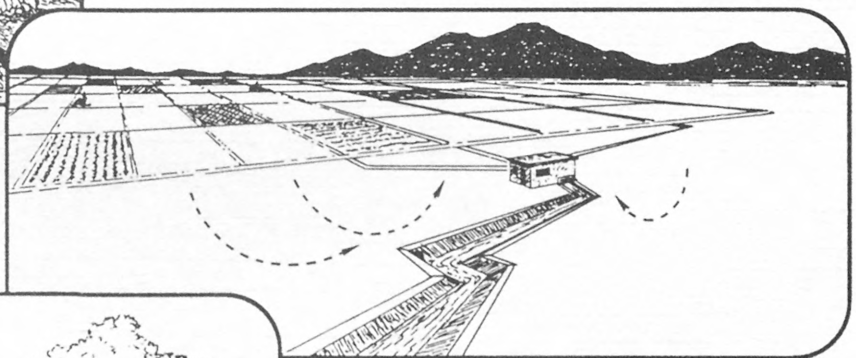
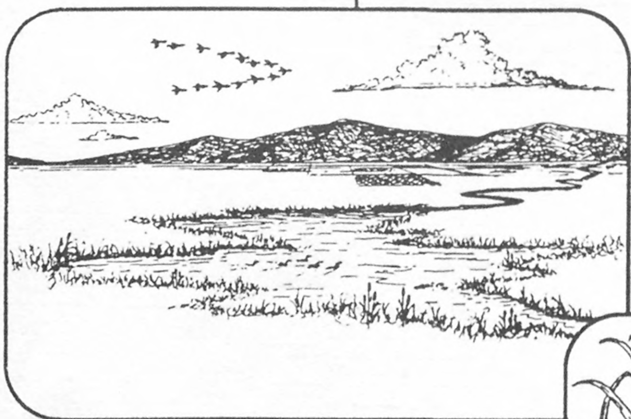
Field Screening of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage In and Near Walker River Indian Reservation, Nevada, 1994-95





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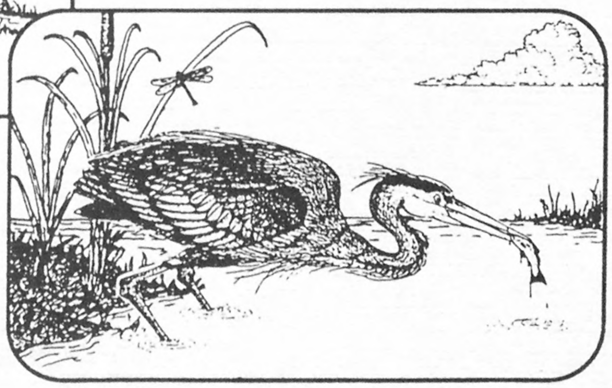

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By Carl E. Thodal, U.S. Geological Survey, and Peter L. Tuttle, U.S. Fish and Wildlife Service

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U.S. Geological Survey
U.S. Fish and Wildlife Service
Bureau of Indian Affairs and
Bureau of Reclamation

Carson City, Nevada
1996

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per year (ft/yr)	0.3048	meter per year
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square foot (ft^2)	0.09290	square meter
square mile (mi^2)	2.590	square kilometer

Temperature: Degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by using the formula °F = [1.8(°C)]+32.

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called "Sea-Level Datum of 1929"), which is derived from a general adjustment of the first-order leveling networks of the United States and Canada.

Water-quality abbreviations used in this report

mg/L	milligram per liter
μg/g	microgram per gram
μg/L	microgram per liter
μm	micrometer
μS/cm	microsiemens per centimeter at 25 degrees Celsius

Field Screening of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage In and Near Walker River Indian Reservation, Nevada, 1994-95

By Carl E. Thodal, U.S. Geological Survey, *and* Peter L. Tuttle, U.S. Fish and Wildlife Service

ABSTRACT

A study was begun in 1994 to determine whether the quality of irrigation drainage from the Walker River Indian Reservation, Nevada, has caused or has potential to cause harmful effects on human health or on fish and wildlife, or may adversely affect the suitability of the Walker River for other beneficial uses. Samples of water, bottom sediment, and biota were collected during June-August 1994 (during a drought year) from sites upstream from and on the Walker River Indian Reservation for analyses of trace elements. Other analyses included physical characteristics, major dissolved constituents, selected species of water-soluble nitrogen and phosphorus, and selected pesticides in bottom sediment. Water samples were collected again from four sites on the Reservation in August 1995 (during a wetter-than-average year) to provide data for comparing extreme climatic conditions.

Water samples collected from the Walker River Indian Reservation in 1994 equaled or exceeded the Nevada water-quality standard or level of concern for at least one of the following: water temperature, pH, dissolved solids, un-ionized ammonia, phosphate, arsenic, boron, chromium, lead, and molybdenum; in 1995, only a single sample from one site exceeded a Nevada water-quality standard for molybdenum. Levels of concern for trace elements in bottom sediment collected in 1994 were equaled or exceeded for arsenic, iron, manganese, and zinc. Concentrations of organochlorine pesticide residues in bottom sediment were below analytical reporting limits. Levels of concern for trace-elements in samples of biota were equaled or exceeded for arsenic, boron, copper, and mercury. Results of toxicity testing indicate that only water samples from Walker Lake caused a toxic response in test bacteria.

Arsenic and boron concentrations in water, bottom sediment, and biological tissue exceeded levels of concern throughout the Walker River Basin, but most commonly in the lower Walker River Basin. Mercury also was elevated in several biological samples collected throughout the Basin, although concentrations in water and bottom sediment were below analytical reporting limits. Sources of arsenic, boron, and mercury in the Basin are uncertain, but ambient levels reported for a variety of sample matrices collected from western Nevada generally exceed ranges cited as natural background levels. Because these potentially toxic constituents exceeded concern levels in areas that do not directly receive irrigation drainage, concentrations measured in samples collected for this study may not necessarily be attributable to agricultural activities.

Diversion of river water for irrigation may have greater effects on beneficial uses of water and on fish and wildlife than does drainage from agricultural areas on the Reservation. In 1994, agricultural water consumption precluded dilution of ground-water seepage to the river channel. This resulted in concentrations of potentially toxic solutes that exceeded levels of concern. Diversion of irrigation water also may have facilitated leaching

of potentially toxic solutes from irrigated soil on the Reservation, but during this study all water applied for irrigation on the Reservation was either consumed by evapotranspiration or infiltrated to recharge shallow ground water. No irrigation drainage was found on the Reservation during this study. However, because 1994 samples of ground-water seepage to the Walker River channel exceeded at least six Nevada water-quality standards, water-quality problems may result should ground-water levels rise enough to cause ground-water discharge to the agricultural drain on the Reservation. Nevertheless, the potential for adverse effects from irrigation drainage on the Reservation is believed to be small because surface-water rights for the Walker River Indian Reservation amount to only 2 percent of total surface-water rights in the entire Walker River Basin.

INTRODUCTION

Background

Concern about the quality of irrigation drainage and its potentially adverse effects on human health, fish, and wildlife prompted the Department of the Interior (DOI) to identify DOI-sponsored projects and activities in the western United States that might have irrigation-induced water-quality problems. The Walker River Basin (fig. 1) was recognized in 1993 by the Bureau Coordinators for the National Irrigation Water Quality Program (NIWQP) as an area that receives drainage from a DOI irrigation project and may contain elevated concentrations of potentially harmful constituents. The Basin is hydrologically and geologically similar to nearby wetland areas previously investigated by NIWQP studies (Hoffman and others, 1990; Lico, 1992; Hallock and Hallock, 1993; Seiler and others, 1993). These investigations identified elevated levels of trace elements in water, sediment, and biota collected from agricultural drains, wetlands, and other aquatic areas associated with DOI agricultural projects. Soil and shallow ground water associated with pluvial lakebed deposits were identified as potential sources of trace elements and much of the area used for agriculture in the lower Walker River Basin occurs on similar deposits.

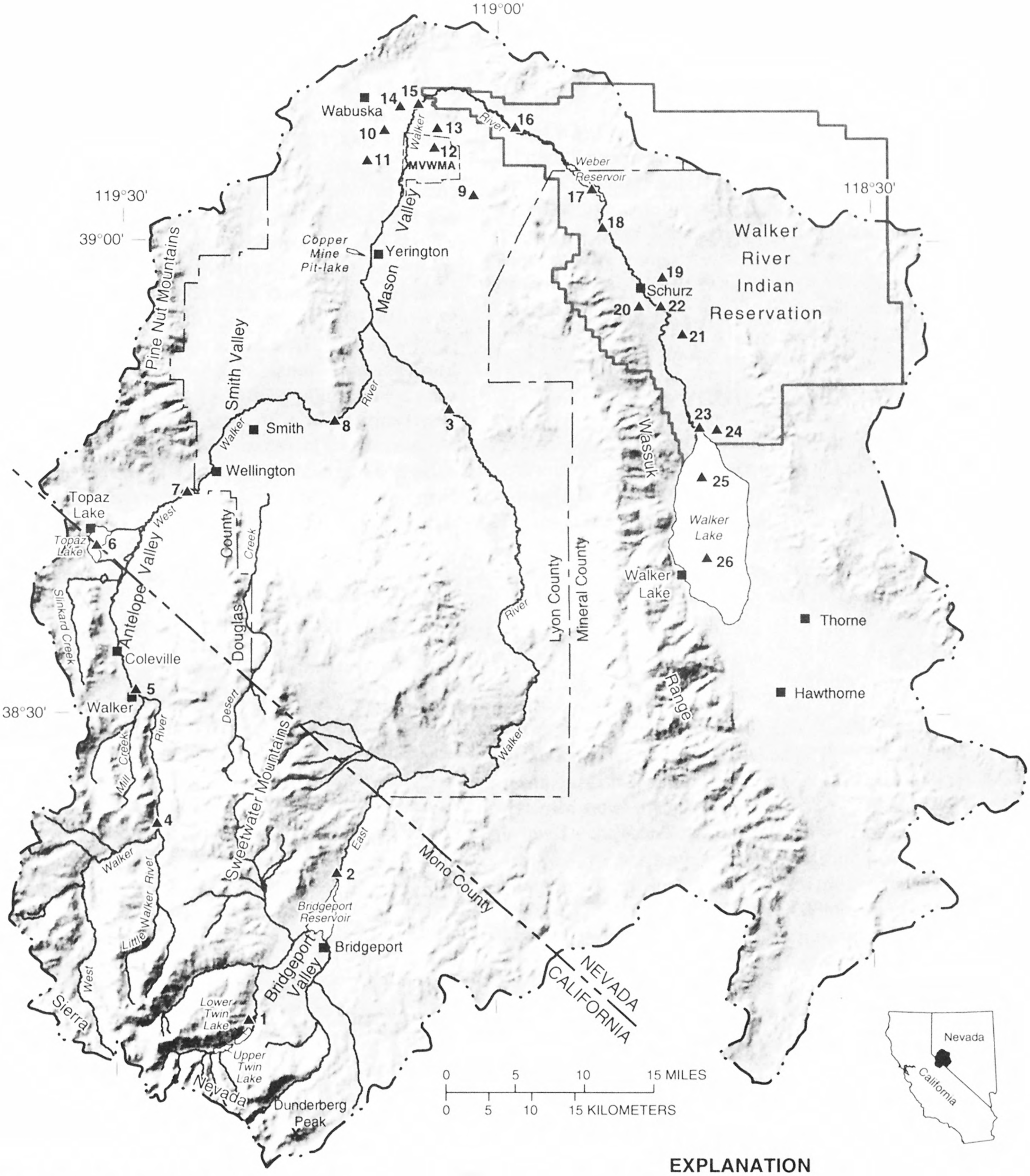
Irrigation-delivery facilities on the Walker River Indian Reservation are sponsored by the DOI; therefore, an interagency team was assembled to study irrigation drainage from the Reservation to help determine its potentially adverse effects to fish and wildlife and to other beneficial uses of the Walker River. Team members from the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service (USFWS), and the Bureau of Indian Affairs (BIA) collaborated on the field-screening study.

The objective of this study was to determine if DOI-sponsored irrigation on the Walker River Indian Reservation has caused or has the potential to cause significant harmful effects on human health, fish and wildlife, or has impaired other beneficial water uses. The study focused on irrigation drainage on the Walker River Indian Reservation, but, because irrigated agriculture is the dominant use of water throughout the Walker River Basin, samples also were collected at sites representative of irrigation drainage upstream from the Reservation and at Walker Lake.

Published reports and historical data were reviewed to characterize conditions throughout the Walker River Basin. Appropriate water, bottom-sediment, and biological samples from representative surface-water sites on and near the Walker River Indian Reservation were collected during the mid-irrigation season (May through August 1994) to identify areas with elevated concentrations of potentially toxic elements. Additional water samples from four sites on the Walker River Indian Reservation were collected in August 1995. The data represent two extremes in hydrologic conditions—below normal precipitation in 1994 and above normal precipitation in 1995.

Purpose and Scope

This report presents results of the study and describes the general physiography, hydrology, and biota that may be affected by irrigation drainage from the Walker River Indian Reservation. Concentrations of inorganic constituents in water, bottom sediment, and biota are compared to Nevada water-quality standards for protection of aquatic life and to guidelines established for bottom sediment and biota. In addition, samples of bottom sediment from the Reservation were collected and analyzed for organochlorine compounds.



Base from U.S. Geological Survey digital elevation data, 1:250,000, 1987, and digital data, 1:100,000, 1979-85; Universal Transverse Mercator projection, Zone 11. Shaded-relief base from 1:250,000-scale Digital Elevation Model; sun illumination from northwest at 30 degrees above horizon.

EXPLANATION

—·—·— **Basin boundary**

▲4 **Sampling site**—Number corresponds to table 2

MVWMA **Mason Valley Wildlife Management Area**

Figure 1. Location of sampling sites in Walker River Basin, Nevada and California, 1994-95.

Acknowledgments

The authors gratefully acknowledge E. Samuel Stegeman, Walker River Indian Reservation, Robert L. Hussey, Nevada Division of Wildlife, and Patrick Williams, Bureau of Indian Affairs, for providing information concerning the irrigation-water delivery system on the Walker River Indian Reservation, the fish and wildlife habitat of the Mason Valley Wildlife Management Area, and the history of irrigation on the Walker River Indian Reservation, respectively.

DESCRIPTION OF STUDY AREA

The Walker River Indian Reservation, which has the only irrigation project in the Walker River Basin sponsored by the DOI, is the focus of this study, but the study area includes all the Walker River Basin. In Nevada, the study area largely coincides with five Hydrographic Areas: Antelope Valley, Smith Valley, East Walker Area, Mason Valley, and Walker Lake Valley[1].

Physical Setting

The Walker River Basin is primarily in west-central Nevada, with its headwaters in the eastern Sierra Nevada of California (fig. 1). The area includes parts of Mono County in California and parts of Lyon, Mineral, and Douglas Counties in Nevada. The Walker River and its two principal tributaries, East and West Walker Rivers, are within a closed hydrologic basin draining an area of about 4,050 mi^2. The river system begins at the crest of the Sierra Nevada and flows north and northeast before bending sharply to the southeast at the north end of Mason Valley and ultimately discharging into Walker Lake. Mountain ranges in the Basin typically are 2,000 to 4,000 ft above the valley floors, which range from about 4,000 ft above sea level near Walker Lake to about 7,000 ft in the upland meadows of the Sierra Nevada. Dunderberg Peak in the Sierra Nevada, near Bridgeport, Calif., is the highest peak in the Basin at an altitude of 12,374 ft, and peaks in the Sweetwater Mountains and in the Wassuk Range exceed 11,000 ft.

