	1.2
Tantalum	<0.10	<0.4	<0.10	<0.4	<0.11	<0.4	0.11	<0.4	<0.13	<0.4	<0.17	<0.4
Vanadium	0.37	1.4	0.34	1.5	0.19	0.7	0.19	0.7	<0.09	<0.3	0.51	1.2
Zinc	<42.02	161	36.12	140	37.10	140	41.80	152.0	42.31	151	65.18	153.0
Moisture content (percent)		73.9		74.2		73.5		72.5		71.9		57.4

[1]Locations shown in figures 1 and 6.

Table 19.—Trace-element residues in carp tissue from fish collected from the Bosque del Apache National Wildlife Refuge, La Joya State Game Management Area, and Elephant Butte Reservoir, 1986

[Results in micrograms per gram wet-weight and dry-weight; <, less than]

Trace element	Collection site[1]											
	Bosque del Apache National Wildlife Refuge								La Joya State Game Management Area		Elephant Butte Reservoir	
	Canal		18BE		25A		18D					
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Aluminum	74.7	300.0	62.7	220.00	31.33	130.0	101.77	396.00	42.94	190	28.8	100.0
Arsenic	.25	1.0	0.13	0.47	0.14	0.58	0.10	0.39	0.135	0.6	0.16	0.57
Barium	3.31	13.3	2.70	9.44	3.01	12.5	4.57	17.8	3.75	16.6	3.74	13.0
Beryllium	<.002	<0.01	<0.003	<0.01	<.002	<0.01	<.003	<0.01	<0.0023	<0.01	<0.003	<0.01
Boron	<.50	<2	<0.57	<2	<0.72	<3.0	<0.51	<2.0	<0.45	<2	<0.58	<2.0
Cadmium	0.02	0.089	0.01	0.05	0.01	0.06	0.02	0.09	0.01	0.05	0.034	0.12
Chromium	0.15	0.61	0.13	0.47	.05	0.2	0.20	0.78	0.45	0.2	<0.29	<0.1
Copper	1.54	6.2	0.85	3.0	0.62	2.8	0.98	3.81	0.90	4.0	0.89	3.1
Iron	105.01	422.0	45.90	161.0	39.04	162.0	8.48	333.0	61.25	271.0	36	125.0
Lead	.12	0.5	0.14	<0.5	<0.12	<0.5	0.128	<0.5	0.113	0.5	<.144	<0.5
Magnesium	3,111.13	1,370.0	316.35	1,110.0	322.94	1,340.0	416.34	1,620.0	343.52	1,520.0	357.12	1,240.0
Manganese	11.70	47.0	3.42	12.0	6.33	27.1	6.43	25.0	16.68	73.8	4.03	14.0
Mercury	0.03	0.13	0.04	0.14	0.05	0.21	.0012	0.047	0.036	0.16	0.10	0.36
Molybdenum	<.25	<1.0	<.29	<1.0	<.241	<1.0	<.257	<1.0	<0.23	<1.0	0.29	<1.0
Nickel	0.92	3.7	0.14	0.48	0.20	0.81	0.14	0.54	0.015	0.3	0.32	1.1
Selenium	0.29	1.2	0.14	0.48	0.20	0.81	0.14	0.54	0.21	0.95	0.32	1.1
Silver	<.50	<2	<0.57	<2.0	<0.48	<2.0	<0.51	<2.0	<0.45	<2	<0.58	<2.0
Strontium	39.59	159.0	54.44	191.0	40.01	166.0	61.94	241.0	61.71	232.0	39.17	136.0
Tantalum	<0.12	<0.5	0.14	<0.5	0.12	0.5	<0.10	<0.4	0.113	<0.5	<1.15	<0.4
Vanadium	0.17	0.7	0.08	0.3	0.12	0.5	0.23	0.91	0.14	0.6	0.14	0.5
Zinc	61.00	245	43.61	153.0	29.88	124.0	50.37	196	44.92	199.0	62.49	217
Moisture content (percent)		75.1		71.5		75.9		74.3		77.4		71.2

[1] Locations shown in figures 1 and 6.

Table 20.—Trace-element residues in plant samples collected from the Bosque del Apache National Wildlife Refuge, 1986

[Results in micrograms per gram wet-weight and dry-weight; <, less than]

Trace element	Collection site[1] (plant)							
	18BE (sedge)		18BE (bullrush)		25A (curlyleaf pondweed)		25A (coontail)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Aluminum	57.72	120.0	544	6,800.0	1,551.5	14,500.0	1,056.00	8,000.0
Arsenic	<0.096	<0.2	0.24	3.0	0.35	3.3	0.81	6.1
Barium	61.09	127.0	9.92	124.0	17.87	167.0	28.64	217.0
Beryllium	<.0481	<0.1	.016	0.2	.041	0.38	0.03	0.24
Boron	23.57	49.0	.536	6.7	.642	6.0	8.43	26.0
Cadmium	0.034	0.07	.015	0.19	.032	0.3	.026	0.2
Chromium	.0481	0.1	.344	4.3	0.94	8.8	.57	4.3
Copper	1.09	2.28	0.6	7.5	0.96	8.96	1.13	8.55
Iron	45.70	95.0	296.8	3,710.0	700.85	6,550.0	627	4,750.0
Lead	<0.193	<0.4	0.32	4.0	0.86	8	0.59	4.5
Magnesium	553.15	1,150.0	266.4	3,330.0	655.54	6,220.0	452.76	3,430.0
Manganese	208.75	434	23.6	295.0	120.91	1,130.0	419.76	3,180.0
Mercury	0.010	0.021	.002	0.024	.005	0.043	.004	0.03
Molybdenum	<.481	<1	0.08	1.0	<.107	<1.0	<.264	<2
Nickel	0.40	0.84	0.312	3.9	.78	7.3	.713	5.4
Selenium	.048	0.1	0.008	0.1	0.011	0.1	.0132	0.1
Silver	0.962	2	0.16	2.0	214	2.0	.264	2
Strontium	67.34	140.0	33.52	419	45.26	423	25.48	193.0
Tantalum	<.1924	<0.4	<0.05	<0.6	<.075	<0.7	<.053	<0.4
Vanadium	.1443	0.3	0.74	9.3	1.71	16.0	1.98	15.0
Zinc	4.65	9.66	9.4	118.0	26.00	243.0	14.52	110.0
Moisture content (percent)		51.9		92.0		89.3		86.8

[1]Locations shown in figure 6.

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988

[µg/g, micrograms per gram; <, less than]

Sample	Matrix	Collection site[1]	Number per com- posite	Per- cent mois- ture	Elu- triate weight, in grams	Aluminum µg/g (wet)	Aluminum µg/g (dry)	Antimony µg/g (wet)	Antimony µg/g (dry)
Mallard, adult	Liver/kidney	18BE, 24C, triangle	3	75.0	79.0	3.60	14.40	<0.025	<0.100
Mallard, adult	Liver/kidney	18BE, 24C, ditch between 18A&B	3	73.6	44.5	4.80	18.20	<0.025	<0.095
Mallard, adult	Liver/kidney	24C	3	76.2	85.6	<2.00	<8.40	<0.025	<0.105
Mallard, adult	Liver/kidney	18BW, 18BE	3	73.2	61.3	2.60	9.70	<0.025	<0.093
American coot, adult	Liver/kidney	18BW, 18BE	3	74.6	61.1	2.60	10.20	<0.025	<0.098
American coot, adult	Liver/kidney	18BE	3	73.2	59.8	3.00	11.20	<0.025	<0.093
American coot, adult	Liver/kidney	18BE, 18BW	3	72.3	62.5	3.00	10.80	<0.025	<0.090
American coot, adult	Liver/kidney	18BW, 24C	3	74.6	64.2	<2.00	<7.87	0.070	0.276
Black-necked stilt, adult	Liver/kidney	18A, 18BE	3	73.8	19.8	<2.00	<7.63	<0.025	<0.095
Black-necked stilt, adult	Liver/kidney	18A, 18BE	3	73.6	17.5	<2.00	<7.58	<0.025	<0.095
Black-necked stilt, adult	Liver/kidney	18AN, 18BE, triangle	3	75.0	17.9	6.40	25.60	<0.025	<0.100
Black-necked stilt, adult	Liver/kidney	18BE, triangle	3	73.9	16.8	2.00	7.66	<0.025	<0.096
Mallard, immature	Liver/kidney	18BW	3	74.2	28.7	4.00	15.50	<0.025	<0.097
Mallard, immature	Liver/kidney	18BE	3	76.7	9.0	14.40	61.80	<0.025	<0.107
Mallard, immature	Liver/kidney	18BW	3	75.9	35.7	2.40	9.96	<0.025	<0.104
Mallard, immature	Liver/kidney	Ditch between 18A & triangle	3	72.3	26.1	2.20	7.94	<0.025	<0.090
American coot, immature	Liver/kidney	24B, 24C	4	76.3	26.6	<2.00	<8.44	<0.025	<0.105
American coot, immature	Liver/kidney	24C	3	74.4	13.5	<2.00	<7.81	<0.025	<0.098
American coot, immature	Liver/kidney	18BW, 24C	3	78.8	13.7	2.60	12.30	<0.025	<0.118
American coot, immature	Liver/kidney	24B, 24C	3	75.8	19.9	<2.00	<8.26	<0.025	<0.103
Black-necked stilt, immature	Liver/kidney	18A, 18BW	3	73.3	11.6	6.20	23.20	<0.025	<0.094
Black-necked stilt, immature	Liver/kidney	18BW	3	75.9	7.6	2.80	11.60	<0.025	<0.104
Black-necked stilt, immature	Liver/kidney	18A, 18BW	3	75.9	14.2	<2.00	<8.30	<0.025	<0.104
Avocet, immature	Liver/kidney	18BW	3	76.6	5.5	<2.00	<8.55	<0.025	<0.107
Mallard	Egg	24B	1	68.4	35.2	4.60	14.60	<0.025	<0.079
Mallard	Egg	15B	1	69.8	35.1	<2.00	<6.62	<0.025	<0.083
Mallard	Egg	18A	1	66.2	32.1	<2.00	<5.92	<0.025	<0.074
Mallard	Egg	15B	1	63.1	39.8	5.20	14.10	<0.025	<0.068
Mallard	Egg	24C	1	68.9	33.0	<2.00	<6.43	<0.025	<0.080
American coot	Egg	24C	1	72.3	19.8	<2.00	<7.22	<0.025	<0.090
American coot	Egg	24C	1	73.4	21.6	<2.00	<7.52	<0.025	<0.094
American coot	Egg	24C	1	73.8	19.6	<2.00	<7.63	<0.025	<0.095
American coot	Egg	24C	1	73.7	17.7	<2.00	<7.60	<0.025	<0.095
American coot	Egg	18D	1	70.0	15.4	<2.00	<6.85	<0.025	<0.086

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Continued

Sample	Matrix	Collection site[1]	Number per composite	Percent moisture	Eluriate weight, in grams	Aluminum µg/g (wet)	Aluminum µg/g (dry)	Antimony µg/g (wet)	Antimony µg/g (dry)
Black-necked stilt	Egg	18A	1	56.0	15.1	<2.00	<4.55	<0.025	<0.057
Black-necked stilt	Egg	18BW	1	68.3	14.4	2.00	6.31	<0.025	<0.079
Black-necked stilt	Egg	18BW	1	70.4	13.8	<2.00	<6.76	<0.025	<0.084
Black-necked stilt	Egg	18BW	1	69.6	12.1	<2.00	<6.58	<0.025	<0.082
Black-necked stilt	Egg	18BW	1	72.0	14.7	<2.00	<7.14	<0.025	<0.089
Carp	Whole body	24B		80.0	990.0	18.20	91.00	<0.025	<0.125
Carp	Whole body	25A		79.8	1,830.0	21.20	105.00	<0.025	<0.124
Carp	Whole body	18D		81.5	1,100.0	51.20	277.00	<0.025	<0.135
Carp	Whole body	24C		75.9	2,220.0	15.60	64.70	<0.025	<0.104
Centrarchidae	Whole body	18B		79.1	543.0	12.00	57.40	<0.025	<0.120
Centrarchidae	Whole body	25A		76.5	503.0	2.20	9.36	<0.025	<0.106
Centrarchidae	Whole body	24B		78.5	1,020.0	41.60	193.00	<0.025	<0.116
Centrarchidae	Whole body	24C		79.2	195.0	51.40	247.00	<0.025	<0.120
Threadfin shad	Whole body	18D		74.5	1,730.0	164.00	643.00	<0.025	<0.098
Mosquitofish	Whole body	24B		78.3	1,180.0	36.60	169.00	<0.025	<0.115
Mosquitofish	Whole body	24C		78.0	1,070.0	32.80	149.00	<0.025	<0.114
Brown bullhead	Whole body	24B		79.3	336.0	12.80	61.80	<0.025	<0.121
Brown bullhead	Whole body	24C		82.6	270.0	14.20	81.60	<0.025	<0.144
Brown bullhead	Whole body	25A		82.4	579.0	3.40	19.30	<0.025	<0.142
Dragonfly/damselfly	Whole body	18BE		82.4	113.0	49.40	281.00	<0.025	<0.142
Dragonfly/damselfly	Whole body	18BW		81.8	53.2	32.80	180.00	<0.025	<0.137
Dragonfly/damselfly	Whole body	24C		82.9	35.9	58.40	342.00	<0.025	<0.146
Dragonfly/damselfly	Whole body	24B		82.2	61.7	32.40	182.00	<0.025	<0.140
Crayfish	Whole body	24B		71.6	87.1	39.80	140.00	<0.025	<0.088
Crayfish	Whole body	18BE		74.3	56.2	219.00	852.00	<0.025	<0.097
Crayfish	Whole body	24C		71.9	37.4	39.40	140.00	<0.025	<0.089
Crayfish	Whole body	18D		81.4	63.5	54.20	291.00	<0.025	<0.134
Order Hemiptera	Whole body	18BW		62.8	56.8	509.00	1,370.00	<0.025	<0.067
Order Hemiptera	Whole body	24B		72.2	79.8	129.00	464.00	<0.025	<0.090
Order Hemiptera	Whole body	18BE		66.8	65.4	64.60	195.00	<0.025	<0.075
Hemiptera/Coleoptera	Whole body	24C		74.3	72.2	97.80	381.00	<0.025	<0.097
P. foliosus	Plant	24B		84.0	78.4	290.00	1,810.00	<0.025	<0.156
Z. palustris	Plant	18BE		89.3	159.0	254.00	2,370.00	<0.025	<0.234
Z. palustris	Plant	18BW		88.4	193.0	161.00	1,390.00	<0.025	<0.216
Z. palustris	Plant	24C		91.1	136.0	191.00	2,150.00	<0.025	<0.281