The geology of the Walker River Basin is discussed by Ross (1961), Moore and Archibald (1969), and Willden and Speed (1974). Consolidated rocks include volcanic rocks (basalt, rhyolite, and andesite), quartz monzonite, and granodiorite, and ages range from Triassic to Quaternary. Sedimentary rocks of Mesozoic age are exposed in the southern and eastern parts of the Basin and in the southwestern part of the Basin exposed Mesozoic-age sedimentary rocks typically are metamorphosed. Sedimentary rocks also are found interbedded with some volcanic rocks. Valley-fill deposits are of Tertiary and Quaternary age deposited by glacial, alluvial, and lacustrine processes. Near-surface sediments consist of gravel, sand, silt, and clay, with sand- to clay-sized particles dominating. Clay deposits of lacustrine origin, which are at least 200 ft thick, are exposed near Weber Reservoir (Ross, 1961, p. 51).

The Walker River Indian Reservation occupies about 500 mi^2 in Mineral and Lyon Counties in west-central Nevada (Schaefer, 1980, p. 2). Within the Reservation, the Walker River extends from a point about one-half mile below the USGS stream-gaging station near Wabuska, Nev. (station number 10301500), to Walker Lake. The town of Schurz is the population center, with about 620 inhabitants in 1990 (U.S. Bureau of Census, 1992). Much of the Reservation is open range used for grazing cattle and about 2,400 acres have surface-water irrigation rights (representing about 2 percent of area in the Walker River Basin with surface-water rights for irrigation) used primarily for cultivation of alfalfa and pastureland. Weber Reservoir provides storage of irrigation water for the Walker River Indian Reservation.

Hydrologic Setting

Hydrology in the Walker River Basin is dominated by the Walker River and by winter precipitation that typically accumulates as snowpack in the Sierra Nevada. The Sierras also intercept most of the available atmospheric water and the eastern part of the Basin is relatively dry. A schematic diagram of the surface-water flow system for the Basin is shown in figure 2. Mean-annual flow measured at USGS stream-gaging stations for the 50 years from 1945-94 is about 106,000 acre-ft/yr at the East Walker River near

[1] Formal Hydrographic Areas in Nevada were delineated systematically by the U.S. Geological Survey and Nevada Division of Water Resources in the late 1960's for scientific and administrative purposes (Rush, 1968; Cardinalli and others, 1968). The official Hydrographic Area names, numbers, and geographic boundaries continue to be used in Geological Survey scientific reports and Division of Water Resources administrative activities.

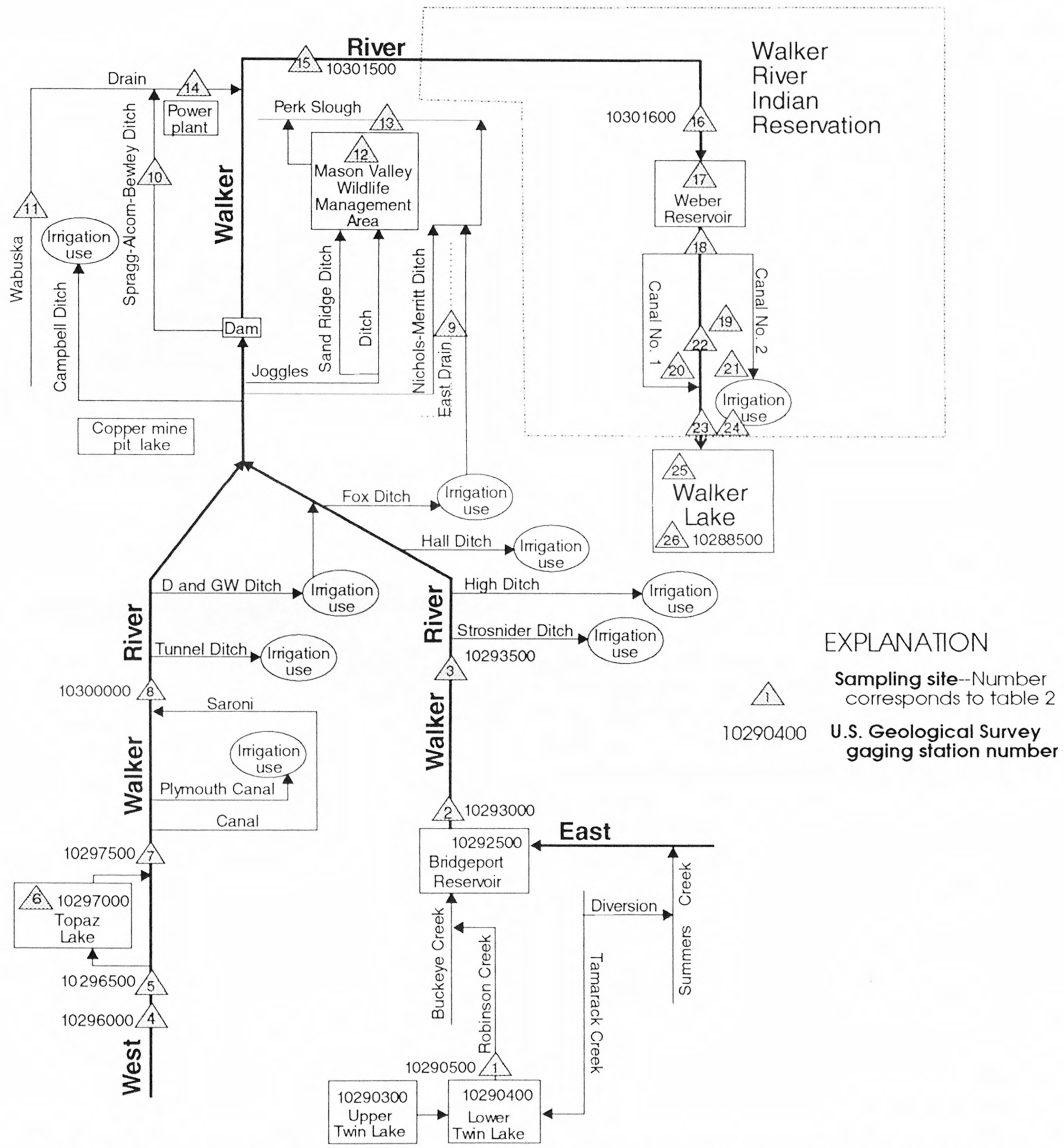


Figure 2. Schematic diagram of flow system for Walker River Basin, Nevada and California. Modified from Clary and others (1995, figure 19).

Bridgeport, Calif., 183,000 acre-ft/yr at the West Walker River below Little Walker River, near Coleville, Calif., and 126,000 acre-ft/yr at the Walker River near Wabuska, Nev. Flow at the Wabuska station accounts for only 44 percent of the combined flows of the two tributaries. Huxel (1969, p. 41) estimated by mass balance that 45 percent of the inflow to Mason Valley was consumed by evapotranspiration by crops, pastures, and other vegetation; Rush and Schroer (1976, p. 70) estimated that evapotranspiration accounted for 42 percent of the river inflow to Smith Valley; and Everett and Rush (1967, p. 26) estimated that about 22 percent of the flow at the Wabuska station was consumed by evapotranspiration in Walker Lake Valley. River inflow not accounted for by river outflow or evapotranspiration is assumed to recharge ground water.

Irrigation is the dominant water use in the Walker River Basin, with most agricultural areas along the river in Bridgeport, Antelope, Smith, and Mason Valleys and on the Walker River Indian Reservation. The Walker River is the principal source of irrigation water and about 125,000 acres in the Basin have surface-water irrigation rights (State of California, 1992, p. 76). Federal Court records indicate that non-Indian irrigation began in the Basin in 1860 (U.S. Department of Agriculture, 1969, p. 53). By the early 1900's, demand for irrigated crops by area mining camps and supporting communities resulted in irrigation-water use exceeding the natural flow of the river. Consequently, nearly all the surface water in the Walker River Basin was placed under the jurisdiction of the Federal Court.

The Walker River Irrigation District (WRID) was organized in 1919 to manage distribution of irrigation water to about 80,000 acres in Nevada (State of California, 1992, p. 75). WRID authorized a bond issue for construction of two reservoirs for upstream storage of irrigation water. Topaz Lake is an off-stream storage reservoir first used in 1922 by diverting water from the West Walker River into a small closed basin on the California-Nevada State line, and thereby creating an impoundment with an original capacity of 45,000 acre-ft (expanded to 59,440 acre-ft in 1937). Bridgeport Reservoir was completed on the East Walker River in 1924 with a nominal capacity of 44,000 acre-ft (State of California, 1992, p. 26).

Irrigation activities on the Walker River Indian Reservation began in 1866, about 7 years after the Reservation was set aside by the Commissioner of Indian Affairs, but 8 years before the executive order by President Grant that formally established the Reservation in 1874. An irrigation ditch (about 1,000 ft long) was constructed to divert water from the Walker River for irrigation of 4 acres of vegetables in Campbell Valley, upstream of where Weber Reservoir is now located (fig. 1; H.A. Thomas, Department of the Interior, Office of Indian Affairs, Nevada Agency, written commun., 1866). A new irrigation ditch was constructed downstream from the present location of Schurz (fig. 1) in 1872. The combined irrigated area was estimated to be 150 acres and produced more than $3,000 worth of crops. By 1894, about 850 acres of alfalfa, clover, wheat, barley, and melons were grown on irrigated fields of the Reservation (Cooper Consultants, Inc., 1989, p. II-6).

In 1905, the Commissioner of Indian Affairs authorized expenditure of up to $50,000 to extend the irrigation system on the Walker River Indian Reservation. Under this authorization, Assistant Engineer E.E. Jones surveyed land and existing ditches and directed construction, during 1906-10, of a canal system with concrete headgates and a flume crossing the Walker River. Tribal heads of families were allotted 20-acre tracts of irrigable land beginning in 1906, and allotments continued as the irrigation-canal system was extended.

In 1924, the Federal government brought suit against upstream irrigation-water users of the Walker River on behalf of the Walker River Paiute Tribe. This legal action resulted in Decree C-125 in 1936, which made the tribe's water rights the most senior priority on the river. Decree C-125 remains the primary regulatory control on water use of the Walker River (State of California, 1992, p. 59-61).

The first survey of a reservoir site for the Walker River Indian Reservation was made by Assistant Engineer F.E. Weber (U.S. Indian Irrigation Service) in 1915, and by 1927 three reservoir sites had been surveyed for consideration for storage of irrigation water (E.W. Kronquist, U.S. Indian Irrigation Service, written commun., 1927). Weber Reservoir was constructed on the mainstem of the Walker River with funds allocated to the U.S. Indian Irrigation Service (now Bureau of Indian Affairs) from the National Industrial Recovery Act of 1933. Construction of Weber Dam, an earth-filled structure, began in 1933 and water storage began 10 months later (Katzer and Harmsen, 1973).

Weber Reservoir provides storage of irrigation water for the only DOI-sponsored irrigation project in the Walker River Basin. The reservoir is operated by the BIA to provide irrigation water to the Reservation during the irrigation season (May to October) and also provides flood protection and recreational opportunities. The reservoir has an average capacity of about 9,000 acre-ft with a maximum storage of just over 14,000 acre-ft reported in 1963 (Katzer and Harmsen, 1973).

As of 1994, the irrigation system on the Walker River Indian Reservation consisted of Weber Reservoir and Dam, a diversion structure about 3 mi downstream from the dam on the Walker River, and a canal system on each side of the river that delivers river water to irrigate about 2,400 acres by the border method (Lewis J. Fry, Bureau of Indian Affairs, written commun., 1994). In addition to these BIA facilities, the Walker River Paiute Tribe has constructed an open drain through areas irrigated on the south side of the river. A schematic diagram of the surface-water flow system on the Walker River Indian Reservation is shown in figure 3. The delivery system on the south side of the river above Schurz (Canal No. 1) can supply about 2,000 acres and the system on the north and east sides of the river and on the west side below Schurz (Canal No. 2) can supply about 4,000 acres (Cooper Consultants, Inc., 1989, p. II-8).

Walker Lake, the terminus of the Walker River, is a remnant of Lake Lahontan, which covered about 8,600 mi^2 during its last highstand and may have begun to recede as early as 14,000 years ago (Benson and others, 1990, p. 248 and 280). The altitude of Walker Lake has changed considerably, with at least one period of desiccation (Rush, 1970). Recently, surface altitude and volume have declined. Since the lake was first surveyed in 1908, surface altitude has declined from 4,086 ft above sea level to 3,946 ft in 1993 and volume has decreased by 72 percent (Horne and others, 1994). Corresponding to this decline, dissolved-solids concentrations have increased from about 2,500 mg/L in 1882 (Russell, 1885) to 8,610 mg/L in 1965 (Rush, 1970) to 13,300 mg/L in 1994 (Thomas, 1995, p. 1). The record of lake-surface decline and increase in the dissolved-solids concentrations is shown in figure 4. Loss of habitat and changes in limnological characteristics and lake-water quality have affected biological conditions in Walker Lake (Koch and others, 1979) and several species have been eliminated or have declined in abundance (Sevon, 1993).

Data from a USGS National Stream Quality Accounting Network station on the Walker River near Wabuska, Nev. (period of record 1968-93), indicate that river water about one-half mile upstream from the Walker River Indian Reservation generally was of good quality. However, Nevada water-quality standards for protection of aquatic life were exceeded for pH, ammonia, boron, mercury, and molybdenum in 5 percent or more of the samples. Other data include two samples of tailings fluid and one of acid brine, collected in 1976 and associated with copper-ore mining and milling near Yerington, Nev., which exceeded public-supply standards for several constituents and properties including pH, sulfate, dissolved solids, and selected trace elements (Seitz and others, 1982, p. 23-27, 29). In addition, data provided by the Nevada Division of Environmental Protection for water samples collected in 1994 from the abandoned copper mine pit lake, which exceeded Nevada water-quality standards for dissolved solids, pH, sulfate, and selenium. No data on the quality of irrigation drainage were found for the Walker River Basin.

Biota

The species composition of biological communities in the Walker River Basin differs with altitude and proximity to surface water. Uplands in the lower Basin, including the Walker River Indian Reservation, are characterized by vegetation types associated with the salt desert shrub zone (Fowler and Koch, 1982). Lacustrine, palustrine, and riverine wetlands occur throughout the Basin. On the Reservation, palustrine wetlands, including riparian forests, wet meadows, and emergent marshes, are perhaps the most important habitat to wildlife resources. These areas provide foraging, nesting, and resting habitat for a variety of wildlife species. Wildlife species that have been identified in the lower Walker River Basin include 174 avian, 46 mammalian, 20 reptilian, and 5 amphibian species (Robert L. Hussey, Nevada Division of Wildlife, written commun., 1994). Eight fish species are native to the Walker River Basin (La Rivers, 1962), and at least 12 non-native species of fish have become established. Recreational warm-water fisheries are maintained in a cooling pond at the Fort Churchill power-generating facility, in ponds on the Mason Valley WMA, in Weber Reservoir, and in Walker Lake, but little effort is devoted to maintenance of the fishery in the lower Walker River because of summer low flows and high water temperatures. Currently (1996), hatchery-propagated Lahontan cutthroat trout are released into Walker Lake in an effort to maintain a population for recreational fishing.