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Continued

Sample	Matrix	Arsenic µg/g (wet)	Arsenic µg/g (dry)	Barium µg/g (wet)	Barium µg/g (dry)	Beryllium µg/g (wet)	Beryllium µg/g (dry)	Boron µg/g (wet)	Boron µg/g (dry)	Cadmium µg/g (wet)	Cadmium µg/g (dry)
Mallard, adult	Liver/kidney	0.072	0.228	<1.00	<4.00	<0.10	<0.40	<1.00	<4.00	<0.10	<0.40
Mallard, adult	Liver/kidney	0.054	0.205	<1.00	<3.79	<0.10	<0.38	<1.00	<3.79	0.12	0.45
Mallard, adult	Liver/kidney	0.065	0.273	<1.00	<4.20	<0.10	<0.42	<1.00	<4.20	<0.10	<0.42
Mallard, adult	Liver/kidney	0.038	0.142	<1.00	<3.73	<0.10	<0.37	<1.00	<3.73	<0.10	<0.37
American coot, adult	Liver/kidney	0.208	0.819	<1.00	<3.94	<0.10	<0.39	<1.00	<3.94	<0.10	<0.39
American coot, adult	Liver/kidney	0.272	1.010	<1.00	<3.73	<0.10	<0.37	<1.00	<3.73	<0.10	<0.37
American coot, adult	Liver/kidney	0.302	1.090	<1.00	<3.61	<0.10	<0.36	<1.00	<3.61	0.12	0.43
American coot, adult	Liver/kidney	0.178	0.701	<1.00	<3.94	<0.10	<0.39	<1.00	<3.94	<0.10	<0.39
Black-necked stilt, adult	Liver/kidney	0.040	0.153	<1.00	<3.82	<0.10	<0.38	<1.00	<3.82	0.10	0.38
Black-necked stilt, adult	Liver/kidney	0.042	0.159	<1.00	<3.79	<0.10	<0.38	<1.00	<3.79	0.10	0.38
Black-necked stilt, adult	Liver/kidney	0.046	0.184	<1.00	<4.00	<0.10	<0.40	<1.00	<4.00	<0.10	<0.40
Black-necked stilt, adult	Liver/kidney	0.024	0.092	<1.00	<3.83	<0.10	<0.38	<1.00	<3.83	<0.10	<0.38
Mallard, immature	Liver/kidney	0.073	0.283	<1.00	<3.88	<0.10	<0.39	<1.00	<3.88	0.18	0.70
Mallard, immature	Liver/kidney	0.033	0.142	<1.00	<4.29	<0.10	<0.43	1.34	5.75	<0.10	<0.43
Mallard, immature	Liver/kidney	0.068	0.282	<1.00	<4.15	<0.10	<0.41	<1.00	<4.15	0.24	1.00
Mallard, immature	Liver/kidney	0.059	0.213	<1.00	<3.61	<0.10	<0.36	<1.00	<3.61	<0.10	<0.36
American coot, immature	Liver/kidney	0.278	1.170	<1.00	<4.22	<0.10	<0.42	<1.00	<4.22	0.10	0.42
American coot, immature	Liver/kidney	0.092	0.359	<1.00	<3.91	<0.10	<0.39	<1.00	<3.91	<0.10	<0.39
American coot, immature	Liver/kidney	0.050	0.236	<1.00	<4.72	<0.10	<0.47	<1.00	<4.72	<0.10	<0.47
American coot, immature	Liver/kidney	0.198	0.818	<1.00	<4.13	<0.10	<0.41	<1.00	<4.13	0.14	0.58
Black-necked stilt, immature	Liver/kidney	0.036	0.135	<1.00	<3.75	<0.10	<0.37	1.30	4.87	<0.10	<0.37
Black-necked stilt, immature	Liver/kidney	0.042	0.174	<1.00	<4.15	<0.10	<0.41	<1.00	<4.15	0.84	3.49
Black-necked stilt, immature	Liver/kidney	0.034	0.141	<1.00	<4.15	<0.10	<0.41	<1.00	<4.15	<0.10	<0.41
Avocet, immature	Liver/kidney	0.032	0.137	<1.00	<4.27	<0.10	<0.43	<1.00	<4.27	0.16	0.68
Mallard	Egg	0.026	0.082	4.64	14.70	<0.10	<0.32	<1.00	<3.16	<0.10	<0.32
Mallard	Egg	0.032	0.106	6.78	22.50	<0.10	<0.33	<1.00	<3.31	<0.10	<0.33
Mallard	Egg	0.037	0.109	3.10	9.17	<0.10	<0.30	<1.00	<2.96	<0.10	<0.30
Mallard	Egg	0.030	0.081	5.46	14.80	<0.10	<0.27	<1.00	<2.71	<0.10	<0.27
Mallard	Egg	0.030	0.096	2.52	8.10	<0.10	<0.32	<1.00	<3.22	<0.10	<0.32
American coot	Egg	0.052	0.188	4.74	17.10	<0.10	<0.36	<1.00	<3.61	<0.10	<0.36
American coot	Egg	0.066	0.248	1.60	6.02	<0.10	<0.38	<1.00	<3.76	<0.10	<0.38
American coot	Egg	0.098	0.374	<1.00	<3.82	<0.10	<0.38	<1.00	<3.82	<0.10	<0.38
American coot	Egg	0.052	0.198	2.28	8.67	<0.10	<0.38	<1.00	<3.80	<0.10	<0.38
American coot	Egg	0.080	0.274	3.74	12.80	<0.10	<0.34	<1.00	<3.42	<0.10	<0.34
Black-necked stilt	Egg	0.024	0.055	2.78	6.32	<0.10	<0.23	1.88	4.27	<0.10	<0.23
Black-necked stilt	Egg	0.030	0.095	<1.00	<3.15	<0.10	<0.32	2.20	6.94	<0.10	<0.32
Black-necked stilt	Egg	0.025	0.084	1.30	4.39	<0.10	<0.34	1.06	3.58	<0.10	<0.34
Black-necked stilt	Egg	0.025	0.082	1.34	4.41	<0.10	<0.33	<1.00	<3.29	<0.10	<0.33
Black-necked stilt	Egg	0.022	0.079	<1.00	<3.57	<0.10	<0.36	3.20	11.40	<0.10	<0.36

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Continued

Sample	Matrix	Arsenic µg/g (wet)	Arsenic µg/g (dry)	Barium µg/g (wet)	Barium µg/g (dry)	Beryllium µg/g (wet)	Beryllium µg/g (dry)	Boron µg/g (wet)	Boron µg/g (dry)	Cadmium µg/g (wet)	Cadmium µg/g (dry)
Carp	Whole body	0.108	0.540	3.32	16.60	<0.10	<0.50	<1.00	<5.00	<0.10	<0.50
Carp	Whole body	0.092	0.455	2.30	11.40	<0.10	<0.50	<1.00	<4.95	<0.10	<0.50
Carp	Whole body	0.220	1.190	6.74	36.40	<0.10	<0.54	<1.00	<5.41	<0.10	<0.54
Carp	Whole body	0.084	0.349	1.40	5.81	<0.10	<0.41	<1.00	<4.15	<0.10	<0.41
Panfish (Centrarchidae)	Whole body	0.078	0.373	1.00	4.78	<0.10	<0.48	<1.00	<4.78	<0.10	<0.48
Panfish (Centrarchidae)	Whole body	0.078	0.332	<1.00	<4.26	<0.10	<0.43	<1.00	<4.26	<0.10	<0.43
Panfish (Centrarchidae)	Whole body	0.113	0.526	3.40	15.80	<0.10	<0.47	<1.00	<4.65	<0.10	<0.47
Panfish (Centrarchidae)	Whole body	0.102	0.490	2.82	13.60	<0.10	<0.48	<1.00	<4.81	<0.10	<0.48
Threadfin shad	Whole body	0.598	2.350	5.98	23.50	<0.10	<0.39	<1.00	<3.92	<0.10	<0.39
Mosquitofish	Whole body	0.152	0.700	8.12	37.40	<0.10	<0.46	<1.00	<4.61	<0.10	<0.46
Mosquitofish	Whole body	0.172	0.782	6.34	28.80	<0.10	<0.45	<1.00	<4.55	<0.10	<0.45
Brown bullhead	Whole body	0.028	0.135	1.18	5.70	<0.10	<0.48	<1.00	<4.83	<0.10	<0.48
Brown bullhead	Whole body	0.054	0.310	1.62	9.31	<0.10	<0.57	<1.00	<5.75	<0.10	<0.57
Brown bullhead	Whole body	0.037	0.210	3.28	18.60	<0.10	<0.57	<1.00	<5.68	<0.10	<0.57
Dragonfly/damselfly	Whole body	0.282	1.600	1.78	10.10	<0.10	<0.57	1.12	6.36	<0.10	<0.57
Dragonfly/damselfly	Whole body	0.240	1.320	1.66	9.12	<0.10	<0.55	1.08	5.93	<0.10	<0.55
Dragonfly/damselfly	Whole body	0.425	2.490	3.58	20.90	<0.10	<0.58	1.34	7.84	<0.10	<0.58
Dragonfly/damselfly	Whole body	0.368	2.070	5.18	29.10	<0.10	<0.56	1.30	7.30	<0.10	<0.56
Crayfish	Whole body	0.650	2.290	65.00	229.00	<0.10	<0.35	1.76	6.20	1.76	6.20
Crayfish	Whole body	0.480	1.870	31.70	123.00	<0.10	<0.39	1.26	4.90	<0.10	<0.39
Crayfish	Whole body	0.725	2.580	41.40	147.00	<0.10	<0.36	1.46	5.20	<0.10	<0.36
Crayfish	Whole body	0.495	2.660	27.90	150.00	<0.10	<0.54	<1.00	<5.38	<0.10	<0.54
Order Hemiptera	Whole body	0.134	0.360	10.80	29.00	<0.10	<0.27	1.52	4.09	<0.10	<0.27
Order Hemiptera	Whole body	0.296	1.060	5.70	20.50	<0.10	<0.36	1.62	5.83	<0.10	<0.36
Order Hemiptera	Whole body	0.215	0.648	2.80	8.43	<0.10	<0.30	1.20	3.61	<0.10	<0.30
Hemiptera/Coleoptera	Whole body	0.688	2.680	7.78	30.30	<0.10	<0.39	1.48	5.76	<0.10	<0.39
Leafy pondweed (P. foliosus)	Plant	0.690	4.310	40.00	250.00	<0.10	<0.62	2.52	15.80	<0.10	<0.62
Horned pondweed (Z. palustris)	Plant	0.765	7.150	25.40	237.00	<0.10	<0.93	3.18	29.70	<0.10	<0.93
Horned pondweed (Z. palustris)	Plant	0.650	5.600	12.40	107.00	<0.10	<0.86	5.86	50.50	<0.10	<0.86
Horned pondweed (Z. palustris)	Plant	0.086	0.966	31.10	349.00	<0.10	<1.12	28.90	325.00	<0.10	<1.12

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Continued

		Chromium		Copper		Iron		Lead		Magnesium	
Sample	Matrix	µg/g (wet)	µg/g (dry)	µg/g (wet)	µg/g (dry)	µg/g (wet)	µg/g (dry)	µg/g (wet)	µg/g (dry)	µg/g (wet)	µg/g (dry)
Mallard, adult	Liver/kidney	<0.20	<0.80	28.40	114.00	563.0	2,250.0	<2.00	<8.00	194.0	776.0
Mallard, adult	Liver/kidney	<0.20	<0.76	60.00	227.00	1,650.0	6,250.0	<2.00	<7.58	190.0	720.0
Mallard, adult	Liver/kidney	<0.20	<0.84	23.60	99.20	706.0	2,970.0	<2.00	<8.40	164.0	689.0
Mallard, adult	Liver/kidney	<0.20	<0.75	3.98	14.90	887.0	3,310.0	<2.00	<7.46	212.0	791.0
American coot, adult	Liver/kidney	<0.20	<0.79	5.48	21.60	502.0	1,980.0	<2.00	<7.87	172.0	677.0
American coot, adult	Liver/kidney	<0.20	<0.75	6.96	26.00	6.9	26.0	<2.00	<7.46	164.0	612.0
American coot, adult	Liver/kidney	<0.20	<0.72	7.60	27.40	627.0	2,260.0	<2.00	<7.22	178.0	643.0
American coot, adult	Liver/kidney	<0.20	<0.79	8.12	32.00	715.0	2,820.0	<2.00	<7.87	170.0	669.0
Black-necked stilt, adult	Liver/kidney	<0.20	<0.76	4.28	16.30	285.0	1,090.0	<2.00	<7.63	188.0	718.0
Black-necked stilt, adult	Liver/kidney	<0.20	<0.76	5.30	20.10	310.0	1,180.0	<2.00	<7.58	212.0	803.0
Black-necked stilt, adult	Liver/kidney	<0.20	<0.80	4.12	16.50	223.0	891.0	<2.00	<8.00	186.0	744.0
Black-necked stilt, adult	Liver/kidney	<0.20	<0.77	5.02	19.20	290.0	1,110.0	<2.00	<7.66	204.0	782.0
Mallard, immature	Liver/kidney	<0.20	<0.78	24.90	96.50	335.0	1,300.0	<2.00	<7.75	214.0	829.0
Mallard, immature	Liver/kidney	<0.20	<0.86	18.40	79.00	171.0	736.0	<2.00	<8.58	222.0	953.0
Mallard, immature	Liver/kidney	<0.20	<0.83	54.40	226.00	324.0	1,350.0	<2.00	<8.30	218.0	905.0
Mallard, immature	Liver/kidney	<0.20	<0.72	10.20	36.70	187.0	676.0	<2.00	<7.22	222.0	801.0
American coot, immature	Liver/kidney	<0.20	<0.84	6.24	26.30	249.0	1,050.0	<2.00	<8.44	172.0	726.0
American coot, immature	Liver/kidney	<0.20	<0.78	18.10	70.60	129.0	504.0	<2.00	<7.81	200.0	781.0
American coot, immature	Liver/kidney	<0.20	<0.94	15.30	72.20	205.0	967.0	<2.00	<9.43	210.0	991.0
American coot, immature	Liver/kidney	<0.20	<0.83	7.18	29.70	204.0	842.0	<2.00	<8.26	178.0	736.0
Black-necked stilt, immature	Liver/kidney	<0.20	<0.75	2.54	9.51	134.0	502.0	<2.00	<7.49	208.0	779.0
Black-necked stilt, immature	Liver/kidney	<0.20	<0.83	3.52	14.60	115.0	477.0	<2.00	<8.30	208.0	863.0
Black-necked stilt, immature	Liver/kidney	<0.20	<0.83	3.84	15.90	150.0	622.0	<2.00	<8.30	188.0	780.0
Avocet, immature	Liver/kidney	<0.20	<0.85	2.94	12.60	88.2	377.0	<2.00	<8.55	104.0	444.0
Mallard	Egg	<0.20	<0.63	1.28	4.05	37.6	119.0	<2.00	<6.33	128.0	405.0
Mallard	Egg	<0.20	<0.66	0.66	2.19	45.2	150.0	<2.00	<6.62	112.0	371.0
Mallard	Egg	<0.20	<0.59	1.34	3.96	47.6	141.0	<2.00	<5.92	114.0	337.0
Mallard	Egg	<0.20	<0.54	0.66	1.79	40.6	110.0	<2.00	<5.42	112.0	304.0
Mallard	Egg	<0.20	<0.64	1.22	3.92	25.0	80.4	<2.00	<6.43	118.0	379.0
American coot	Egg	<0.20	<0.72	0.78	2.82	21.4	77.3	<2.00	<7.22	112.0	404.0
American coot	Egg	<0.20	<0.75	0.52	1.95	17.6	66.2	<2.00	<7.52	116.0	436.0
American coot	Egg	<0.20	<0.76	0.76	2.90	26.6	102.0	<2.00	<7.63	120.0	458.0
American coot	Egg	<0.20	<0.76	0.52	1.98	19.6	74.5	<2.00	<7.60	118.0	449.0
American coot	Egg	<0.20	<0.68	0.70	2.40	26.8	91.8	<2.00	<6.85	112.0	384.0
Black-necked stilt	Egg	<0.20	<0.45	1.52	3.45	62.8	143.0	<2.00	<4.55	144.0	327.0
Black-necked stilt	Egg	<0.20	<0.63	1.36	4.29	27.6	87.1	<2.00	<6.31	108.0	341.0
Black-necked stilt	Egg	<0.20	<0.68	1.34	4.53	30.2	102.0	<2.00	<6.76	110.0	372.0
Black-necked stilt	Egg	<0.20	<0.66	1.22	4.01	38.6	127.0	<2.00	<6.58	132.0	434.0
Black-necked stilt	Egg	<0.20	<0.71	1.14	4.07	35.0	125.0	<2.00	<7.14	108.0	386.0

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Continued

Sample	Matrix	Chromium µg/g (wet)	Chromium µg/g (dry)	Copper µg/g (wet)	Copper µg/g (dry)	Iron µg/g (wet)	Iron µg/g (dry)	Lead µg/g (wet)	Lead µg/g (dry)	Magnesium µg/g (wet)	Magnesium µg/g (dry)
Carp	Whole body	<0.20	<1.00	0.56	2.80	40.4	202.0	<2.0	<10.00	336.0	1,680.0
Carp	Whole body	<0.20	<0.99	1.24	6.14	51.0	252.0	<2.0	<9.90	290.0	1,440.0
Carp	Whole body	<0.20	<1.08	0.92	4.97	90.0	486.0	<2.0	<10.80	342.0	1,850.0
Carp	Whole body	<0.20	<0.83	5.36	22.20	46.6	193.0	<2.0	<8.30	274.0	1,140.0
Centrarchidae	Whole body	<0.20	<0.96	0.82	3.92	28.6	137.0	<2.0	<9.57	368.0	1,760.0
Centrarchidae	Whole body	<0.20	<0.85	0.68	2.89	17.8	75.7	<2.0	<8.51	316.0	1,340.0
Centrarchidae	Whole body	0.26	1.21	1.44	6.70	63.0	293.0	<2.0	<9.30	370.0	1,720.0
Centrarchidae	Whole body	0.28	1.35	0.82	3.94	66.0	317.0	<2.0	<9.62	330.0	1,590.0
Threadfin shad	Whole body	1.86	7.29	1.10	4.31	256.0	1,000.0	<2.0	<7.84	398.0	1,561.0
Mosquitofish	Whole body	<0.20	<0.92	1.40	6.45	57.6	265.0	<2.0	<9.22	382.0	1,760.0
Mosquitofish	Whole body	<0.20	<0.91	2.36	10.70	56.2	255.0	<2.0	<9.09	380.0	1,730.0
Brown bullhead	Whole body	<0.20	<0.97	1.02	4.93	35.8	173.0	<2.0	<9.66	280.0	1,350.0
Brown bullhead	Whole body	<0.20	<1.15	1.32	7.59	42.0	241.0	<2.0	<11.50	250.0	1,440.0
Brown bullhead	Whole body	<0.20	<1.14	0.90	5.11	34.0	193.0	<2.0	<11.40	312.0	1,770.0
Dragonfly/damselfly	Whole body	<0.20	<1.14	4.74	26.90	73.4	417.0	<2.0	<11.40	274.0	1,560.0
Dragonfly/damselfly	Whole body	<0.20	<1.10	2.32	12.70	68.4	376.0	<2.0	<11.00	244.0	1,340.0
Dragonfly/damselfly	Whole body	<0.20	<1.17	4.00	23.40	98.6	577.0	<2.0	<11.70	288.0	1,680.0
Dragonfly/damselfly	Whole body	<0.20	<1.12	3.32	18.70	76.0	427.0	<2.0	<11.20	286.0	1,610.0
Crayfish	Whole body	<0.20	<0.70	10.90	38.40	57.6	203.0	<2.0	<7.04	854.0	3,010.0
Crayfish	Whole body	<0.20	<0.78	33.90	132.00	221.0	860.0	<2.0	<7.78	552.0	2,150.0
Crayfish	Whole body	<0.20	<0.71	11.30	40.20	48.8	174.0	<2.0	<7.12	704.0	2,510.0
Crayfish	Whole body	<0.20	<1.08	14.50	78.00	74.0	398.0	<2.0	<10.80	434.0	2,330.0
Order Hemiptera	Whole body	0.56	1.51	9.24	24.80	566.0	1,520.0	<2.0	<5.38	490.0	1,320.0
Order Hemiptera	Whole body	<0.20	<0.72	11.30	40.60	192.0	691.0	<2.0	<7.19	310.0	1,120.0
Order Hemiptera	Whole body	<0.20	<0.60	5.50	16.60	118.0	355.0	<2.0	<6.02	316.0	952.0
Hemiptera/Coleoptera	Whole body	<0.20	<0.78	5.18	20.20	147.0	572.0	<2.0	<7.78	380.0	1,480.0
Leafy pondweed (P. foliosus)	Plant	0.32	2.00	1.12	7.00	280.0	1,750.0	<2.0	<12.50	648.0	4,050.0
Horned pondweed (Z. palustris)	Plant	0.30	2.80	1.38	12.90	416.0	1,890.0	<2.0	<18.70	458.0	4,280.0
Horned pondweed (Z. palustris)	Plant	0.32	2.76	2.06	17.80	234.0	1,020.0	<2.0	<17.20	456.0	3,930.0
Horned pondweed (Z. palustris)	Plant	<0.20	<2.25	1.08	12.10	322.0	3,620.0	<2.0	<22.50	454.0	5,100.0