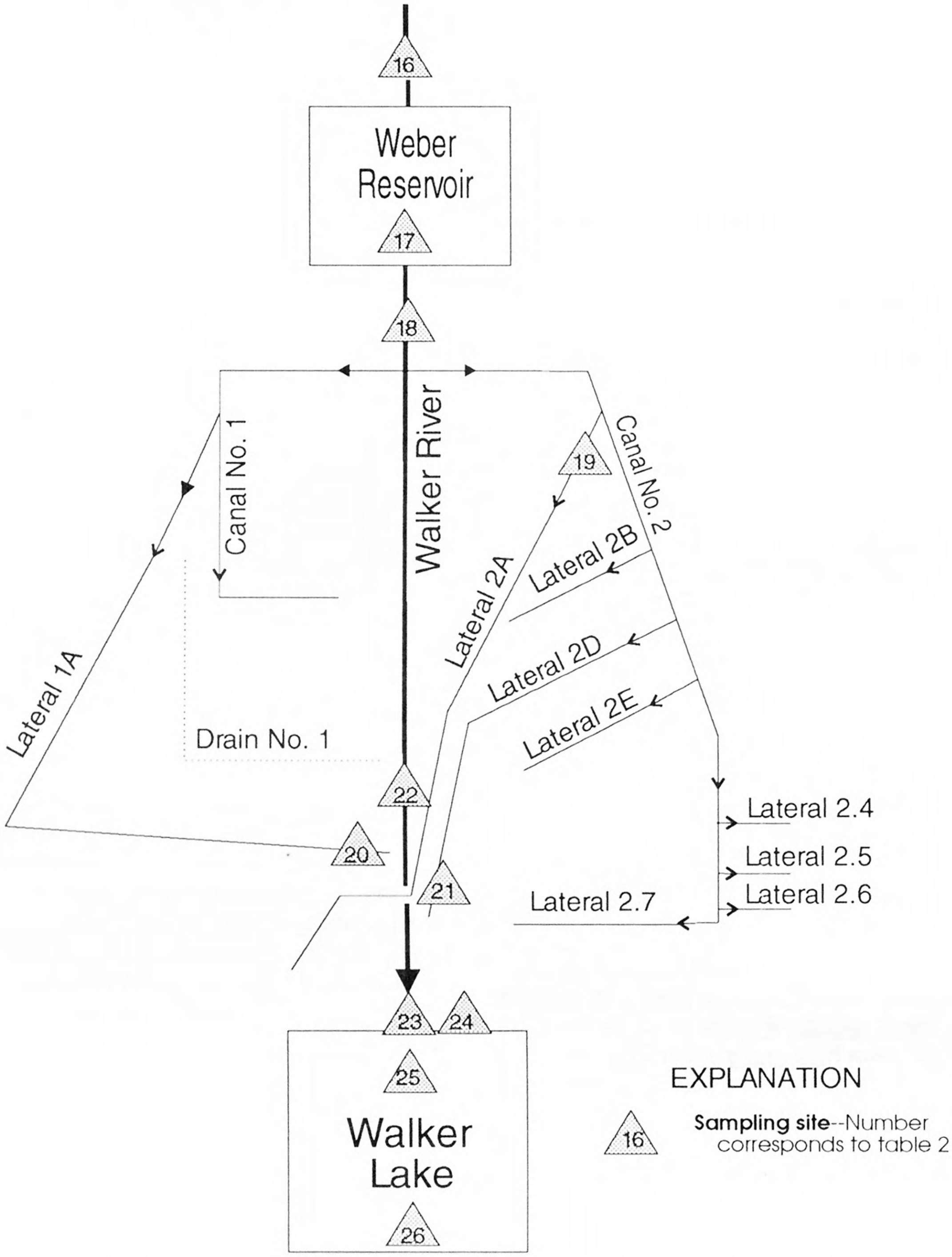


Figure 3. Schematic diagram of irrigation-water delivery system for Walker River Indian Reservation, Nevada.

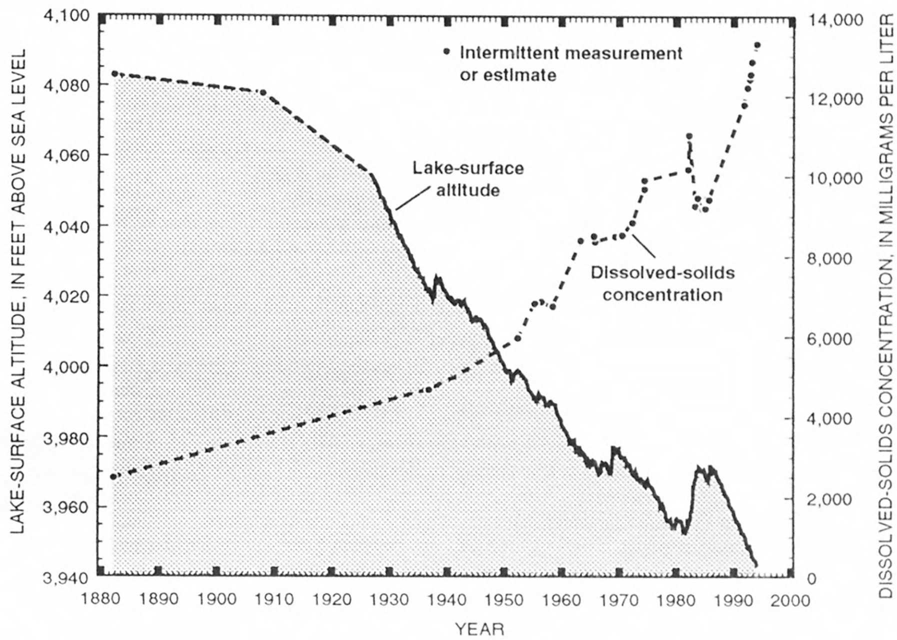


Figure 4. Dissolved-solids concentration and lake-surface altitude for Walker Lake, Nevada, 1882-1994 (Thomas, 1995).

One federally listed endangered species (American peregrine falcon) and two threatened species (bald eagle and Lahontan cutthroat trout) inhabit the lower Walker River Basin. Additionally, 20 species of concern that were formerly category-2 candidates for listing as endangered or threatened under the Endangered Species Act of 1973, as amended, also have been identified in the lower Basin (table 1). These include 10 mammals, 5 birds, and 5 plants. American peregrine falcons have been identified in the lower Basin, but are believed only to be migrants to the area (Herron and others, 1985). More than 125 bald eagles winter in Nevada and typically are associated with wetland areas in western Nevada. Historically, Lahontan cutthroat trout existed throughout the Basin, with Walker Lake supporting a lacustrine population (U.S. Fish and Wildlife Service, 1995). Today, only one endemic riverine population remains in the Basin and Lahontan cutthroat trout in Walker Lake have been maintained exclusively through hatchery propagation since 1948 (Sevon, 1988). Increasing concentrations of dissolved solids in Walker Lake make the prospects for continued existence of Lahontan cutthroat trout and many other aquatic species questionable (Koch and others, 1979; Horne and others, 1994).

SAMPLE COLLECTION, MEASUREMENT, AND ANALYSIS

Sampling sites for this field-screening study were selected to determine concentrations of constituents in water, bottom sediment, and selected biota in areas upstream from DOI-sponsored irrigation, in areas used by migratory birds, including Walker Lake, and in the immediate vicinity of DOI-sponsored irrigation on the Walker River Indian Reservation. These sites were grouped into four categories to facilitate evaluation of water quality from DOI-sponsored irrigation: (1) Reference area, eight sites on the East and West Walker Rivers upstream from Mason Valley; (2) Mason Valley, seven sites downstream from the confluence of the East and West Walker Rivers, where 47 percent of the estimated area with surface-water rights in the Basin is located (State of California, 1992, p. 76); (3) Walker River Indian Reservation, nine sites on the Reservation where the only DOI-sponsored irrigation occurs in the Basin; and (4) Walker Lake, two sites on the terminal lake of the Walker River. The sites sampled and types of analyses are listed in table 2.

Drought conditions had persisted during 6 of the 7 years prior to and including 1994, limiting availability of water for both chemical analysis and for the habitat of aquatic biota targeted for tissue analysis.

Table 1. Biological species of concern in Walker River Basin, Nevada and California

Species of concern	Status [a]
American peregrine falcon (*Falco peregrinus anatum*)	Endangered
Bald eagle (*Haliaeetus leucocephalus*)	Threatened
Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*)	Threatened
Black tern (*Chlidonias niger*)	Concern
Least bittern (*Ixobrychus exilis hesperis*)	Concern
Northern goshawk (*Accipiter gentilis*)	Concern
Western burrowing owl (*Athene cunicularia hypugea*)	Concern
White-faced ibis (*Plegadis chihi*)	Concern
Fletcher dark kangaroo mouse (*Microdipodus megacephalus nasutus*)	Concern
Fringed Myotis bat (*Myotis thysanodes*)	Concern
Long-eared myotis bat (*Myotis evotis*)	Concern
Long-legged myotis bat (*Myotis volans*)	Concern
Pacific Townsend's big-eared bat (*Plecotus townsendii townsendii*)	Concern
Pale Townsend's big-eared bat (*Plecotus townsendii pallescens*)	Concern
Pygmy rabbit (*Brachylagus idahoensis*)	Concern
Small-footed myotis bat (*Myotis ciliolabrum*)	Concern
Spotted bat (*Euderma maculatum*)	Concern
Eastwood's milkvetch (*Asclepias eastwoodiana*)	Concern
Masonia mountain jewelflower (*Streptanthus oliganthus*)	Concern
Mono phacelia (*Phacelia monoensis*)	Concern
Nevada dune beardtongue (*Penstemon arenarius*)	Concern
Nevada oryctes (*Oryctes nevadensis*)	Concern
Yuma myotis bat (*Myotis yumanensis*)	Concern

[a] Endangered, species so listed under Endangered Species Act of 1973, as amended; Threatened, species so listed under the Endangered Species Act of 1973, as amended; Concern, existing information indicates that species listing may be warranted, but substantial biological information to support proposed rule is lacking.

Return flow from irrigated fields on the Walker River Indian Reservation was not found during this study because of reduced availability of irrigation water and because shallow ground water is drained by the channel of the Walker River. Hydrologic conditions changed in 1995, with snow-water content estimated for the Walker River Basin on April 1, 1995, to be 185 percent of the 1961-90 average and 421 percent of what was measured on April 1, 1994 (Natural Resources Conservation Service, 1995). Therefore, four of the sites on the Walker River Indian Reservation were resampled in August 1995 to provide data for comparing the two extremes. However, return flow from irrigated fields on the Reservation again was not found, despite above-normal precipitation and increased availability of river water for irrigation.

Water-Quality Samples

The USGS collected 30 sets of water samples (26 in 1994, 4 in 1995) from 26 sites for determination of major constituents, selected trace elements, and selected species of nitrogen and phosphorus. In addition, 20 samples were collected in 1994 and immediately chilled on ice for toxicity tests by the USFWS. Site locations are shown in figure 1 and sites are described in table 2. All water samples collected for chemical analyses were shipped to the USGS National Water-Quality Laboratory in Arvada, Colo. Laboratory analytical and quality-control procedures that were used are described by Friedman and Erdmann (1982) and Jones (1987). Analytical reporting limits for constituents in water determined for this study are listed in table 3.

Water samples were collected at sites with sufficient flow using a DH81 standard hand-held, depth-integrating sampler following the equal-width-increment method described by Edwards and Glysson (1988, p. 61-65). Water samples from sites with minimal flow were grab-sampled using a clean polyethylene sample bottle pre-rinsed with native water. Field measurements of pH, specific conductance, dissolved oxygen, alkalinity, and water temperature were made by the USGS at each sampling site. Stream discharge was measured at sites associated with flowing surface water and field-measurement profiles were made along able 2. Sampling sites selected for collection of water, bottom sediment, and biota in Walker River Basin, Nevada and California, 994-95

Abbreviations: DOI, Department of the Interior; WMA, Wildlife Management Area]

Site no. (fig. 1)	Site location (in downstream order)	U.S. Geological Survey site identification[a]	Types of samples collected[b]	Rationale for site selection
		Reference Area		
1	Robinson Creek at Twin Lakes Outlet, near Bridgeport, Calif.	10290500	W	Reference site
2	East Walker River near Bridgeport, Calif.	10293000	W, E, I, F, V	Reference site
3	East Walker River above Strosnider Ditch, near Mason, Nev.	10293500	W	Reference site
4	West Walker River below Little Walker River, near Coleville, Calif.	10296000	W	Reference site
5	West Walker River near Coleville, Calif.	10296500	W, Q	Reference site
6	Topaz Lake near Topaz, Calif.	10297000	W, SI, I, F, V	Reference site; reservoir for irrigation-water storage
7	West Walker River at Hoye Bridge, near Wellington, Nev.	10297500	W, Q	Reference site
8	West Walker River near Hudson, Nev.	10300000	W	Reference site
		Mason Valley		
9	East Drain above Mason Valley WMA, near Yerington, Nev.	10301180	W, SI	Agricultural drain
10	West Branch Spragg-Alcorn-Bewley Ditch at Sierra Way, near Yerington, Nev.	10301470	W	Agricultural drain
11	Wabuska Drain at Sierra Rd., near Yerington, Nev.	10301480	W, E	Agricultural drain
12	East Honker Pond at Mason Valley WMA, near Yerington, Nev.	10301375	W, E, Q	Waterfowl habitat
13	Perk Slough at Mason Valley WMA, near Yerington, Nev.	10301280	W, SI, Q	Waterfowl habitat
14	Wabuska Drain above Confluence with Walker River, near Parker Butte	10301495	W, E	Agricultural drain
15	Walker River near Wabuska, Nev.	10301500	W, I, V	Upstream from DOI-sponsored irrigation
		Walker River Indian Reservation		
16	Walker River above Weber Reservoir, near Schurz, Nev.	10301600	W, F, V	Upstream from DOI-sponsored irrigation
17	Weber Reservoir near Schurz, Nev.	10301700	W, SI, E, F, V, SO	DOI-sponsored reservoir
18	Walker River above Canal 1-2 Diversion Weir near Schurz, Nev.	10301740	W, E, F	Discharge from DOI-sponsored reservoir
19	Lateral 2A at takeout near Schurz, Nev.	10301770	W	DOI-sponsored irrigation water
20	Lateral 1A above Highway 95 at Schurz, Nev.	10301765	W	DOI-sponsored irrigation water
21	Lateral 2D below Schurz, Nev.	10301780	W, SI, SO	DOI-sponsored irrigation water
22	Walker River at Schurz, Nev.	10302000	W, I, V	Downstream from DOI-sponsored irrigation
23	Walker River near Mouth at Walker Lake	10302025	W, SI, Q, SO	Downstream from DOI-sponsored irrigation
24	Spring near delta at Walker Lake	384728118433401	W	Downstream from DOI-sponsored irrigation

Table 2. Sampling sites selected for collection of water, bottom sediment, and biota in Walker River Basin, Nevada and California, 1994-95

Site no. (fig. 1)	Site location (in downstream order)	U.S. Geological Survey site identification [a]	Types of samples collected [b]	Rationale for site selection
		Walker Lake		
25	Walker Lake near delta	384715118432201	W, SI, SO	Terminal lake
26	Walker Lake near Hawthorne, Nev.	10288500	W, I, F, V, Q	Terminal lake

[a] Many sample sites are assigned a unique identification number on the basis of geographic location. The eight-digit numbers are station numbers that follow the "downstream-order system": The first two digits, or part number, refer to the regional drainage basin (Part 10 is Great Basin). The following six digits are the downstream-order number, which is assigned according to the geographic location of the site in the drainage basin; larger number stations are downstream from smaller number stations. The 15-digit numbers are based on the grid system of latitude and longitude. The first six digits denote degrees, minutes and seconds of latitude; the next seven digits denote the degrees, minutes, and seconds of longitude; the last two digits (assigned sequentially) identify the sites within a 1-second grid. For example, site 384728118433401 is at 38°47′28″ latitude and 118°43′34″ longitude and is the first site recorded in that 1-second grid. The assigned number is retained as a permanent identifier even if a more precise latitude and longitude are later determined.