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Continued

Sample	Matrix	Manganese µg/g (wet)	Manganese µg/g (dry)	Mercury µg/g (wet)	Mercury µg/g (dry)	Molybdenum µg/g (wet)	Molybdenum µg/g (dry)	Nickel µg/g (wet)	Nickel µg/g (dry)	Selenium µg/g (wet)	Selenium µg/g (dry)
Mallard, adult	Liver/kidney	4.10	16.40	0.226	0.904	<1.00	<4.00	<0.80	<3.20	1.90	7.60
Mallard, adult	Liver/kidney	3.04	11.50	0.238	0.902	1.48	5.60	1.26	4.77	2.40	9.10
Mallard, adult	Liver/kidney	2.84	11.90	0.061	0.256	<1.00	<4.20	<0.80	<3.36	0.80	3.40
Mallard, adult	Liver/kidney	4.62	17.20	0.167	0.623	1.08	4.03	<0.80	<2.99	1.70	6.30
American coot, adult	Liver/kidney	3.86	15.20	0.158	0.622	<1.00	<3.94	<0.80	<3.15	0.80	3.10
American coot, adult	Liver/kidney	2.82	10.50	0.216	0.806	<1.00	<3.73	<0.80	<2.99	0.90	3.40
American coot, adult	Liver/kidney	4.70	17.00	0.167	0.603	2.62	9.46	<0.80	<2.89	0.70	2.50
American coot, adult	Liver/kidney	3.42	13.50	0.125	0.492	<1.00	<3.94	1.18	4.65	0.70	2.80
Black-necked stilt, adult	Liver/kidney	3.50	13.40	0.196	0.748	<1.00	<3.82	<0.80	<3.05	2.10	8.00
Black-necked stilt, adult	Liver/kidney	4.26	16.10	0.440	1.670	<1.00	<3.79	<0.80	<3.03	2.10	8.00
Black-necked stilt, adult	Liver/kidney	3.40	13.60	0.190	0.760	<1.00	<4.00	<0.80	<3.20	1.80	7.20
Black-necked stilt, adult	Liver/kidney	4.00	15.30	0.425	1.630	<1.00	<3.83	<0.80	<3.07	1.80	6.90
Mallard, immature	Liver/kidney	3.94	15.30	0.183	0.709	<1.00	<3.88	1.92	7.44	1.30	5.00
Mallard, immature	Liver/kidney	4.50	19.30	0.310	1.330	<1.00	<4.29	<0.80	<3.43	1.30	5.60
Mallard, immature	Liver/kidney	4.70	19.50	0.168	0.697	<1.00	<4.15	1.98	8.22	1.30	5.40
Mallard, immature	Liver/kidney	4.62	16.70	0.134	0.484	1.04	3.75	<0.80	<2.89	1.30	4.70
American coot, immature	Liver/kidney	4.08	17.20	0.108	0.456	<1.00	<4.22	3.94	16.60	0.30	1.30
American coot, immature	Liver/kidney	4.66	18.20	0.234	0.914	<1.00	<3.91	<0.80	<3.12	0.50	2.00
American coot, immature	Liver/kidney	3.66	17.30	0.155	0.731	<1.00	<4.72	<0.80	<3.77	0.40	1.90
American coot, immature	Liver/kidney	4.70	19.40	0.148	0.612	<1.00	<4.13	2.16	8.93	0.30	1.20
Black-necked stilt, immature	Liver/kidney	2.88	10.80	0.058	0.217	<1.00	<3.75	1.26	4.72	1.00	3.70
Black-necked stilt, immature	Liver/kidney	2.68	11.10	0.055	0.228	<1.00	<4.15	26.80	111.00	0.70	2.90
Black-necked stilt, immature	Liver/kidney	2.24	9.29	0.056	0.232	<1.00	<4.15	5.56	23.10	0.90	3.70
Avocet, immature	Liver/kidney	1.46	6.24	No data	No data	<1.00	<4.27	15.60	66.70	0.20	0.85
Mallard	Egg	1.12	3.54	0.038	0.120	<1.00	<3.16	<0.80	<2.53	0.30	0.95
Mallard	Egg	1.14	3.77	0.034	0.113	<1.00	<3.31	<0.80	<2.65	0.30	0.99
Mallard	Egg	1.22	3.61	0.096	0.284	<1.00	<2.96	<0.80	<2.37	0.40	1.20
Mallard	Egg	0.88	2.38	0.046	0.125	<1.00	<2.71	<0.80	<2.17	0.40	1.10
Mallard	Egg	0.48	1.54	0.076	0.244	<1.00	<3.22	<0.80	<2.57	0.30	0.96
American coot	Egg	0.38	1.37	0.040	0.144	<1.00	<3.61	<0.80	<2.89	0.20	0.72
American coot	Egg	0.80	3.01	0.055	0.207	<1.00	<3.76	<0.80	<3.01	0.20	0.75
American coot	Egg	1.24	4.73	0.363	1.000	<1.00	<3.82	<0.80	<3.05	0.20	0.76
American coot	Egg	1.10	4.18	0.058	0.221	<1.00	<3.80	<0.80	<3.04	0.20	0.76
American coot	Egg	1.02	3.49	0.042	0.144	<1.00	<3.42	<0.80	<2.74	<0.10	<0.34
Black-necked stilt	Egg	1.00	2.27	0.084	0.191	<1.00	<2.28	<0.80	<1.82	0.80	1.80
Black-necked stilt	Egg	1.06	3.34	0.320	1.010	<1.00	<3.15	<0.80	<2.52	0.80	2.50
Black-necked stilt	Egg	0.44	1.49	0.112	0.378	<1.00	<3.38	<0.80	<6.76	0.50	1.70
Black-necked stilt	Egg	0.74	2.43	0.088	0.289	<1.00	<3.29	<0.80	<2.63	0.60	2.00
Black-necked stilt	Egg	0.42	1.50	0.130	0.464	<1.00	<3.57	<0.80	<2.86	0.60	2.10

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Continued

Sample	Matrix	Manganese µg/g (wet)	Manganese µg/g (dry)	Mercury µg/g (wet)	Mercury µg/g (dry)	Molybdenum µg/g (wet)	Molybdenum µg/g (dry)	Nickel µg/g (wet)	Nickel µg/g (dry)	Selenium µg/g (wet)	Selenium µg/g (dry)
Carp	Whole body	2.06	10.30	<0.025	<0.125	<1.00	<5.00	<0.80	<4.00	0.20	1.00
Carp	Whole body	5.20	25.70	<0.025	<0.124	<1.00	<4.95	<0.80	<3.96	0.20	0.99
Carp	Whole body	7.86	42.50	<0.025	<0.135	<1.00	<5.41	<0.80	<4.32	0.20	1.10
Carp	Whole body	1.30	5.39	<0.025	<0.104	<1.00	<4.15	<0.80	<3.32	0.20	0.83
Centrarchidae	Whole body	4.90	23.40	0.046	0.220	<1.00	<4.78	<0.80	<3.83	0.20	0.96
Centrarchidae	Whole body	1.50	6.38	0.025	0.106	<1.00	<4.26	<0.80	<3.40	0.30	1.30
Centrarchidae	Whole body	5.88	27.30	0.088	0.409	<1.00	<4.65	<0.80	<3.72	0.20	0.93
Centrarchidae	Whole body	4.34	20.90	0.058	0.279	<1.00	<4.81	<0.80	<3.85	0.20	0.96
Threadfin shad	Whole body	23.30	91.40	<0.025	<0.098	<1.00	<3.92	0.86	3.37	0.20	0.78
Mosquitofish	Whole body	7.10	32.70	0.056	0.258	<1.00	<4.61	<0.80	<3.69	0.20	0.92
Mosquitofish	Whole body	12.00	54.40	0.052	0.236	<1.00	<4.55	<0.80	<3.64	0.20	0.91
Brown bullhead	Whole body	1.66	8.02	0.060	0.290	<1.00	<4.83	<0.80	<3.86	0.30	1.40
Brown bullhead	Whole body	3.48	20.00	0.070	0.402	<1.00	<5.75	<0.80	<4.60	0.30	1.70
Brown bullhead	Whole body	6.14	34.90	0.027	0.153	<1.00	<5.68	<0.80	<4.55	0.10	0.57
Dragonfly/damselfly	Whole body	7.50	42.60	0.034	0.193	<1.00	<5.68	<0.80	<4.55	0.20	1.10
Dragonfly/damselfly	Whole body	12.90	70.90	<0.025	<0.137	<1.00	<5.49	<0.80	<4.40	0.20	1.10
Dragonfly/damselfly	Whole body	29.70	174.00	<0.025	<0.146	<1.00	<5.85	<0.80	<4.68	0.20	1.20
Dragonfly/damselfly	Whole body	71.30	401.00	0.032	0.180	<1.00	<5.62	<0.80	<4.49	0.20	1.10
Crayfish	Whole body	36.40	128.00	<0.025	<0.088	<1.00	<3.52	<0.80	<2.82	<0.10	<0.35
Crayfish	Whole body	50.70	197.00	<0.025	<0.097	<1.00	<3.89	<0.80	<3.11	0.20	0.78
Crayfish	Whole body	29.50	105.00	<0.025	<0.089	<1.00	<3.56	<0.80	<2.85	<0.10	<0.36
Crayfish	Whole body	90.80	488.00	<0.025	<0.134	<1.00	<5.38	<0.80	<4.30	0.10	0.54
Order Hemiptera	Whole body	27.30	73.40	0.040	0.108	<1.00	<2.69	<0.80	<2.15	<0.10	<0.27
Order Hemiptera	Whole body	23.90	86.00	0.055	0.198	<1.00	<3.60	<0.80	<2.88	0.10	0.36
Order Hemiptera	Whole body	12.00	36.10	0.068	0.205	<1.00	<3.01	<0.80	<2.41	<0.10	<0.30
Hemiptera/Coleoptera	Whole body	58.40	227.00	0.046	0.179	<1.00	<3.89	<0.80	<3.11	<0.10	<0.39
Leafy pondweed (P. foliosus)	Plant	82.00	512.00	<0.025	<0.156	<1.00	<6.25	<0.80	<5.00	<0.10	<0.62
Horned pondweed (Z. palustris)	Plant	208.00	1,940.00	<0.025	<0.234	<1.00	<9.35	<0.80	<7.48	<0.10	<0.93
Horned pondweed (Z. palustris)	Plant	102.00	881.00	<0.025	<0.216	<1.00	<8.62	1.18	10.20	<0.10	<0.86
Horned pondweed (Z. palustris)	Plant	230.00	2,590.00	0.056	0.629	<1.00	<11.20	<0.80	<8.99	<0.10	<1.10

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Continued

Sample	Matrix	Silver µg/g (wet)	Silver µg/g (dry)	Strontium µg/g (wet)	Strontium µg/g (dry)	Thallium µg/g (wet)	Thallium µg/g (dry)	Tin µg/g (wet)	Tin µg/g (dry)	Vanadium µg/g (wet)	Vanadium µg/g (dry)	Zinc µg/g (dry)	Zinc µg/g (dry)
Mallard, adult	Liver/kidney	<1.00	<4.00	0.32	1.28	<0.10	<0.40	2.22	8.88	<1.00	<4.00	34.00	136.00
Mallard, adult	Liver/kidney	<1.00	<3.79	0.28	1.06	<0.10	<0.38	4.02	15.20	<1.00	<3.79	48.80	185.00
Mallard, adult	Liver/kidney	<1.00	<4.20	0.22	0.92	<0.10	<0.42	3.10	13.00	<1.00	<4.20	28.30	119.00
Mallard, adult	Liver/kidney	<1.00	<3.73	0.30	1.12	<0.10	<0.37	2.70	10.10	<1.00	<3.73	40.80	152.00
American coot, adult	Liver/kidney	<1.00	<3.94	0.50	1.97	<0.10	<0.39	2.74	10.80	<1.00	<3.94	26.60	105.00
American coot, adult	Liver/kidney	<1.00	<3.73	<0.20	<0.75	<0.10	<0.37	2.54	9.48	<1.00	<3.73	28.90	108.00
American coot, adult	Liver/kidney	<1.00	<3.61	0.42	1.52	<0.10	<0.36	2.72	9.82	<1.00	<3.61	25.30	91.30
American coot, adult	Liver/kidney	<1.00	<3.94	<0.20	<0.79	<0.10	<0.39	2.44	9.61	<1.00	<3.94	30.20	119.00
Black-necked stilt, adult	Liver/kidney	<1.00	<3.82	0.30	1.14	<0.10	<0.38	2.70	10.30	<1.00	<3.82	19.20	73.30
Black-necked stilt, adult	Liver/kidney	<1.00	<3.79	0.22	0.83	<0.10	<0.38	2.66	10.10	<1.00	<3.79	21.80	82.70
Black-necked stilt, adult	Liver/kidney	<1.00	<4.00	0.64	2.56	<0.10	<0.40	2.22	8.88	<1.00	<4.00	19.60	78.60
Black-necked stilt, adult	Liver/kidney	<1.00	<3.83	<0.20	<0.77	<0.10	<0.38	2.72	10.40	<1.00	<3.83	23.40	89.70
Mallard, immature	Liver/kidney	<1.00	<3.88	0.30	1.16	<0.10	<0.39	2.64	10.20	<1.00	<3.88	28.70	111.00
Mallard, immature	Liver/kidney	<1.00	<4.29	1.34	5.75	<0.10	<0.43	2.16	9.27	<1.00	<4.29	28.40	122.00
Mallard, immature	Liver/kidney	<1.00	<4.15	0.44	1.83	<0.10	<0.41	2.64	11.00	<1.00	<4.15	36.20	150.00
Mallard, immature	Liver/kidney	<1.00	<3.61	0.58	2.09	<0.10	<0.36	2.80	10.10	<1.00	<3.61	30.60	111.00
American coot, immature	Liver/kidney	<1.00	<4.22	0.38	1.60	<0.10	<0.42	2.46	10.40	<1.00	<4.22	30.40	128.00
American coot, immature	Liver/kidney	<1.00	<3.91	0.34	1.33	<0.10	<0.39	2.50	9.77	<1.00	<3.91	37.90	148.00
American coot, immature	Liver/kidney	<1.00	<4.72	0.44	2.08	<0.10	<0.47	2.36	11.10	<1.00	<4.72	40.10	189.00
American coot, immature	Liver/kidney	<1.00	<4.13	0.32	1.32	<0.10	<0.41	2.58	10.70	<1.00	<4.13	30.00	124.00
Black-necked stilt, immature	Liver/kidney	<1.00	<3.75	0.28	1.05	<0.10	<0.37	2.80	10.50	<1.00	<3.75	19.40	72.70
Black-necked stilt, immature	Liver/kidney	<1.00	<4.15	0.44	1.83	<0.10	<0.41	2.66	11.00	<1.00	<4.15	18.40	76.30
Black-necked stilt, immature	Liver/kidney	<1.00	<4.15	0.24	1.00	<0.10	<0.41	2.88	12.00	<1.00	<4.15	18.50	76.80
Avocet, immature	Liver/kidney	<1.00	<4.27	0.54	2.31	<0.10	<0.43	1.60	6.84	<1.00	<4.27	9.42	40.30
Mallard	Egg	<1.00	<3.16	8.58	27.20	<0.10	<0.32	2.70	8.54	<1.00	<3.16	18.50	58.50
Mallard	Egg	<1.00	<3.31	7.56	25.00	<0.10	<0.33	2.72	9.01	<1.00	<3.31	18.50	61.20
Mallard	Egg	<1.00	<2.96	5.10	15.10	<0.10	<0.30	2.52	7.46	<1.00	<2.96	18.70	55.30
Mallard	Egg	<1.00	<2.71	8.08	21.90	<0.10	<0.27	2.78	7.53	<1.00	<2.71	22.20	60.20
Mallard	Egg	<1.00	<3.22	3.50	11.30	<0.10	<0.32	2.82	9.07	<1.00	<3.22	14.50	46.60
American coot	Egg	<1.00	<3.61	4.52	16.30	<0.10	<0.36	2.64	9.53	<1.00	<3.61	14.00	50.50
American coot	Egg	<1.00	<3.76	2.48	9.32	<0.10	<0.38	2.50	9.40	<1.00	<3.76	11.90	44.70
American coot	Egg	<1.00	<3.82	1.78	6.79	<0.10	<0.38	2.28	8.70	<1.00	<3.82	14.10	53.80
American coot	Egg	<1.00	<3.80	3.18	12.10	<0.10	<0.38	2.66	10.10	<1.00	<3.80	13.80	52.50
American Coot	Egg	<1.00	<3.42	6.92	23.70	<0.10	<0.34	2.54	8.70	<1.00	<3.42	17.70	60.60
Black-necked stilt	Egg	<1.00	<2.28	10.00	22.80	<0.10	<0.23	2.98	6.77	<1.00	<2.28	26.30	59.80
Black-necked stilt	Egg	<1.00	<3.15	4.34	13.70	<0.10	<0.32	2.36	7.44	<1.00	<3.15	16.60	52.40
Black-necked stilt	Egg	<1.00	<3.38	6.24	21.10	<0.10	<0.34	2.40	8.11	<1.00	<3.38	17.30	58.40
Black-necked stilt	Egg	<1.00	<3.29	6.82	22.40	<0.10	<0.33	2.46	8.09	<1.00	<3.29	15.90	52.30
Black-necked stilt	Egg	<1.00	<3.57	4.70	16.80	<0.10	<0.36	2.18	7.79	<1.00	<3.57	15.90	56.80