[b] Sample types: E, avian egg; F, fish tissue; I, invertebrate; Q, field blank processed on-site for quality assurance; SI, inorganic constituents in bottom sediment; SO, organic constituents in bottom sediment; V, aquatic vegetation; W, water.

Table 3. Analytical reporting limits for chemical constituents in water, bottom sediment, and biota (tissue)

[µg/L, microgram per liter; µg/g, microgram per gram; mg/L, milligram per liter; --, analyte not determined in sampled medium]

Constituent	Water [a] (µg/L, except as indicated)	Bottom sediment (µg/g, dry weight, except as indicated)	Tissue [a] (µg/g, dry weight)
Hardness	1 mg/L	--	--
Calcium	.02 mg/L	--	--
Magnesium	.01 mg/L	--	50
Sodium	.20 mg/L	--	--
Potassium	.10 mg/L	--	--
Sulfur	--	--	--
Sulfate	.10 mg/L	--	--
Chloride	.10 mg/L	--	--
Fluoride	.10 mg/L	--	--
Silica	.01 mg/L	--	--
Solids, dissolved, residue at 180°C	1 mg/L	--	--
Nitrate (as nitrogen)	.05 mg/L	--	--
Nitrite (as nitrogen)	.01 mg/L	--	--
Ammonia (as nitrogen)	.01 mg/L	--	--
Phosphorus	--		--
Orthophosphate (as phosphorus)	.01 mg/L	--	--
Aluminum	1	.5 mg/g	5
Antimony	1	.1	4
Arsenic	1	.1	.5
Barium	1	1.0	--
Beryllium	1	1.0	--
Bismuth	--	10	--
Boron	10	--	.5
Cadmium	1	.1	.1
Cerium	--	4.0	--

Table 3. Analytical reporting limits for chemical constituents in water, bottom sediment, and biota (tissue)—Continued

Constituent	Water [a] (µg/L, except as indicated)	Bottom sediment (µg/g, dry weight, except as indicated)	Tissue [a] (µg/g, dry weight)
Chromium	1	1.0	0.5
Cobalt	1	1.0	--
Copper	1	1.0	1
Europium	--	2.0	--
Gallium	--	4.0	--
Gold	--	8.0	--
Holmium	--	4.0	--
Iron	3	.5 mg/g	50
Lanthanum	--	2.0	--
Lead	1	4.0	.5
Lithium	--	2.0	--
Manganese	1	4.0	1
Mercury	.1	.02	.1
Molybdenum	1	2.0	.5
Neodymium	--	4.0	--
Nickel	1	2.0	.5
Niobium	--	4.0	--
Scandium	--	2.0	--
Selenium	1	.1	.1
Silver	1	.1	--
Strontium	--	2.0	1
Tantalum	--	40	--
Thorium	--	4.0	--
Tin	--	10	--
Uranium	1	.05	--
Vanadium	--	2.0	.5
Ytterbium	--	1.0	--
Yttrium	--	2.0	--
Zinc	1	4.0	20
Polychlorinated naphthalene (PCN)	--	1.0	--
Aldrin	--	.1	--
Lindane	--	.1	--
Chlordane	--	1.0	--
Dichlorodiphenyldichloroethane (DDD)	--	.1	--
Dichlorodiphenyldichloroethylene (DDE)	--	.1	--
Dichlorodiphenyltrichloroethane (DDT)	--	.1	--
Dieldrin	--	.2	--
Endosulfan	--	.1	--
Endrin	--	.1	--
Toxaphene	--	10	--
Heptachlor	--	.1	--
Heptachlor epoxide	--	.1	--
Methoxychlor	--	.6	--
Polychlorinated biphenyls (PCB)	--	1	--
Mirex	--	.1	--
Carbon, organic	--	.1 mg/g	--
Carbon, total	--	.1 mg/g	--
Carbon, inorganic	--	.1 mg/g	--

[a] Analytical reporting limits increased (1) for water samples with dissolved-solids concentration greater than 6,000 mg/L and (2) among biological matrices and sample sizes. The limits listed herein are the lowest reporting limit.

the water column at lake and reservoir sites. All water samples were collected and processed following procedures described by Ward and Harr (1990) and laboratory methods are described by Fishman and Friedman (1989).

Quality assurance of field-measurement techniques and equipment was determined by calibration of meters with standards and buffers and through annual participation in the USGS National Field Quality Assurance program (Janzer, 1985). Certified inorganic-blank water was processed through all equipment to be used for collection and processing of water samples and submitted as an equipment blank for laboratory analysis. In addition to these standard practices, five field blanks were processed to provide data on potential contamination due to all aspects of collection and processing, transportation, and laboratory handling of a water sample.

Data summarized in table 4 show that nearly all chemical analyses of field blanks were at or below analytical reporting limits. However, low-level concentrations of ammonia (0.03 mg/L or less) were detected in all field blanks and one field blank (processed at site 7) had elevated levels of aluminum (10 µg/L), arsenic (12 µg/L), barium (38 µg/L), chromium (1 µg/L), copper (1 µg/L), molybdenum (6 µg/L), and uranium (3 µg/L). One other field blank (processed at site 13) had measurable levels of aluminum (1 µg/L), iron (5 µg/L), mercury (1.4 µg/L), nickel (2 µg/L), and zinc (1 µg/L). Trace-element concentrations measured in field blanks are unexplained and, except for mercury, are insignificant from a toxicity standpoint. Concentrations of mercury were less than the analytical reporting limit in all water samples collected for this study.

Evaluation of chemical constituents and concentrations in water alone may not provide a definitive indicator of toxicity of water (Finger and others, 1993). Therefore, potential toxicity of water collected during this study also was assessed using Microtox® procedures. Microtox® provides a rapid assessment of the relative toxicity of diverse environmental samples expressed as "effect concentration" (EC_{50}). EC_{50} is the median effective concentration of samples, expressed as percent, causing a 50-percent decrease in light output under identified conditions of exposure time and temperature (Seiler and others, 1993, p. 27). The procedure uses a strain of photoluminescent marine bacteria, *Photobacterium phosphoreum*, as a test organism. The Microtox® instrument measures bacterial luminosity, which is assumed to be a measure of metabolic activity. A decrease in luminosity following exposure of the bacteria to a water sample is interpreted as a depression of metabolic activity, and therefore provides an indicator of toxic response.

Results of Microtox®, however, may vary from results of other toxicity tests. For example, Microtox® was found to be generally more sensitive to organic compounds than acute lethality tests with rainbow trout (*Salmo gairdneri*), fathead minnows (*Pimephales Promelas*), or daphnid (*Daphnia sp*). In contrast, Microtox® was generally less sensitive to inorganic constituents, except for arsenic and mercury, than lethality tests (Munkittrick and others, 1991).

Bottom-Sediment Samples

Bottom-sediment samples were collected in 1994 by the USGS from seven sites (table 2) within 400-ft^2 areas slightly offshore from sheltered shoreline for lakes or reservoirs, and within depositional areas for channelized flow. At each site, five to seven equally spaced samples were collected from the top 2-4 in. of sediment, using a Teflon spatula, and composited in a glass bowl. The composited sediment sample was

Table 4. Dissolved trace-element concentrations in water from five field blanks analyzed for quality assurance for Walker River Basin field-screening study, 1994

[Dissolved concentrations in micrograms per liter; <, less than]

Constituent	Minimum	Median	Maximum
Aluminum	<1	2	10
Antimony	<1	<1	<1
Arsenic	<1	<1	12
Barium	<1	<1	38
Beryllium	<.2	<1	<1
Boron	<2	<10	<10
Cadmium	<.3	<1	<1
Chromium	<1	<1	1
Cobalt	<1	<1	<1
Copper	<1	<1	1
Iron	<3	<3	5
Lead	<1	<1	<1
Manganese	<1	<1	<1
Mercury	<.1	<.1	1.4
Molybdenum	<1	<1	6
Nickel	<1	<1	2
Selenium	<1	<1	<1
Silver	<.2	<1	<1
Strontium	<10	<10	<10
Uranium	<.2	<1	3
Zinc	<1	<1	6

thoroughly mixed and then sieved in the field. Samples for trace-element determination (sites 6, 9, 13, 17, 21, 23, and 25) were passed through a 63-µm mesh-size plastic sieve and samples for determination of organochlorine compounds (sites 17, 21, 23, and 25) were passed through a 2-mm mesh-size stainless-steel sieve. Native water from each site was used to facilitate the sieving process. Sieved samples were collected in plastic jars for trace-element analysis and samples for organochlorine analysis were collected in pretreated glass jars, maintained at 4°C and packed in ice for shipment to the USGS National Water-Quality Laboratory in Arvada, Colo., for analysis using methods described by Fishman and Friedman (1989) and Wershaw and others (1987). Analytical reporting limits are listed in table 3.

Biota Samples

The USFWS collected biological samples to assess the extent and severity of trace-element contamination at different trophic levels, the potential for trace elements to adversely affect fish and wildlife, and the implications of trace-element contamination to human health. Samples of aquatic vegetation, aquatic invertebrates, and fish were used to assess contamination at three trophic levels of the aquatic food web. Many of these samples also represent the primary food of aquatic birds in the system. Waterfowl and shore-bird eggs were used to assess the possible effects of trace elements to the reproductive success of migratory birds. Juvenile waterfowl and shore-bird liver tissue were used to assess the potential for trace elements to adversely affect migratory birds and to determine if higher trophic levels are acquiring trace elements at specific sites. Whole fish and avian muscle tissue also provide a measure of potential hazards to human health (U.S. Environmental Protection Agency, 1989).

A total of 50 biological samples (9 samples of aquatic vegetation, 7 invertebrate, 9 fish, 18 avian egg, 4 avian liver, and 3 avian muscle tissue) were submitted for chemical analyses by laboratories under contract to the Patuxent Analytical Control Facility, Laurel, Md. Quality-control procedures that were used are described by Patuxent Analytical Control Facility (1990). Analytical reporting limits are listed in table 3.

CHEMICAL CHARACTERISTICS

The possibility for impairment of beneficial uses of water or adverse effects to wildlife or aquatic life was determined by comparing analytical results for samples collected during this field-screening study to Nevada water-quality standards listed in table 5 (Chapter 445 of the Nevada Administrative Code), to concern and effect levels identified from published reports and listed in table 6, and to results of toxicity tests made for water samples collected for this study in 1994. The results of this study are presented below and in tables 7-14 of the Supplemental Data section at the end of this report.

Water

Water samples were collected for physical and chemical analyses in June-August 1994 from each of the 26 sites (table 2) selected for this study. Four of these sites (sites 19, 20, 22, and 23) were re-sampled in August 1995. Data from the two sampling periods allow comparison for water quality of samples collected from the Walker River Indian Reservation during drought conditions (1994) and after above-average runoff (1995). Field measurements of physical characteristics and chemical constituents are listed in table 7. Water hardness and concentrations of major dissolved chemical constituents are listed in table 8. Concentrations of selected species of nitrogen and phosphorus are listed in table 9. Concentrations of dissolved trace-element constituents are listed in table 10. Results of toxicity tests are listed in table 11.

Relation of Water Quality to Standards and Criteria

On the basis of Nevada water-quality standards listed in table 5 and of concern-and-effect levels listed in table 6, concentrations of nitrate, nitrite, aluminum, beryllium, cadmium, copper, iron, mercury, nickel, selenium, silver, vanadium, and zinc in water samples collected for this study were below lowest levels of concern or were below analytical reporting limits. Concentrations of dissolved mercury in all water samples were less than the analytical reporting limit (0.1 µg/L), but this concentration is about eight times greater than the Nevada water-quality standard for protection of aquatic life (0.012 µg/L).

Table 5. Nevada water-quality standards and criteria for beneficial use (Nevada Bureau of Health Protection Services, 1992)

[--, no standard or criterion established; µg/L, microgram per liter; mg/L, milligrams per liter]

Constituent	Municipal or domestic supply	Aquatic life	Irrigation	Watering of livestock
Antimony (µg/L)	146	--	--	--
Arsenic (µg/L)	50	(a)	100	200
Barium (µg/L)	1,000	--	--	--
Beryllium (µg/L)	--	--	100	--
Boron (µg/L)	--	(b)	750	5,000
Cadmium (µg/L)	10	[c]0.3-5	10	--
Chloride (mg/L)[d]	250	250	250	250
Chromium (µg/L)	50	(a,c)	100	1,000
Copper (µg/L)	--	[c]3-60	200	500
Dissolved oxygen (mg/L)[d]	6.0	≥6.0	--	6.0
Dissolved solids (mg/L) [d]	500	--	500	500
Iron (µg/L)	300	1,000	5,000	--
Lead (µg/L)	50	[c].4-40	5,000	100
Manganese (µg/L)	50	--	200	--
Mercury (µg/L)	2	.012	--	10
Molybdenum (µg/L)	--	19	--	--
Nickel (µg/L)	13.4	[c]40-800	200	--
Nitrogen:				
Nitrate (mg/L)[d]	10	10	--	10
Nitrite (mg/L)[d,e]	1.0	.06-1.0	--	.06-1.0
Ammonia (mg/L; un-ionized)[d,e]	--	.02-.06	--	.02-.06
pH (standard units)	6.5-8.5	7.0-8.3	7.0-8.3	7.0-8.3
Phosphorus:				
Phosphate (mg/L)d	--	.1-.4	--	--
Selenium (µg/L)	10	5	--	--
Silver (µg/L)	50	[c].2-100	--	--
Sulfate (mg/L)[d]	250	--	--	--
Temperature (°C)[d,e,f]	--	13-28	--	--
Zinc (µg/L)	5,000	[c]20-600	2,000	25,000

[a] Standard for aquatic life is based on oxidation state.

[b] Aquatic-life standard for boron (550 µg/L) eliminated, October 1995.

[c] Criteria for aquatic life calculated according to published formulas that incorporate ambient water hardness values; thus, criteria are calculated using range of hardness values determined for samples collected for this field-screening study (18 to 730 milligrams per liter as $CaCO_3$)

[d] Standards apply only to control points in Nevada on West Walker, East Walker, and Walker Rivers.

Nevada water-quality standards for beneficial uses of the Walker River (table 5) or published levels of concern (table 6) were equaled or exceeded for the following constituents: (1) water temperature, 10 sites above Weber Reservoir (site 17) had water temperatures greater than 17°C during the month of June and one site below Weber Reservoir had a water temperature greater than 28°C during the month of July; (2) pH, 15 samples equaled or exceeded 8.3 pH units and 1 sample was less than 7.0 pH units; (3) dissolved solids, 6 samples equaled or exceeded 500 mg/L; (4) un-ionized ammonia, 5 samples equaled or exceeded 0.02 mg/L; (5) phosphate, 6 samples above Weber Dam equaled or exceeded 0.1 mg/L and 4 samples downstream from Schurz Bridge equaled or exceeded 0.23 mg/L; (6) arsenic, 7 samples equaled or exceeded 40 µg/L; (7) chromium, 2 samples equaled or exceeded 21.5 µg/L; (8) lead, 1 sample exceeded 1 µg/L; and (9) molybdenum, 7 samples exceeded 19 µg/L. The aquatic life standard for boron (550 µg/L) was eliminated in 1995 because the irrigation-water standard (750 µg/L) was deemed adequately protective. The irrigation-water standard was equaled or exceeded in five samples.