Table 21.--Trace elements in biological materials collected from the Bosque del Apache National Wildlife Refuge, 1988--Concluded

Sample	Matrix	Silver μg/g (wet)	Silver μg/g (dry)	Strontium μg/g (wet)	Strontium μg/g (dry)	Thallium μg/g (wet)	Thallium μg/g (dry)	Tin μg/g (wet)	Tin μg/g (dry)	Vanadium μg/g (wet)	Vanadium μg/g (dry)	Zinc μg/g (dry)	Zinc μg/g (dry)
Carp	Whole body	<1.00	<5.00	40.80	204.00	<0.10	<0.50	2.88	14.40	<1.00	<5.00	40.30	202.00
Carp	Whole body	<1.00	<4.95	24.70	122.00	<0.10	<0.50	3.48	17.20	<1.00	<4.95	49.50	245.00
Carp	Whole body	<1.00	<5.41	63.20	342.00	<0.10	<0.54	1.70	9.19	<1.00	<5.41	33.30	180.00
Carp	Whole body	<1.00	<4.15	19.00	78.80	<0.10	<0.41	3.18	13.20	<1.00	<4.15	33.40	139.00
Centrarchidae	Whole body	<1.00	<4.78	14.80	200.00	<0.10	<0.48	2.26	10.80	<1.00	<4.78	21.30	102.00
Centrarchidae	Whole body	<1.00	<4.26	26.30	112.00	<0.10	<0.43	2.20	9.36	<1.00	<4.26	15.00	63.80
Centrarchidae	Whole body	<1.00	<4.65	48.00	223.00	<0.10	<0.47	2.34	10.90	<1.00	<4.65	27.70	129.00
Centrarchidae	Whole body	<1.00	<4.81	37.70	181.00	<0.10	<0.48	2.20	10.60	<1.00	<4.81	23.90	115.00
Threadfin shad	Whole body	<1.00	<3.92	30.30	119.00	<0.10	<0.39	2.12	8.31	<1.00	<3.92	13.40	52.50
Mosquitofish	Whole body	<1.00	<4.61	37.50	173.00	<0.10	<0.46	2.44	11.20	<1.00	<4.61	38.20	176.00
Mosquitofish	Whole body	<1.00	<4.55	36.50	166.00	<0.10	<0.45	2.24	10.20	<1.00	<4.55	41.60	189.00
Brown bullhead	Whole body	<1.00	<4.83	17.40	83.90	<0.10	<0.48	2.50	12.10	<1.00	<4.83	21.20	102.00
Brown bullhead	Whole body	<1.00	<5.75	16.70	96.10	<0.10	<0.57	2.20	12.60	<1.00	<5.75	17.50	101.00
Brown bullhead	Whole body	<1.00	<5.68	33.80	192.00	<0.10	<0.57	1.94	11.00	<1.00	<5.68	16.20	92.00
Dragonfly/damselfly	Whole body	<1.00	<5.68	5.26	29.90	<0.10	<0.57	4.20	23.90	<1.00	<5.68	19.40	110.00
Dragonfly/damselfly	Whole body	<1.00	<5.49	2.76	15.20	<0.10	<0.55	4.98	27.40	<1.00	<5.49	17.60	96.70
Dragonfly/damselfly	Whole body	<1.00	<5.85	6.34	37.10	<0.10	<0.58	6.06	35.40	<1.00	<5.85	25.10	147.00
Dragonfly/damselfly	Whole body	<1.00	<5.62	6.28	35.30	<0.10	<0.56	5.04	28.30	<1.00	<5.62	18.40	103.00
Crayfish	Whole body	<1.00	<3.52	270.00	951.00	<0.10	<0.35	5.32	18.70	<1.00	<3.52	17.90	63.00
Crayfish	Whole body	<1.00	<3.89	165.00	642.00	<0.10	<0.39	6.62	25.80	<1.00	<3.89	23.60	91.80
Crayfish	Whole body	<1.00	<3.56	225.00	801.00	<0.10	<0.36	6.80	24.20	<1.00	<3.56	20.70	73.70
Crayfish	Whole body	<1.00	<5.38	126.00	677.00	<0.10	<0.54	2.68	14.40	<1.00	<5.38	14.90	80.10
Order Hemiptera	Whole body	<1.00	<2.69	19.70	53.00	<0.10	<0.27	3.26	8.76	<1.00	<2.69	39.20	105.00
Order Hemiptera	Whole body	<1.00	<3.60	16.10	57.90	<0.10	<0.36	3.10	11.20	<1.00	<3.60	30.20	109.00
Order Hemiptera	Whole body	<1.00	<3.01	6.80	20.50	<0.10	<0.30	3.84	11.60	<1.00	<3.01	36.30	109.00
Hemiptera/Coleoptera	Whole body	<1.00	<3.89	11.30	44.00	<0.10	<0.39	2.54	9.88	<1.00	<3.89	41.70	162.00
Leafy pondweed (P. foliosus)	Plant	<1.00	<6.25	98.30	614.00	<0.10	<0.62	1.10	6.88	<1.00	<6.25	3.44	21.50
Horned pondweed (Z. palustris)	Plant	<1.00	<9.35	54.40	508.00	<0.10	<0.93	<1.00	<9.35	<1.00	<9.35	3.52	32.90
Horned pondweed (Z. palustris)	Plant	<1.00	<8.62	47.00	405.00	<0.10	<0.86	<1.00	<8.62	<1.00	<8.62	4.06	35.00
Horned pondweed (Z. palustris)	Plant	<1.00	<11.20	51.40	577.00	<0.10	<1.10	<1.00	<11.20	<1.00	<11.20	3.00	33.70

[1] Locations shown in figure 6.