Sources of trace elements are not positively identified for this study. However, soils that have developed during dry climatic conditions are poorly leached. Consequently, soluble minerals (possibly including trace elements) tend to remain in such soils (Hoffman, 1994, p. 7). Trace elements also were accumulated in Pleistocene lakebed soils that developed as Lake Lahontan receded (Seiler, 1993, p. 9).

Sites 19, 20, 22, and 23 on the Walker River Indian Reservation were sampled twice. Samples from these sites had physical characteristics or chemical constituents (from at least one of the four sites) that exceeded levels of concern for water temperature, pH, dissolved solids, arsenic, boron, lead, and molybdenum in 1994; but in 1995, only the Nevada water-quality standard for molybdenum was exceeded at site 23.

Sites 19 and 20 are irrigation laterals that had rates of flow less than 0.5 ft^3/s each time they were sampled. Sites 22 and 23 are on the Walker River; at the times of sample collections in 1994 and 1995, streamflow had increased from <0.01 ft^3/s to 150 ft^3/s and from 0.69 ft^3/s to 60 ft^3/s, respectively. Concentrations of major constituents and trace elements in irrigation laterals (sites 19 and 20) were generally lower in samples collected in 1995 than in those collected in 1994, despite little change in flow rates. The concentration of dissolved solids in the sample collected from Weber Reservoir in 1994 (296 mg/L) was more than twice the concentration measured in samples from irrigation laterals in 1995. Changes in water quality at sites 22 and 23 (for example, dissolved-solids concentrations at site 23: 1,450 mg/L in 1994 and 177 mg/L in 1995) show the effect of diluting poor-quality ground-water seepage with river water.

Nevada water-quality standards for water temperature and pH, and for concentrations of dissolved solids, un-ionized ammonia, and phosphate, are designated for specific control points on the Walker River and Topaz Lake. Therefore, data collected at sites away from these control points (for example, sites in California and the ponds, canals, and drains that were sampled for this study) are not under the jurisdiction of these water-quality standards. In these cases, the water-quality standards are considered for comparison purposes only. The water-quality standard for water temperature was exceeded at sites on the West and East Walker Rivers in Nevada that were sampled during June 1994, probably because of low flows that resulted from the drought.

The two samples from Walker Lake are among those that equaled or exceeded levels of concern for each of the 10 water-quality constituents listed previously, except for water temperature, un-ionized ammonia, and lead. This was expected because Walker Lake, the terminus of the Walker River has no outlet, and evaporation from that lake surface exceeds mean annual precipitation on the lake by more than 3 ft/yr (Thomas, 1995, p. 3). Samples from Walker Lake had the highest measured concentrations for dissolved solids (13,600 mg/L), arsenic (1,200 µg/L), boron (30,000 µg/L), chromium (30 µg/L), and molybdenum (350 µg/L) in the study area (tables 8 and 10).

Concentrations of dissolved arsenic in water samples collected in 1994 from the Walker River Basin (table 10) ranged from <1 µg/L (site 1) to 1,200 µg/L (site 26) and the median concentration was 16 µg/L (mean: 125 µg/L). The Nevada water-quality standard for protection of aquatic life established for arsenic is specific to arsenite (As^{+3}), which was not measured in this study. The 96-hour standard for As^{+3} is 180 µg/L and the 1-hour standard is 360 µg/L. These standards are based on the highest average concentration of As^{+3} that should not result in unacceptable effects on aquatic organisms or their uses when in contact with such water for 4 days (96-hour standard) or 1 hour. Concentrations of arsenic (As^{+3} plus As^{+5}) measured in this study exceeded 360 µg/L in samples from two sites (table 10), but for the range of pH values measured for this study (6.9-9.2) and the oxidation-reduction potential expected for oxygenated surface-water (Eh greater than 0 volts), most of the dissolved arsenic probably occurs as the less-toxic arsenate (As^{+5}; Welch and others, 1988, p. 336). A published effect level for arsenic (As^{+3} plus As^{+5}) of 40 µg/L (U.S. Environmental Protection Agency, 1985a) was equaled or exceeded in samples from seven sites (sites 12-14 and 23-26), including samples from those two sites with arsenic concentrations greater than the As^{+3} standard.

Dissolved boron concentrations (table 10; 1994 samples) ranged from <10 µg/L (site 1) to 30,000 µg/L (site 25). The median concentration was 375 µg/L (mean: 2,910 µg/L). More than half the sites sampled (sites 7-26) exceed the concern level of 200 µg/L for vertebrate embryos (Birge and Black, 1977, p. 27) and five samples (sites 22-26) exceed the Nevada water-quality standard of 750 µg/L for irrigation water.

Table 6. Guidelines for concentrations of constituents in water, bottom sediment, and biota that may adversely affect fish, wildlife, and human health

[Abbreviations: µg/g, microgram per gram; µg/L, microgram per liter; --, no information available.]

Constituent	Category	Water (µg/L)	Concentration (µg/g dry weight, except as noted)					Reference
			Sediment	Whole fish	Avian diet	Avian egg	Avian liver	
Aluminum	Concern	87	--	--	--	--	--	U.S Environmental Protection Agency (1988)
	Effect	150	--	--	5,000	--	--	Hall and others (1988); Sparling (1990)
Arsenic	Concern	--	33	0.22[a]	--	--	--	Schmitt and Brumbaugh (1990); Long and Morgan (1991)
	Effect	40	85	2.1[a]	30	--	4.5	Gilderhus (1966); U.S. Environmental Protection Agency (1985a); Camardese and others (1990); Long and Morgan (1991); Stanley and others (1994)
Boron	Concern	200	--	--	30	13	17	Birge and Black (1977); Smith and Anders (1989)
	Effect	52,200	--	--	1,000	49	51	Gersich (1984); Smith and Anders (1989)
Cadmium	Concern	--	5	.5[a]	200	--	--	Cain and others (1983); Schmitt and Brumbaugh (1990); Long and Morgan (1991)
	Effect	1.0	9	--	--	--	--	Hughes (1973); Long and Morgan (1991)
Chromium	Concern	21.5	80	4.0	10	--	4.0	Birge and others (1979a); Haseltine and others (1985); Eisler (1986); Long and Morgan (1991)
	Effect	190	145	50	50	--	--	Birge and others (1979a); Haseltine and others (1985); Long and Morgan (1991)
Copper	Concern	--	70	.9[a]	--	--	--	Schmitt and Brumbaugh (1990); Long and Morgan (1991)
	Effect	400	390	--	--	--	--	Giles and Klaverkamp (1982); Long and Morgan (1991)
Iron	Concern	--	21,200	--	--	--	--	Persaud and others (1993)
Lead	Concern	1.0	35	.22[a]	25	--	2	Finley and others (1976); U.S. Environmental Protection Agency (1985b); Eisler (1988); Schmitt and Brumbaugh (1990); Long and Morgan (1991)
	Effect	3.5	110	--	125	--	8	Wong and others (1981); Hoffman and others (1985); Eisler (1988); Long and Morgan (1991)
Manganese	Concern	--	460	--	--	--	--	Persaud and others (1993)
Mercury	Concern	--	0.15	.17[a]	--	--	--	Schmitt and Brumbaugh (1990); Long and Morgan (1991)
	Effect	0.1	1.3	.62[a]	.5	0.83[a]	6.6[a]	Heinz (1979); Birge and others (1979b); Snarski and Olson (1982); Long and Morgan (1991)
Molybdenum	Concern	28	--	--	200	--	--	Birge and others (1979a); Eisler (1989)
	Effect	790	--	--	500	16	--	Friberg and others (1975); Birge and others (1979a); Eisler (1989)
Nickel	Concern	--	30	--	--	--	--	Long and Morgan (1991)
	Effect	--	50	--	--	--	--	Long and Morgan (1991)
Selenium	Concern	1.0	4.0	4.0	3	13	10	Lemly and Smith (1987); Lillebo and others (1988); Skorupa and Ohlendorf (1991); Skorupa and others (1996); Ohlendorf and others (1993)
	Effect	2.6	--	10	5	24	30	Lillebo and others (1988); Skorupa and Ohlendorf (1991); Skorupa and others, 1996
Vanadium	Concern	80	--	--	100	--	657	White and Dieter (1978); Holdway and Sprague (1979)
	Effect	1,139	--	--	--	--	--	Holdway and Sprague (1979)
Zinc	Concern	--	120	34.2[a]	178	--	--	Stahl and others (1978); Schmitt and Brumbaugh (1990); Long and Morgan (1991)
	Effect	32	270	--	3,000	--	401	Gasaway and Buss (1972); U.S. Environmental Protection Agency (1987); Long and Morgan (1991)

[a] Wet weight.

Concentrations of chromium (table 10; 1994 samples) ranged from <1 µg/L (14 sites) to 30 µg/L (sites 25 and 26). A published level of concern (21.5 µg/L; Birge and others, 1979a) was exceeded by the two samples from Walker Lake. However, Nevada water-quality standard for protection of aquatic life established for chromium is specific to hexavalent chromium (Cr^{+6}), which was not measured in this study. On the basis of pH of the lake (9.2) and an Eh of 0.1 volts (estimated from temperature and dissolved oxygen), most of the chromium should be present as the less toxic Cr^{+3}. Toxicity of chromium to aquatic organisms also is related to water hardness; therefore, the chromium standards for protection of aquatic life are based on water hardness. Using the hardness formula, the effect level for Walker Lake (hardness: 725 mg/L) would be about 8,800 µg/L for 1-hour average concentration and 1,040 µg/L for 96-hour average concentration.

Concentrations of lead (table 10) were less than the analytical reporting limit (1 µg/L) in all samples except site 23 (2 µg/L; 1994 sample), which exceeds a published level of concern (U.S. Environmental Protection Agency, 1985b). Concentrations of lead from Walker Lake (sites 25 and 26) were less than a higher analytical reporting limit (8 µg/L) that resulted from interferences from the high concentration of dissolved solids; therefore, the status of Walker Lake relative to the 1-µg/L level of concern is unknown. Toxicity of lead to aquatic organisms is related to water hardness; therefore the lead standard for protection of aquatic life is based on water hardness. Using the hardness formula, the Nevada water-quality standard for lead in Walker Lake would be 40 µg/L.

Molybdenum concentrations (table 10; 1994 samples) ranged from <1 µg/L (site 4) to 350 µg/L (site 25) and the median concentration was 10 µg/L (mean: 42 µg/L). The Nevada water-quality standard for molybdenum for protection of aquatic life (19 µg/L) was exceeded in 7 samples (sites 13 and 22-26).

Effect or concern levels for uranium for protection of aquatic life have not been identified, but a maximum contaminant level (MCL) of 20 µg/L total uranium has been proposed for drinking water to protect the public (U.S. Environmental Protection Agency, 1991). Concentrations of dissolved uranium (table 10; 1994 samples) ranged from <1 µg/L (sites 1, 4, and 5) to 200 µg/L (site 25) and the median concentration was 9 µg/L (mean: 22 µg/L). The proposed MCL was exceeded at three sites (sites 22, 25, and 26).

Selenium was not detected above analytical reporting limits in samples of water collected during this study. Doyle and others (1995, p. 559) reported concentrations of selenium in the Walker River Basin that ranged from less than an analytical reporting limit of 0.02 µg/L in samples from the West Walker River to 0.04-0.1 µg/L in the East Walker River and 0.27 µg/L in the Walker River near Wabuska, Nev. (site 15). The concentration of selenium in a sample from Walker Lake was 0.16 µg/L, which suggests that although evaporative concentration may have occurred in the upper river, selenium was not concentrated by evaporation in the terminal lake. Potential removal mechanisms have not yet been verified (Doyle and others, 1995, p. 562). Selenium also has been measured at concentrations above effect levels in water samples from the copper-mine-pit lake and tailings fluid in Mason Valley.

Toxicity Tests

Twenty water samples collected during June-August 1994 were tested for potential toxicity using Microtox® procedures (table 11). With the exception of Walker Lake, water collected for this field-screening study did not produce an effect on bacterial luminosity. In these 18 water samples, the effect concentration (EC_{50}) exceeded 100 percent (EC_{50} >100). Two water samples collected from Walker Lake did cause a toxic response (EC_{50}, 6 percent or less).

Bottom Sediment

The State of Nevada has not established criteria for the protection of aquatic life for trace elements in bottom sediment. Therefore, informal guidelines for sediment quality in marine and estuarine environments (Long and Morgan, 1991) and guidelines for the protection and management of aquatic-sediment quality (Persaud and others, 1993) were used to assess possible biological implications of trace-element concentrations in bottom-sediment samples collected for this study. A concern-level designation was assigned to a sediment concentration reported to cause an effect in 10 percent of the toxicity tests considered (Effect Range-Low; Long and Morgan, 1991) or to a concentration where biological effects first become apparent (Lowest Effect Level; Persaud and others, 1993). Concentrations of trace elements in bottom-sediment samples collected in 1994 for this field-screening study are listed in table 12 and concentrations of organochlorine compounds are listed in table 13. Unless otherwise noted, concentrations in bottom sediment are in dry weight.

Following guidelines listed in table 6, bottom-sediment samples collected for this field-screening study (table 12) were below levels of concern for cadmium, chromium, copper, lead, mercury, nickel, and selenium. The concentration of arsenic in a sediment sample from Mason Valley WMA (75 µg/g) exceeded a concern level (33 µg/g; Persaud and others, 1993) and the concentration of zinc in a sediment sample from Weber Reservoir matched a concern level (120 µg/g; Long and Morgan, 1991). All sediment samples collected during this study exceeded the concern levels for iron (21,200 µg/g) and for manganese (460 µg/g; Persaud and others, 1993).

Because of their hydrophobic property and tendency to sorb to organic material, organochlorine compounds may accumulate in bottom sediments (Nimmo, 1985). Therefore, four samples of bottom sediment were collected from the Reservation and analyzed for these potentially toxic compounds. No organochlorine compound residues were detected (table 13).

Biota

The State of Nevada has not established criteria for the protection of aquatic life for trace elements in biological tissue. Therefore, the potential for biological effects associated with trace-element residues in biological tissue was assessed by comparing measured concentrations with guidelines reported in published literature (table 6). A concern-level designation was assigned to a concentration so noted in the literature or a concentration associated with an apparent minor biological effect (for example, decreased growth rate for a limited time or LC_1). Effect levels were assigned to a concentration so noted in the literature or to a concentration associated with a significant biological effect (for example, reduced growth rate, reproductive disorders, increased mortality, or teratogenesis).

According to guidelines listed in table 6, cadmium, chromium, lead, molybdenum, selenium, vanadium, and zinc residues in biological tissues were below levels of concern or effect. Insufficient information was available to assess implications of aluminum, beryllium, barium, iron, magnesium, manganese, nickel, and strontium residues in biological tissues. Concentrations of trace elements in biological samples collected for this study during 1994 are listed in table 14. Unless otherwise noted, concentrations of trace elements in biological tissue are in dry weight.

Both dry-weight and wet-weight concentrations are referred to in the discussion in the following sections where concentrations are compared to published levels of concern or effect. Dry-weight concentrations and moisture percentage values listed in table 14 can be used to calculate wet-weight equivalent concentrations. The conversion is done by multiplying the dry-weight concentration by 1 minus the sample-moisture percentage expressed as its decimal equivalent.