Table 22.—Geometric mean concentrations and concentration ranges for selected trace elements in bird tissue and bird eggs collected from the Bosque del Apache National Wildlife Refuge, 1988

[Results in micrograms per gram wet-weight. Values for eggs are from composite samples. —, no data; <, less than]

Sample	Geometric mean concentrations (concentration ranges)						Number of compos-ites
	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	
Bird livers and kidneys (combined)							
Mallard[1]	0.059 (0.038–0.072)	— (<0.1–0.12)	26.0 (3.98–60.0)	<2.0 (—)	0.19 (0.061–0.238)	1.8 (0.8–2.4)	4
Mallard[2]	0.063 (0.033–0.073)	— (<0.1–0.24)	21.65 (10.2–54.4)	<2.0 (—)	0.175 (0.134–0.31)	1.3 (1.3–1.3)	4
Coot[1]	0.24 (0.178–0.302)	— (<0.1–0.12)	7.28 (5.48–8.12)	<2.0 (—)	0.162 (0.125–0.216)	0.8 (0.7–0.9)	4
Coot[2]	0.145 (0.05–0.278)	— (<0.1–0.14)	11.24 (6.24–18.1)	<2.0 (—)	0.15 (0.108–0.234)	0.4 (0.3–0.5)	4
Black-necked stilt[1]	0.041 (0.024–0.046)	— (<0.1–0.10)	4.65 (4.12–5.3)	<2.0 (—)	0.31 (0.19–0.44)	1.95 (1.8–2.1)	4
Black-necked stilt[2]	0.036 (0.034–0.042)	— (<0.1–0.84)	3.52 (2.54–3.84)	<2.0 (—)	0.56 (0.055–0.058)	0.9 (0.7–1.0)	4
Avocet[2]	0.032 (—)	0.16 (—)	2.94 (—)	<2.0 (—)	— (—)	0.2 (—)	1
Bird eggs							
Mallard	0.03 (0.026–0.032)	<0.1	1.07 (0.66–1.28)	<2.0	0.053 (0.034–0.096)	0.35 (0.30–0.40)	5
Coot	0.073 (0.052–0.098)	<0.1	0.70 (0.52–0.78)	<2.0	0.051 (0.04–0.363)	0.2 (<0.1–0.2)	5
Black-necked stilt	0.025 (0.022–0.030)	<0.1	1.30 (1.14–1.52)	<2.0	0.11 (0.084–0.32)	0.66 (0.5–0.8)	5

[1]Adult developmental stage.
[2]Immature developmental stage.

Table 23.—Geometric mean concentrations and concentration ranges for selected trace elements in fish, aquatic invertebrates, and plants collected from the Bosque del Apache National Wildlife Refuge, 1988

[Results in micrograms per gram wet-weight. Values are from composite samples. <, less than; —, no data]

Sample	Geometric mean concentrations (concentration ranges)						Number of composites
	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	
Fish							
Carp	0.1 (0.084–0.22)	<0.1 (—)	2.0 (0.56–5.36)	<2.0 (—)	— (<0.025–<0.025)	0.2 (0.2–0.2)	4
Panfish (Centrarchidae)	0.09 (0.078–0.113)	<0.1 (—)	0.98 (0.68–1.4)	<2.0 (—)	0.05 (0.025–0.088)	0.22 (0.2–0.3)	4
Threadfin shad	0.598 (—)	<0.1 (—)	1.1 (—)	<2.0 (—)	<0.025 (—)	0.2 (—)	1
Mosquitofish	0.16–0.16 (0.152–0.172)	<0.1 (—)	1.79–1.79 (1.4–2.3)	<2.0 (—)	0.054 (0.052–0.056)	0.2 0.2–0.2	2
Brown bullhead	0.037 (0.028–0.054)	<0.1 (—)	1.08 (0.9–1.32)	<2.0 (—)	0.05 (0.027–0.07)	0.2 (0.1–0.3)	3
Aquatic invertebrates							
Dragonfly/damselfly (*Odanata* Sp.)	0.325 (0.24–0.42)	<0.1 (—)	3.59 (2.32–4.74)	<2.0 (—)	— (<0.025–0.034)	0.2 (0.2–0.2)	4
Order Hemiptera	0.215 (0.134–0.296)	<0.1 (—)	8.68 (5.5–11.3)	<2.0 (—)	0.05 (0.04–0.068)	— (<0.1–0.1)	3
Hemiptera Coleoptera	0.68 (—)	<0.1 (—)	5.18 (—)	<2.0 (—)	0.046 (—)	<0.1 (—)	1
Crayfish	0.57 (0.48–0.725)	— (<0.1–1.76)	17.65 (10.9–33.9)	<2.0 (—)	— (0.025–<0.025)	— (<0.1–0.2)	4
Plants							
Leafy pondweed (P. foliosus)	0.69 (—)	<0.1 (—)	1.12 (—)	<2.0 (—)	<0.025 (—)	<0.1 (—)	1
Horned pondweed (Z. palustris)	0.65 (0.086–0.765)	<0.1 (—)	1.5 (1.08–2.06)	<2.0 (—)	— (<0.025–0.056)	— (<0.1–<0.1)	3

Table 24.—Organochlorine residues in birds and fish collected from the Bosque del Apache National Wildlife Refuge, 1986

[Results in micrograms per gram wet-weight and dry-weight; ND, not detected]

Organochlorine compound	Collection site[1] (biological sample)														
	18BE (coot)		18BW (coot)		18D (coot)		24C (coot)		18BE (carp)		25A (carp)	Canal (minnow carp)	Bosque del Apache National Wildlife Refuge (carp)	25A (brown bullhead)	25A (green sunfish)
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Dry	Dry	Dry	Dry	Dry
HCB		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
BHC (total)		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Alpha-BHC		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Gamma-BHC		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Beta-BHC		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Delta-BHC		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Oxychlordane		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Heptachlor epoxide		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Gamma-chlordane		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Trans-nonachlor		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Toxaphene		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
PCB's (total)		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
o,p'-DDE		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Gamma-chlordane		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
p,p'-DDE	0.003	0.01	0.003	0.01	0.006	0.02	0.04	0.12	0.002	0.01	ND	ND	ND	ND	ND
Dieldrin		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
o,p'-DDD		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Endrin		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
cis-Nonachlor		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
o,p'-DDT		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
o,p'-DDD		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
p,p'-DDT		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Mirex		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Dacthal		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Dicofol		ND		ND		ND		ND		ND	ND	ND	ND	ND	ND
Moisture content (percent)		72.0		68.4		69.0		64.0		75.8	72.4	76.0	78.4	77.4	75.2

[1]Locations shown in figure 6.

Table 25.--Organochlorine residues in composite samples of plants collected from the Bosque del Apache National Wildlife Refuge, 1986

[Results in micrograms per gram dry-weight; ND, not detected]

Organochlorine compound	Collection site[1] (plant)			
	18BE (bullrush)	18BE (curlyleaf pondweed)	25A (coontail)	25A (sedge)
HCB	ND	ND	ND	ND
BHC (total)	ND	ND	ND	ND
Alpha-BHC	ND	ND	ND	ND
Gamma-BHC	ND	ND	ND	ND
Beta-BHC	ND	ND	ND	ND
Delta-BHC	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND
Gamma-chlordane	ND	ND	ND	ND
Trans-nonachlor	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND
PCB's (total)	ND	ND	ND	ND
o,p'-DDE	ND	ND	ND	ND
Alpha-chlordane	ND	ND	ND	ND
p,p'-DDE	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND
o,p'-DDD	ND	ND	ND	ND
Endrin	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND
o,p'-DDT	ND	ND	ND	ND
p,p'-DDD	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND
Mirex	ND	ND	ND	ND
Dacthal	ND	ND	ND	ND
Dicofol	ND	ND	ND	ND
Moisture content (percent)	55.8	91.4	90.4	87.8

[1] Locations shown in figure 6.

Table 26.—Organochlorine residues in biological samples collected from the Bosque del Apache National Wildlife Refuge, 1988

[Results in micrograms per gram wet-weight; ND, not detected]

Collection sites [1]	Sample	Oxy-chlor-dane	p,p,'DDE	p,p'DDD	p,p'DDT	Total DDT homologs	PCB (CL-5)	PCB (CL-7)	PCB (CL-8)
18A, 18BE, triangle	Black-necked stilt (adult)[2]	ND	2.49	0.10	0.08	2.67	ND	0.20	0.18
18BW	Black-necked stilt (immature)[2]	ND	0.08	ND	ND	0.08	ND	ND	ND
15B, 24C	Mallard egg[2]	ND	0.07	ND	ND	0.70	ND	ND	ND
18D, 24C	Coot egg[2]	ND	0.27	ND	ND	0.27	ND	ND	ND
18BW	Black-necked stilt egg	0.15	2.29	ND	ND	2.29	ND	ND	ND
25A	Threadfin shad	ND	0.07	ND	ND	0.07	ND	ND	ND
18D, 25A	Brown bullhead	ND	ND	ND	ND	ND	0.15	ND	ND

[1] Locations shown in figure 6.
[2] Composite sample.

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