Aquatic Vegetation

Samples of aquatic vegetation collected for this study included six of pondweed (*Potamogeton sp.*), two of waterweed (*Elodea sp.*), and one of widgeon grass (*Ruppia maritima*; table 14). Aquatic vegetation is an important dietary item for many species of dabbling ducks, some diving ducks, and some species of fish. Arsenic in aquatic vegetation collected from one reference site (site 6, 32.5 µg/g) and one site on the Walker River Indian Reservation (site 22, 57.5 µg/g) exceeded dietary effect levels for birds (30 µg/g; Camardese and others, 1990) and for fish (30 µg/g; Oladimeji and others, 1984). Boron concentrations in aquatic vegetation collected at all sites except for two samples from the reference area—Bridgeport Reservoir (above site 2) and Topaz Lake (site 6)—exceeded an avian dietary level associated with reduced weight gain of mallard ducklings (30 µg/g; Smith and Anders, 1989). Mercury residues in one sample of aquatic vegetation collected from Mason Valley WMA (site 12) exceeded an avian dietary effect level (0.5 µg/g; Heinz, 1979).

Aquatic Invertebrates

Aquatic invertebrates collected for this study included four samples of aquatic and semiaquatic bugs (*Hemiptera sp.*), one damselfly (*Odonata sp.*), and two crayfish (*Decapoda sp.*). Aquatic invertebrates are common dietary items consumed by fish, waterfowl, and shorebirds. In the seven invertebrate samples, all trace elements, except boron and mercury, were at concentrations less than the lowest guidelines listed in table 6. One damselfly sample collected from Walker Lake (112 µg/g; site 26) exceeded an avian dietary concern level for boron associated with reduced weight gain of mallard ducklings (30 µg/g; Smith and Anders, 1989). No samples exceeded an avian dietary effect level associated with reduced hatching success or duckling survival (1,000, μg/g; Smith and Anders, 1989). Mercury residues in crayfish (site 15; 0.51 μg/g) and in hemiptera (site 12; 2.78 μg/g) collected in Mason Valley and in a backswimmer sample collected from the Walker River on the Walker River Indian Reservation (site 22; 1.32 μg/g) exceeded an avian dietary effect level (0.5 μg/g; Heinz, 1979).

Fish

Nine composite samples of whole fish were collected for this study. These included largemouth bass (*Micropterus salmoides*, three samples), Lahontan redside (*Richardsonius egregius*, two samples), black bullhead (*Ictalurus melas*, two samples), and tui chub (*Gila bicolor*, two samples). Fish may be consumed by humans and a variety of piscivorous birds. Arsenic concentrations in fish samples collected from the Walker River above Weber Reservoir (site 16; 0.24 μg/g, wet weight) and Walker Lake (site 26; 0.95 μg/g, wet weight) exceeded a concern level for whole fish (0.22 μg/g, wet weight; Schmitt and Brumbaugh, 1990), but were below a concentration associated with decreased growth and survival (2.1 μg/g, wet weight; Gilderhus, 1966). Copper concentrations in one fish sample collected from Bridgeport Reservoir (above site 2; 1.3 μg/g, wet weight) exceeded a concern level for whole fish (0.9 μg/g, wet weight; Schmitt and Brumbaugh, 1990). Mercury residues in composite-fish samples collected from Bridgeport Reservoir (above site 2; 0.18 μg/g, wet weight), Walker River near Wabuska (site 15; 0.20 μg/g, wet weight), and Walker River below Weber Reservoir (site 18; 0.24 μg/g, wet weight) exceeded a concern level for whole fish (0.17 μg/g, wet weight; Schmitt and Brumbaugh, 1990). These three composite-fish samples and two samples collected above Weber Reservoir (site 16, 0.72 μg/g and 0.57 μg/g, dry weight) exceed an avian dietary effect level (0.5 μg/g, dry weight; Heinz, 1979).

Concentrations of mercury in composite-fish samples were well below the regulatory limits for human consumption (1.0 μg/g, wet weight; U.S. Environmental Protection Agency, 1989). However, the fish sampled for this study may not reflect accumulation or magnification found in mature fish or higher trophic levels.

Bird Eggs, Livers, and Muscle Tissue

A total of 18 avian eggs, including 9 American coot eggs (*Fulica americana*), 6 American avocet eggs (*Recurvirostra americana*), and 3 mallard eggs (*Anas platyrhynchos*), were collected for this study. Four liver (one American avocet and three American coot) and three muscle (one American avocet and two American coot) samples from juvenile birds also were collected. Mercury residues in a mallard egg collected from Mason Valley WMA (1.54 μg/g, wet weight) exceed an effect level for avian eggs (0.83 μg/g, wet weight; Heinz, 1979). An American avocet egg collected from a wetland north of the WMA (0.80 μg/g, wet weight) approached this effect level. Mercury residues in avian liver and muscle tissues were below levels of concern. According to guidelines in table 6, concentrations of all other trace-element residues in eggs, liver, or muscle tissue were below levels of concern where such levels been established.

SUMMARY AND CONCLUSIONS

The Walker River Basin was recognized in 1993 by the Bureau Coordinators for the National Irrigation Water Quality Program as an area that receives drainage from DOI-sponsored irrigation, and thus was identified as a field-screening study area. The purpose of this study was to determine if DOI-sponsored irrigation on the Walker River Indian Reservation has caused or has the potential to cause significant harmful effects on human health or fish and wildlife, or has impaired other beneficial water uses. Water, bottom-sediment, and biological samples were collected during the mid-irrigation season (May through August 1994) to characterize conditions throughout the Basin and to identify areas with concentrations of potentially toxic elements that exceeded criteria or standards. In August 1995, water samples were collected again from four sites on the Walker River Indian Reservation. Data from the two periods allow comparison of water quality during the drought conditions in 1994 and after above-normal precipitation in 1995.

The Walker River Indian Reservation occupies about 500 mi^2 in Mineral and Lyon Counties in west-central Nevada. Much of the Reservation is open range used for grazing cattle, and about 2,400 acres have surface-water irrigation rights (representing about 2 percent of the total area in the Walker River Basin having surface-water rights for irrigation) used primarily for cultivation of alfalfa and pastureland.

Weber Reservoir provides storage of irrigation water for the Walker River Indian Reservation. Irrigation on the Reservation began in 1866. In 1924, the federal government brought suit against irrigation-water users of the Walker River on behalf of the Walker River Paiute Tribe. This suit resulted in the tribe's water rights being designated as the most senior on the river.

As of 1994, the irrigation system on the Walker River Indian Reservation consisted of Weber Reservoir and Dam, a diversion structure about 3 mi downstream from the dam on the Walker River, and a canal system on each side of the river that delivers river water to irrigate about 2,400 acres by the border method. The entire irrigation system can supply about 6,000 acres.

Water-quality standards or levels of concern were equaled or exceeded for the following constituents: water temperature, pH, dissolved solids, un-ionized ammonia, phosphate, arsenic, boron, chromium, lead, and molybdenum. The four sites that were sampled both years had physical measurements or chemical constituents in at least one sample that exceeded levels for water temperature, pH, dissolved solids, arsenic, boron, lead, and molybdenum in 1994; but in 1995, only molybdenum exceeded the Nevada water-quality standard, at one site. Concentrations in irrigation laterals were generally lower in samples collected in 1995 than in those collected in 1994, despite little change in flow rates. Changes in water quality at Walker River sites that were sampled in both years show the effect of diluting poor-quality ground-water seepage with river water.

Results of toxicity testing indicate that only water samples from Walker Lake elicited a toxic response by test microorganisms. Published levels of concern for trace-elements in bottom sediment were equaled or exceeded for arsenic, iron, manganese, and zinc. Concentrations of all organochlorine compounds analyzed in bottom sediment were below the analytical reporting limit. Published levels of concern for trace elements in samples of biota collected for this study were equaled or exceeded for arsenic, boron, copper, and mercury.

Mercury concentrations (wet weight) ranged from 0.10 to 0.25 μg/g in avian muscle tissue and from 0.04 to 0.24 μg/g in whole fish. These concentrations were well below the regulatory limits for fish or waterfowl for human consumption for mercury (1.0 μg/g, wet weight). However, fish sampled for this study may not reflect accumulation or magnification found in mature fish or higher trophic levels.

Arsenic and boron concentrations in water, bottom sediment, and biological tissue commonly exceeded levels of concern throughout the Walker River Basin, but levels were exceeded most commonly in the lower Basin. However, concern levels were exceeded even in areas that do not directly receive agricultural drainage and therefore may not be directly associated with agricultural drainage activities. Sources of arsenic and boron are not positively identified, but elevated levels of arsenic and boron in bottom sediment in other wetlands in west-central Nevada have been reported. These trace elements occur naturally in Pleistocene lakebed soils in this area.

Similarly, mercury was elevated in several biological samples collected throughout the Walker River Basin. However, mercury was below levels of detection in water and bottom sediment. Like arsenic and boron, the wide distribution and occurrence of mercury in areas not receiving agricultural drainage suggests that elevated levels of mercury in biological samples are not directly attributable to agricultural activities. Sources of mercury in the Basin are uncertain, but ambient levels reported for different matrices collected from western Nevada generally exceed ranges cited as natural background levels.

Selenium was not detected in samples of water or bottom sediment collected for this study and samples of biota had concentrations below levels of concern. Selenium has been measured at concentrations above effect levels in water samples from the copper-mine-pit lake and tailings fluid in Mason Valley.

Persistent drought conditions limited availability of water for chemical analysis and for the habitat of aquatic biota targeted for tissue analysis. The only established drain on the Walker River Indian Reservation remained dry during the study period (1994-95), and in 1994, virtually all water released from Weber Reservoir was diverted for crop irrigation on the Reservation. Ground-water seepage to the otherwise dry river channel on the Reservation exceeded Nevada water-quality standards for dissolved solids, sulfate, phosphate, arsenic, boron, and molybdenum. In 1995, increased flows in the river diluted concentrations of most water-quality constituents of concern. These data suggest that if ground-water levels were raised high enough to result in ground-water discharge to the agricultural drain, associated water-quality problems might result.

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Supplemental Data

Table 7. Field measurements of physical properties and chemical constituents in surface-water samples from Walker River Basin, Nevada and California, 1994-95

[Abbreviations: ft^3/s, cubic foot per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degree Celsius; mg/L, milligram per liter; --, no data available; <, less than]

Site no. (fig. 1)	Date	Discharge, instantaneous (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)
			Background Area				
1	06-23-94	[a]89	54	7.8	16.0	7.9	104
2	06-23-94	[a]127	230	8.6	19.0	6.4	87
3	06-28-94	75	276	8.2	25.0	7.2	103
4	06-24-94	[a]242	56	7.7	10.0	9.0	101
5	06-24-94	[a]254	61	7.7	14.0	8.3	99
6	07-26-94	--	151	6.9	22.5	8.9	122
7	06-29-94	238	168	8.9	23.5	8.1	114
8	06-29-94	120	250	8.1	19.0	7.5	96
			Mason Valley				
9	06-22-94	.04	250	8.2	24.0	6.6	93
10	06-15-94	1.5	401	8.5	18.0	10.4	130
11	06-13-94	.17	521	8.5	20.0	12.8	167
12	06-15-94	--	660	8.7	24.5	--	--
13	06-14-94	.04	739	8.5	23.5	14.0	196
14	06-13-94	2.6	438	8.6	23.5	9.1	128
15	06-14-94	29	338	8.1	16.0	8.1	98
			Walker River Indian Reservation				
16	07-21-94	20	292	8.1	26.0	8.7	127
17	07-28-94	--	487	8.4	28.0	5.3	80
18	06-16-94	61	487	8.8	23.0	9.2	126
19	06-16-94	.05	483	8.5	17.5	8.3	101
	08-15-95	.3	187	8.1	20.0	8.7	113
20	07-25-94	.01	498	9.0	29.5	15.7	234
	08-15-95	<.01	204	7.8	17.0	4.9	60
21	06-17-94	.02	489	8.2	21.0	--	--
22	07-15-94	<.01	927	7.6	23.0	--	--
	08-15-95	150	270	8.0	22.0	6.5	88
23	08-31-94	.69	2,310	9.0	24.0	7.2	100
	08-14-95	60	328	7.4	22.5	7.1	96
24	08-31-94	.06	1,890	9.2	21.5	--	--
			Walker Lake				
25	07-29-94	--	19,300	9.2	24.0	6.1	91
26	07-29-94	--	19,300	9.2	17.0	3.0	39

[a] Discharge determined from stage-discharge relation for established USGS stream-gaging station.

Table 8. Water hardness and concentrations of major dissolved chemical constituents in surface-water samples from Walker River Basin, Nevada and California, 1994-95

[Abbreviations: mg/L, milligram per liter; °C, degree Celsius]

Site no. (fig. 1)	Date	Hardness (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as HCO_3)	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)	Solids, dissolved, residue at 180°C (mg/L)
							Reference Area							
1	06-23-94	21	7.3	0.7	2.0	0.6	21	25	<1	4.8	0.4	0.2	5.0	40
2	06-23-94	71	21	4.5	19	3.5	92	110	9	16	3.2	.3	16	151
3	06-28-94	85	25	5.3	22	4.2	106	129	<1	23	4.4	.4	17	173
4	06-24-94	18	5.3	1.2	4.3	.5	24	29	<1	2.6	.9	<.1	7.4	35
5	06-24-94	20	5.8	1.2	4.6	.6	25	30	<1	2.8	1.6	.1	8.5	34
6	07-26-94	47	13	3.5	11	1.9	66	80	<1	4.9	4.9	.3	2.5	84
7	06-29-94	47	13	3.6	14	1.8	63	67	5	8.0	7.1	.4	2.8	93
8	06-29-94	69	19	5.2	23	2.9	95	116	<1	18	9.2	.5	7.8	146
							Mason Valley							
9	06-22-94	66	19	4.5	21	3.3	90	110	<1	17	8.8	.5	7.1	136
10	06-15-94	120	40	5.8	32	5.8	108	127	2	72	12	.6	13	268
11	06-13-94	160	45	11	50	6.0	200	210	17	56	17	.7	30	348
12	06-15-94	180	51	12	86	11	318	329	29	22	16	2.2	30	476
13	06-14-94	230	70	14	76	8.8	210	242	7	130	25	1.5	23	514
14	06-13-94	97	28	6.6	54	8.3	140	171	12	54	17	1.1	27	302
15	06-14-94	100	29	7.1	32	3.5	132	161	<1	31	12	.6	16	170
							Walker River Indian Reservation							
16	07-21-94	82	23	5.9	29	3.9	104	127	<1	23	10	.5	12	158
17	07-28-94	130	38	9.0	48	6.1	174	198	7	44	17	.9	16	296
18	06-16-94	140	40	9.5	50	5.7	176	209	12	51	17	.8	18	314
19	06-16-94	140	41	9.8	51	5.5	176	205	5	52	18	.8	18	312
	08-15-95	59	17	3.9	15	2.7	74	90	<1	12	4.7	.3	15	121
20	07-25-94	140	39	9.7	56	6.1	178	190	13	48	18	.8	21	300
	08-15-95	64	19	4.1	17	2.9	80	98	<1	13	5.2	.3	16	122
21	06-17-94	140	41	9.7	50	6.1	175	214	<1	51	17	.8	18	308
22	07-15-94	240	66	18	110	8.4	326	398	<1	110	34	.8	36	574
	08-15-95	86	25	5.7	22	3.5	104	127	<1	20	7.2	.3	20	157
23	08-31-94	80	17	9.0	510	20	456	468	43	320	230	5.0	54	1,450
	08-14-95	91	26	6.4	30	4.3	105	130	<1	40	10	.4	19	177
24	08-31-94	48	10	5.6	380	20	[a]414	(a)	(a)	290	150	3.2	40	1,180
							Walker Lake							
25	07-29-94	720	8.6	170	4,700	220	3,260	2,030	960	3,100	3,300	27	.5	13,600
26	07-29-94	730	8.4	170	4,100	210	3,120	2,440	672	3,000	3,200	26	.8	13,300

[a] Laboratory determination of alkalinity only—field determinations not made.

Table 9. Concentrations of selected species of nitrogen and phosphorus in surface-water samples from Walker River Basin, Nevada and California, 1994

[Abbreviations: mg/L, milligram per liter; N, nitrogen; P, phosphorus; --, samples not collected]

Site no. (fig. 1)	Date	Nitrate, dissolved (mg/L as N)	Nitrite, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Ammonia, un-ionized (mg/L as N)	Orthophosphate, dissolved (mg/L as P)
			Reference Area			
1	06-23-94	<0.05	<0.01	0.02	<0.01	<0.01
2	06-23-94	<.05	<.01	.06	<.01	.05
3	06-28-94	<.05	<.01	.02	<.01	.05
4	06-24-94	<.05	<.01	.02	<.01	<.01
5	06-24-94	<.05	<.01	.02	<.01	<.01
6	07-26-94	<.05	<.01	.42	<.01	.13
7	06-29-94	<.05	<.01	.02	<.01	<.01
8	06-29-94	.08	<.01	.03	<.01	.04
			Mason Valley			
9	06-22-94	<.05	<.01	.02	<.01	.04
10	06-15-94	.06	<.01	.11	.01	.36
11	06-13-94	<.05	<.01	.09	.01	.09
12	06-15-94	<.05	<.01	.11	.03	.85
13	06-14-94	<.05	<.01	.10	.01	.15
14	06-13-94	<.05	<.01	.09	.02	.18
15	06-14-94	<.05	<.01	.09	<.01	.06
			Walker River Indian Reservation			
16	07-21-94	--	--	--	--	--
17	07-28-94	<.05	<.01	.01	<.01	.26
18	06-16-94	<.05	<.01	.09	.02	.08
19	06-16-94	<.05	<.01	<.01	<.01	.08
20	07-25-94	<.05	<.01	.02	<.01	.24
21	06-17-94	<.05	<.01	.02	<.01	.075
22	07-15-94	.10	<.01	.03	<.01	.14
23	08-31-94	<.05	<.01	.03	.01	.49
24	08-31-94	--	--	--	--	--
			Walker Lake			
25	07-29-94	<.05	<.01	.03	.02	.55
26	07-29-94	<.05	.01	.13	.05	.62

Table 10. Concentrations of dissolved trace-element constituents in surface-water samples from Walker River Basin, Nevada and California, 1994-95

[Abbreviations: µg/L, microgram per liter; <, less than]

Site no. (fig. 1)	Date	Aluminum, dissolved (µg/L as Al)	Antimony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium dissolved (µg/L as Be)	Boron, dissolved (µg/L as B)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved, (µg/L as Co)	Copper, dissolved (µg/L as Cu)
					Reference Area						
1	06-23-94	3	<1	<1	7	<1	<10	<1	<1	<1	<1
2	06-23-94	10	<1	11	18	<1	120	<1	1	<1	2
3	06-28-94	30	<1	36	29	<1	110	<1	1	<1	1
4	06-24-94	8	<1	4	11	<1	40	<1	<1	<1	<1
5	06-24-94	8	<1	4	10	<1	50	<1	<1	<1	1
6	07-26-94	4	<1	11	22	<1	190	<1	<1	<1	<1
7	06-29-94	10	<1	9	16	<1	210	<1	<1	<1	1
8	06-29-94	10	<1	10	31	<1	250	<1	<1	<1	<1
					Mason Valley						
9	06-22-94	30	<1	10	27	<1	270	<1	2	<1	1
10	06-15-94	30	<1	27	33	<1	360	<1	<1	<1	4
11	06-13-94	5	<1	15	43	<1	360	<1	<1	<1	3
12	06-15-94	10	<1	75	27	<1	660	<1	1	<1	2
13	06-14-94	4	<1	48	35	<1	580	<1	<1	<1	2
14	06-13-94	40	<1	40	28	<1	440	<1	<1	<1	2
15	06-14-94	10	<1	13	34	<1	290	<1	<1	<1	1
					Walker River Indian Reservation						
16	07-21-94	20	<1	12	37	<1	290	<1	1	<1	2
17	07-28-94	8	<1	35	43	<1	460	<1	2	<1	3
18	06-16-94	8	<1	16	45	<1	390	<1	<1	<1	2
19	06-16-94	9	<1	16	44	<1	390	<1	<1	<1	2
	08-15-95	30	<1	6	28	<1	140	<1	1	<1	2
20	07-25-94	30	<1	34	45	<1	460	<1	2	<1	4
	08-15-95	40	<1	9	31	<1	140	<1	1	<1	2
21	06-17-94	10	<1	16	45	<1	410	<1	<1	<1	2
22	07-15-94	2	<1	27	100	<1	850	<1	6	<1	<1
	08-15-95	40	<1	11	43	<1	190	<1	2	<1	2
23	08-31-94	10	<1	230	28	<1	4,800	<1	4	<1	6
	08-14-95	20	<1	14	35	<1	230	<1	2	<1	2
24	08-31-94	8	<1	350	17	<1	4,700	<1	6	<1	3
					Walker Lake						
25	07-29-94	50	9	1,000	140	<8	30,000	<8	30	<8	10
26	07-29-94	30	8	1,200	140	<8	29,000	<8	30	<8	<8

Table 10. Concentrations of dissolved trace-element constituents in surface-water samples from the Walker River Basin, Nevada and California, 1994-95—Continued

Site no. (fig. 1)	Date	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Uranium, dissolved (µg/L as U)	Zinc, dissolved (µg/L as Zn)
					Reference Area						
1	06-23-94	8	<1	<1	<0.1	4	<1	<1	<1	<1	<1
2	06-23-94	88	<1	58	<.1	5	<1	<1	<1	2	<1
3	06-28-94	110	<1	18	<.1	6	<1	<1	<1	2	<1
4	06-24-94	20	<1	2	<.1	<1	<1	<1	<1	<1	<1
5	06-24-94	17	<1	2	<.1	2	<1	<1	<1	<1	<1
6	07-26-94	140	<1	220	<.1	3	<1	<1	<1	2	1
7	06-29-94	34	<1	7	<.1	4	<1	<1	<1	2	<1
8	06-29-94	35	<1	29	<.1	5	<1	<1	<1	5	<1
					Mason Valley						
9	06-22-94	39	<1	4	<.1	6	<1	<1	<1	4	<1
10	06-15-94	36	<1	23	<.1	10	<1	<1	<1	10	3
11	06-13-94	36	<1	12	<.1	9	<1	<1	<1	15	2
12	06-15-94	230	<1	86	<.1	13	<1	<1	<1	10	<1
13	06-14-94	120	<1	120	<.1	27	<1	<1	<1	7	<1
14	06-13-94	120	<1	16	<.1	14	<1	<1	<1	4	1
15	06-14-94	31	<1	49	<.1	7	<1	<1	<1	6	<1
					Walker River Indian Reservation						
16	07-21-94	63	<1	75	<.1	9	<1	<1	<1	5	<1
17	07-28-94	6	<1	44	<.1	12	<1	<1	<1	9	3
18	06-16-94	<3	<1	29	<.1	11	<1	<1	<1	9	<1
19	06-16-94	5	<1	61	<.1	11	<1	<1	<1	9	<1
	08-15-95	59	<1	49	--	6	1	<1	<1	2	1
20	07-25-94	14	<1	6	<.1	13	<1	<1	<1	9	<1
	08-15-95	67	<1	4	--	6	1	<1	<1	1	3
21	06-17-94	<3	<1	2	<.1	11	<1	<1	<1	9	<1
22	07-15-94	38	<1	390	<.1	26	1	<1	<1	26	1
	08-15-95	74	<1	170	--	10	2	<1	<1	3	3
23	08-31-94	35	2	10	<.1	57	<1	<1	<1	15	3
	08-14-95	28	<1	66	--	26	2	<1	<1	8	<1
24	08-31-94	23	<1	31	<.1	130	<1	<1	<1	12	2
					Walker Lake						
25	07-29-94	50	<8	20	<.1	350	<8	<2	<8	200	23
26	07-29-94	40	<8	20	<.1	340	<8	<1	<8	190	22

Table 11. Results of Microtox® toxicity tests on water samples from selected sites, Walker River Basin, Nevada and California, 1994

[Abbreviations: EC_{50}, effect concentration; >, greater than]

Site no. (fig. 1)	Date	EC_{50} [a] (percent) 5-minute test	15-minute test
Reference Area			
1	6-23-94	>100	>100
4	6-24-94	>100	>100
5	6-24-94	>100	>100
6	7-26-94	>100	>100
Mason Valley Area			
9	6-22-94	>100	>100
10	6-15-94	>100	>100
11	6-13-94	>100	>100
12	6-15-94	>100	>100
13	6-14-94	>100	>100
14	6-13-94	>100	>100
15	6-14-94	>100	>100
Walker River Indian Reservation			
17	7-28-94	>100	>100
18	7-28-94	>100	>100
19	6-16-94	>100	>100
20	7-25-94	>100	>100
22	7-15-94	>100	>100
23	8-31-94	>100	>100
Walker Lake			
26	7-29-94	6.0	4.5

[a] The median effective concentration of sample, expressed as percent, causing a 50 percent decrease in light output under identified conditions of exposure time and temperature (Seiler and others, 1993, p. 27).

Table 12. Concentrations of selected chemical constituents and percent carbon in bottom-sediment samples from selected sites, Walker River Basin, Nevada and California, 1994

[Abbreviations: <, less than; µm, micron; µg/g, microgram per gram]

Site no. (fig. 1)	Date	Fraction	Carbon, inorganic (percent)	Carbon, organic (percent)	Carbon, total (percent)	Aluminum, total (µg/g)	Antimony, total (µg/g)	Arsenic, total (µg/g)	Barium, total (µg/g)	Beryllium, total (µg/g)	Bismuth, total (µg/g)	Cadmium, total (µg/g)	Cerium, total (µg/g)	Chromium, total (µg/g)	Cobalt, total (µg/g)
Reference Area															
6	07-26-94	<62 µm	<0.01	1.3	1.3	87,000	1	14	1,100	2	<10	<0.1	69	62	17
Mason Valley															
9	07-14-94	<62 µm	.31	0.94	1.2	83,000	2	17	740	2	<10	<.1	69	38	19
13	06-14-94	<62 µm	.08	5.4	5.5	64,000	2	75	820	2	<10	1	49	26	29
Walker River Indian Reservation															
17	07-28-94	<62 µm	.14	1.5	1.7	82,000	1	17	800	2	<10	<.1	76	49	26
21	07-13-94	<62 µm	.23	1.7	1.9	80,000	2	15	850	2	<10	<.1	64	35	18
23	07-29-94	<62 µm	.24	.78	1.0	84,000	2	21	960	2	<10	<.1	60	36	15
Walker Lake															
25	08-31-94	<62 µm	.31	3.5	3.8	75,000	2	28	940	2	<10	<.1	52	28	13

Site no. (fig. 1)	Copper, total (µg/g)	Europium, total (µg/g)	Gallium, total (µg/g)	Gold, total (µg/g)	Holmium, total (µg/g)	Iron, total (µg/g)	Lanthanum, total (µg/g)	Lead, total (µg/g)	Lithium, total (µg/g)	Manganese, total (µg/g)	Mercury, total (µg/g)	Molybdenum, total (µg/g)	Neodymium, total (µg/g)	Nickel, total (µg/g)	Niobium, total (µg/g)
Reference Area															
6	40	<2	21	<8	<4	43,000	41	15	40	770	<0.02	<2	34	20	20
Mason Valley															
9	59	<2	22	<8	<4	46,000	39	14	60	810	<.02	<2	31	21	19
13	53	<2	25	<8	<4	45,000	29	14	50	6,100	<.02	2	22	21	15
Walker River Indian Reservation															
17	61	<2	28	<8	<4	56,000	45	20	60	4,400	<.02	<2	35	26	20
21	49	<2	25	<8	<4	45,000	37	16	60	3,100	<.02	<2	28	22	18
23	38	<2	20	<8	<4	37,000	36	17	60	740	<.02	<2	28	17	19
Walker Lake															
25	27	<2	9	<8	<4	31,000	32	13	50	780	<.02	2	24	14	18

Table 12. Concentrations of selected chemical constituents and percent carbon in bottom-sediment samples from selected sites, Walker River Basin, Nevada and California, 1994—Continued

Site no. (fig. 1)	Scandium, total (μg/g)	Selenium, total (μg/g)	Silver, total (μg/g)	Strontium, total (μg/g)	Tantalum, total (μg/g)	Thorium, total (μg/g)	Tin, total (μg/g)	Uranium, total (μg/g)	Vanadium, total (μg/g)	Ytterbium, total (μg/g)	Yttrium, total (μg/g)	Zinc, total (μg/g)
Reference Area												
6	13	<0.1	<0.1	630	<40	18	<10	7	140	2	18	93
Mason Valley												
9	14	<.1	<.1	490	<40	21	<10	8	120	2	17	100
13	11	<.1	<.1	390	<40	13	<10	9	120	1	13	110
Walker River Indian Reservation												
17	15	<.1	<.1	390	<40	23	<10	7	160	2	18	120
21	13	<.1	<.1	450	<40	17	<10	6	120	2	15	100
23	11	<.1	<.1	650	<40	16	<10	7	110	1	15	77
Walker Lake												
25	10	<.1	<.1	710	<40	13	<10	6	93	1	14	71

Table 13. Concentrations of organochlorine compounds and carbon in bottom-sediment samples from selected sites, Walker River Indian Reservation, Nevada, 1994

[Abbreviations: PCB, polychlorinated biphenyls; PCN, polychlorinated naphthalene; DDD, dichlorodiphenyldichloroethane; DDE, dichlorodiphenyldichloroethylene; DDT, dichlorodiphenyltrichloroethane; mm, millimeter; μg/kg, microgram per kilogram; <, less than]

Site no. (fig. 1)	Date	Fraction	Carbon, inorganic (percent)	Carbon, organic (percent)	Carbon, total (percent)	PCB, total (μg/kg)	PCN, total (μg/kg)	Aldrin, total (μg/kg)	Chlorodane, total (μg/kg)	DDD, total (μg/kg)	DDE, total (μg/kg)	DDT, total (μg/kg)
17	07-28-94	2 mm	0.14	1.5	1.7	<1	<1	<0.1	<1	<0.1	<0.1	<0.1
21	07-13-94	2 mm	.23	1.7	1.9	<1	<1	<.1	<1	<.1	<.1	<.1
23	07-29-94	2 mm	.24	0.78	1.0	<1	<1	<.1	<1	<.1	<.1	<.1
25	08-31-94	2 mm	.31	3.5	3.8	<1	<1	<.1	<1	<.1	<.1	<.1

Site no. (fig. 1)	Dieldrin, total (μg/kg)	Endosulfan, total (μg/kg)	Endrin, total (μg/kg)	Heptachlor, total (μg/kg)	Heptachlor epoxide, total (μg/kg)	Lindane, total (μg/kg)	Methoxychlor, total (μg/kg)	Mirex, total (μg/kg)	Perthane, total (μg/kg)	Toxaphene, total (μg/kg)
17	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.6	<0.1	<1	<1
21	<.2	<.1	<.1	<.1	<.1	<.1	<.6	<.1	<1	<1
23	<.2	<.1	<.1	<.1	<.1	<.1	<.6	<.1	<1	<1
25	<.2	<.1	<.1	<.1	<.1	<.1	<.6	<.1	<1	<1

Table 14. Concentrations of selected chemical constituents and percent moisture in biological samples collected from selected sites, Walker River Basin, Nevada and California, 1994

[Abbreviation: <, less than]

Site no. (fig. 1)	Sample matrix	Species	Date	Percent moisture	Concentration (micrograms per gram, dry weight)									
					Aluminum	Arsenic	Boron	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Mercury
Reference Area														
2	vegetation	pondweed	07-08-94	90.8	459.0	15.8	28.4	424.4	<0.1	<0.2	<1.0	12.8	749.9	<0.10
2	vegetation	waterweed	06-23-94	92.6	1,865.0	8.6	51.0	83.4	<.2	<.2	3.6	12.1	3,100	<.10
6	vegetation	waterweed	07-08-94	96.2	9.7	32.5	22.4	220.6	<.2	<.2	5.1	10.4	5,352	<.10
2	invertebrate	hemiptera	07-08-94	89.0	126.2	1.6	2.7	13.5	<.2	1.1	<1.0	14.8	349.7	<.19
2	invertebrate	crayfish	06-24-94	73.4	288.6	3.0	5.3	155.8	<.2	<.2	<1.0	31.7	280.2	<.20
6	invertebrate	hemiptera	07-08-94	88.9	275.0	2.2	1.8	133.0	<.2	.5	<1.0	15.1	544.6	<.19
2	fish	tui chub	07-08-94	82.6	5.0	<0.5	<1.5	5.3	<.1	<.1	1.0	7.5	21.3	1.02
2	fish	redside	06-23-94	87.9	6.1	.7	4.4	19.7	<.1	<.1	1.8	3.8	282.8	.32
6	fish	redside	07-08-94	85.9	5.0	1.1	<1.5	6.3	<.1	<.1	0.8	2.8	68.2	.45
2	avian egg	avocet	06-23-94	73.4	8.0	<.5	2.3	3.1	<.1	<.1	<.5	2.4	67.2	.63
2	avian egg	avocet	06-23-94	73.1	9.4	<.5	<1.5	2.0	<.1	<.1	.9	2.7	50.8	.92
Mason Valley														
12	vegetation	pondweed	06-16-94	92.7	10.2	29.1	126.0	93.2	<.2	<.2	2.6	16.8	5,061	.55
15	vegetation	pondweed	06-14-94	86.7	9.9	4.5	152.2	120.4	<.2	<.2	1.0	10.4	501.6	<.10
12	invertebrate	hemiptera	06-16-94	85.7	268.8	2.4	3.3	9.6	<.2	.3	<1.0	14.7	583.7	2.78
15	invertebrate	crayfish	06-14-94	79.9	300.7	2.5	6.2	144.3	<.2	<.2	1.3	65.3	244.4	.51
15	fish	blk bullhead	06-14-94	77.3	4.9	<.5	<1.5	6.5	<.1	<.1	1.1	3.2	110.3	.87
12	avian egg	avocet	05-13-94	75.5	11.2	<.5	<1.5	2.5	<.1	<.1	<.5	3.5	115.3	.51
12	avian egg	avocet	05-25-94	73.7	8.6	<.5	<1.5	3.8	<.1	<.1	<.5	2.8	103.7	1.43
12	avian egg	avocet	05-25-94	75.4	8.5	<.5	<1.5	4.4	<.1	<.1	<.5	3.1	115.6	.64
12	avian egg	mallard	05-05-94	70.9	6.5	<.5	<1.5	2.7	<.1	<.1	<.5	2.6	73.8	5.28
12	avian egg	mallard	05-05-94	68.7	8.7	<.5	<1.4	5.2	<.1	<.1	<.5	3.1	112.1	.66
12	avian egg	coot	05-13-94	75.1	6.6	<.5	<1.5	4.5	<.1	<.1	<.5	2.8	102.5	1.91
12	avian egg	coot	05-25-94	76.0	5.4	<.5	<1.5	8.6	<.1	<.1	<.5	2.2	55.3	.42
12	avian egg	coot	05-25-94	72.3	5.7	.9	1.8	3.6	<.1	<.1	<.5	2.7	64.3	.62
14	avian egg	coot	05-25-94	75.2	5.4	.5	2.2	0.6	<.1	<.1	<.5	2.6	84.3	.33
14	avian egg	avocet	06-02-94	75.0	9.3	<.5	2.9	1.1	<.1	<.1	<.5	2.5	86.6	3.20

Table 14. Concentrations of selected chemical constituents and percent moisture in biological samples collected from selected sites, Walker River Basin, Nevada and California, 1994—Continued

Site no. (fig. 1)	Sample matrix	Species	Date	Percent moisture	Concentration (micrograms per gram, dry weight)									
					Aluminum	Arsenic	Boron	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Mercury
12	avian liver	avocet	07-14-94	75.5	<5.0	<0.5	<1.5	<0.5	<0.1	0.3	<0.5	23.8	628.6	1.89
12	avian liver	coot	07-14-94	75.5	10.4	.6	4.3	<.5	<.1	.2	<.5	70.0	3,715	2.06
12	avian liver	coot	07-14-94	75.9	<5.0	.6	3.5	<.5	<.1	.1	<.5	29.2	1,463	2.01
12	avian liver	coot	07-14-94	77.1	<5.0	.7	4.0	<.5	<.1	<.1	<.5	48.2	1,197	1.94
12	avian muscle	avocet	07-14-94	75.3	<5.0	<.5	<1.5	<.5	<.1	<.1	.7	23.3	205.3	0.99
12	avian muscle	coot	07-14-94	72.7	<5.0	<.5	1.9	<.5	<.1	<.1	.9	28.3	263.6	.36
12	avian muscle	coot	07-14-94	77.6	10.7	.6	3.0	<.5	<.1	<.1	1.7	31.1	375.4	.59
Walker River Indian Reservation														
16	vegetation	pondweed	06-20-94	86.4	10.2	8.9	153.7	131.6	<.2	<.2	2.1	10.6	1,499	<.10
17	vegetation	pondweed	07-20-94	93.6	9.7	10.6	97.3	164.6	.3	<.2	6.7	19.9	6,414	<.12
22	vegetation	pondweed	07-15-94	94.0	10.0	57.5	72.3	1,005	<.2	<.2	<1.0	26.8	1,722	.12
22	invertebrate	hemiptera	07-15-94	84.6	27.2	1.9	3.7	19.9	<.2	1.5	<1.0	19.1	125.9	1.32
16	fish	blk bullhead	06-20-94	84.4	4.9	1.5	1.8	9.5	<.1	<.1	2.8	3.5	475.3	.72
16	fish	lrg mth bass	06-23-94	82.6	5.0	<.5	2.7	8.8	<.1	<.1	1.1	2.5	46.9	.57
17	fish	lrg mth bass	07-20-94	83.3	5.0	.7	4.0	6.3	<.1	<.1	.9	1.4	48.7	.41
18	fish	lrg mth bass	06-24-94	81.8	4.9	.6	<1.5	5.8	<.1	<.1	1.2	1.7	97.4	1.31
18	avian egg	mallard	05-25-94	69.5	11.1	<.5	<1.5	17.7	<.1	<.1	<.5	3.8	125.0	1.08
17	avian egg	coot	05-17-94	75.2	10.5	<.6	1.6	7.1	<.1	<.1	<.5	3.7	89.0	.94
17	avian egg	coot	06-02-94	74.7	11.4	<.5	<1.5	12.4	<.1	<.1	1.0	1.8	71.5	1.08
17	avian egg	coot	06-02-94	76.4	9.2	<.5	2.3	12.7	<.1	<.1	<.5	3.5	90.4	1.23
17	avian egg	coot	06-02-94	76.4	6.5	<.5	2.2	2.7	<.1	<.1	<.5	2.4	67.1	1.10
17	avian egg	coot	06-02-94	75.2	8.9	<.5	<1.5	5.4	<.1	<.1	<.5	2.9	84.5	2.08
Walker Lake														
26	vegetation	widgeon grass	07-15-94	91.7	10.0	18.2	641.2	18.2	<.2	<.2	2.1	9.5	347.3	<.10
26	invertebrate	damsel fly	07-15-94	86.8	27.0	7.1	112.5	1.4	<.2	<.2	<1.0	12.3	74.6	.28
26	fish	tui chub	07-15-94	77.3	4.9	4.2	49.1	27.6	<.1	<.1	1.6	1.9	50.0	.68

Table 14. Concentrations of selected chemical constituents and percent moisture in biological samples collected from selected sites, Walker River Basin, Nevada and California, 1994—Continued

Site no. (fig. 1)	Sample matrix	Date	Concentration (micrograms per gram, dry weight)								
			Magnesium	Manganese	Molybdenum	Nickel	Lead	Selenium	Strontium	Vanadium	Zinc
					Reference Area						
2	vegetation	07-08-94	5,666	10,140	<1.5	<0.5	6.4	<0.50	496.4	2.6	21.8
2	vegetation	06-23-94	3,049	2,323	2.0	1.7	1.8	<.50	125.4	6.2	60.1
6	vegetation	07-08-94	4,179	1,327	<1.5	2.8	3.9	<.50	151.0	10.7	48.4
2	invertebrate	07-08-94	1,341	702.7	1.0	<1.0	<1.0	<.97	22.2	<0.5	129.8
2	invertebrate	06-24-94	1,606	552.4	<1.0	<1.0	1.3	<.99	446.7	1.2	76.3
6	invertebrate	07-08-94	1,346	554.1	1.1	<1.0	<1.0	<.95	22.3	1.6	107.9
2	fish	07-08-94	979.0	7.6	<.5	<.5	<0.5	.81	67.4	<.5	76.6
2	fish	06-23-94	986.4	187.8	<.6	<.6	.7	.82	167.7	<.6	179.7
6	fish	07-08-94	882.9	10.1	<.5	<.5	1.1	.92	58.3	<.5	117.4
2	avian egg	06-23-94	322.8	3.3	<.5	<.5	1.1	2.32	7.4	<.5	28.2
2	avian egg	06-23-94	272.3	2.5	<.5	<.5	.5	2.29	8.1	<.5	21.9
					Mason Valley						
12	vegetation	06-16-94	3,681	2,264	4.9	3.4	4.6	.75	181.4	22.3	48.6
15	vegetation	06-14-94	4,244	2,782	3.3	<1.5	2.2	<.51	135.3	2.8	39.3
12	invertebrate	06-16-94	1,203	254.9	<1.0	<1.0	<1.0	<.94	15.7	1.6	112.9
15	invertebrate	06-14-94	2,154	1,495	<1.0	<1.0	5.2	<.10	587.7	<1.0	77.5
15	fish	06-14-94	825.2	58.8	<.5	<.5	.6	1.73	62.7	<.5	55.8
12	avian egg	05-13-94	433.6	9.6	.6	<.5	<.5	1.84	12.3	<.5	41.2
12	avian egg	05-25-94	352.4	3.2	<.5	<.5	<.5	2.84	10.9	<.5	40.3
12	avian egg	05-25-94	382.0	3.0	<.5	<.5	.8	1.81	11.5	<.5	43.0
12	avian egg	05-05-94	300.6	1.7	<.5	<.5	<.5	2.04	9.7	<.5	43.7
12	avian egg	05-05-94	346.2	3.9	<.5	<.5	<.5	1.86	8.9	<.5	38.3
12	avian egg	05-13-94	366.5	2.5	<.5	<.5	<.5	1.21	9.2	<.5	41.5
12	avian egg	05-25-94	348.3	1.0	<.5	<.5	<.5	1.13	15.2	<.5	38.8
12	avian egg	05-25-94	320.3	3.0	.5	<.5	<.5	1.30	10.2	<.5	42.3
14	avian egg	05-25-94	265.3	0.8	<.5	<.5	<.5	1.40	18.3	<.5	34.6
14	avian egg	06-02-94	355.9	1.1	<.5	<.5	<.5	2.60	47.3	<.5	36.7

Table 14. Concentrations of selected chemical constituents and percent moisture in biological samples collected from selected sites, Walker River Basin, Nevada and California, 1994—Continued

Site no. (fig. 1)	Sample matrix	Date	Concentration (micrograms per gram, dry weight)								
			Magnesium	Manganese	Molybdenum	Nickel	Lead	Selenium	Strontium	Vanadium	Zinc
12	avian liver	07-14-94	917.6	13.8	2.3	<0.5	<0.5	8.60	1.1	<0.5	93.4
12	avian liver	07-14-94	839.7	8.4	6.1	<.5	1.2	2.39	1.3	<.5	226.4
12	avian liver	07-14-94	517.9	4.6	3.3	<.5	<.5	2.36	1.3	<.5	126.0
12	avian liver	07-14-94	548.4	6.1	2.0	<.5	<.5	2.51	2.1	<.5	136.7
12	avian muscle	07-14-94	1,147	1.8	<0.5	<.5	<.5	2.07	0.5	<.5	39.1
12	avian muscle	07-14-94	938.7	1.3	<.5	<.5	<.5	1.28	.5	<.5	44.7
12	avian muscle	07-14-94	863.8	3.0	<.5	<.5	.5	1.54	1.8	<.5	55.4
					Walker River Indian Reservation						
16	vegetation	06-20-94	4,422	3,815	3.7	1.7	3.9	<0.51	126.0	5.8	41.2
17	vegetation	07-20-94	6,856	1,656	1.9	5.6	9.2	<.62	234.3	16.6	70.8
22	vegetation	07-15-94	4,443	28,740	10.5	4.2	8.6	<.52	511.9	14.6	64.3
22	invertebrate	07-15-94	1,436	1,003	1.0	<1.0	<1.0	<.98	22.6	<1.0	134.6
16	fish	06-20-94	976.1	127.7	<.5	<.5	.7	1.81	84.9	1.7	61.7
16	fish	06-23-94	771.5	82.2	<.5	<.5	1.0	1.02	92.6	.5	44.5
17	fish	07-20-94	1,349	49.3	<.5	<.5	.7	.85	91.9	<.5	59.3
18	fish	06-24-94	982.1	58.7	<.5	<.5	<.5	1.19	86.0	<.5	56.6
18	avian egg	05-25-94	364.7	11.8	<.5	<.5	<.5	1.69	8.5	<.5	44.5
17	avian egg	05-17-94	421.0	1.5	1.1	<.5	<.5	1.16	9.8	<.5	38.0
17	avian egg	06-02-94	377.5	2.1	<.5	<.5	<.5	1.34	9.4	<.5	41.7
17	avian egg	06-02-94	594.4	2.7	<.5	<.5	<.5	1.15	9.3	<.5	51.9
17	avian egg	06-02-94	430.7	1.6	<.5	<.5	<.5	1.02	4.7	<.5	33.1
17	avian egg	06-02-94	458.4	4.1	<.5	<.5	<.5	1.17	9.4	<.5	46.5
					Walker Lake						
26	vegetation	07-15-94	5,695	135	4.8	<1.5	1.1	<.50	363.2	1.5	27.1
26	invertebrate	07-15-94	1,167	16.4	1.2	<1.0	<1.0	1.63	36.6	<1.0	68.1
26	fish	07-15-94	1,212	5.3	.6	<.5	<.5	2.50	213.7	<.5	60.5

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