Reconnaissance Investigation of Water Quality, Bottom Sediment,and Biota associated with Irrigation Drainage in the Owyhee and Vale Projects, Oregon and Idaho, 1990-91

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U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 93-4156

Prepared in cooperation with the
U.S. FISH AND WILDLIFE SERVICE,
BUREAU OF RECLAMATION, and
BUREAU OF INDIAN AFFAIRS

Portland, Oregon
1994

U. S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS

Multiply	By	To obtain
acre	4,047	square meter (m^2)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
inch	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
pound (lb)	2.205	kilogram (kg)

Electrical conductivity is measured as specific electrical conductance, in units of µS/cm (microsiemens per centimeter) at 25°C.

Chemical concentrations in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the solute mass (milligrams) per unit volume (liter) of water, and is about the same as parts per million (ppm), by volume, unless concentrations are more than 7,000 mg/L. One thousand micrograms per liter are equivalent to 1 mg/L. One million nanograms per liter (ng/L) is equivalent to 1 mg/L. Chemical concentration in sediment is given in micrograms per gram (µg/g) for trace elements and micrograms per kilogram (µg/kg) or picograms per gram (pg/g) for organic compounds; biological tissues are given in µg/g—dry weight for trace elements and wet weight for organic compounds. One thousand µg/kg is equivalent to 1 µg/g or 1 million picograms per gram (pg/g).

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\,(°C) + 32.$$

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

Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Owyhee and Vale Projects, Oregon and Idaho, 1990–91

By Frank A. Rinella, William H. Mullins, *and* Carol A. Schuler

Abstract

A reconnaissance investigation was conducted during 1990–91 in the Owyhee and Vale projects in eastern Oregon and southwestern Idaho, as well as at a number of sites in the Snake River and tributaries to the Snake River in the area of study. The objective of the study was to determine if agricultural drainwater entering the study area was causing, or had the potential to cause, significant harmful effects to human health, fish and wildlife, or may adversely affect the suitability of water for beneficial uses.

Approximately 153,000 acres of land are irrigated annually within the areas of the Owyhee and Vale projects. Large quantities of water are required because of the semiarid climate and relatively high evaporation rates. Several reservoirs in the area are filled annually during the wet, nonirrigation season to sustain irrigation during the dry summer months. During the irrigation season, this impounded water, along with direct diversions from the Malheur, Owyhee, and Snake Rivers, is transported to the irrigated areas through a series of diversion tunnels, siphons, canals, aqueducts, ditches, and drains. Major crops grown in the area include sugar beets, alfalfa hay and other hay crops, onions, and winter wheat. Minor crops include corn, potatoes, mint, various seed crops, and fruit. In 1987, it was estimated that the following amounts of pesticides were used in the project areas: 2,4-D (21,000 lbs [pounds]), chlorpyrifos (1,000 lbs), dacthal (40,000 lbs), dicamba (320 lbs), endosulfan (2,500 lbs), ethion (11,000 lbs), malathion (24,000 lbs), parathion (5,000 lbs), and phorate (11,000 lbs).

Median concentrations and values for total dissolved solids, alkalinity, sodium adsorption ratio, and hardness in the Vale project area were greater than 1.5 times those values observed in the Owyhee project area or at other Snake River locations. During irrigation (August 1990), total dissolved solids, alkalinity, sodium adsorption ratio, and hardness values increased in a downstream manner. Constituent values at drainwater sites generally were comparable to concentrations below the irrigated areas in the Owyhee and Vale project areas.

The trace elements arsenic, boron, copper, molybdenum, vanadium, and zinc were detected in most water samples; cadmium, chromium, lead, and selenium were detected in some samples at concentrations generally near the analytical reporting limit; mercury was not detected in any samples. In some water samples, concentrations of arsenic, boron, cadmium, copper, and lead exceeded State or Federal water-quality standards or criteria.

Most trace elements in bottom sediment were detected at concentrations within the expected 95-percent baseline range for soils from the Western United States. Concentrations that exceeded the 95-percent baseline range for study area soils were: (1) arsenic and lead in one sample from a

site in the Vale project area; (2) mercury, lead, and tin in one sample from a site in the Snake River system; (3) manganese in two samples from two sites in the Snake River system; and (4) manganese from one sample from a site in the Vale project area.

Fifteen pesticides and metabolites were detected in whole-water samples collected from 11 sites in the study area. DDT, plus its metabolites (DDE and DDD), dieldrin, endrin, 2,4-D, dicamba, and dacthal were detected in samples collected from seven or more sites. Other pesticides detected included chlorpyrifos, endosulfan, ethion, malathion, parathion, phorate, and lindane. Most of the detected pesticide concentrations generally were largest in drainwater and at the most downstream sampling locations in the Owyhee and Vale project areas. Concentrations exceeded water-quality criteria established for the protection of freshwater aquatic life in 86 percent of the whole-water samples analyzed for DDT plus its metabolites, 71 percent of the dieldrin samples, 14 percent of the endrin samples, and 10 percent of the parathion samples.

Eight pesticides and metabolites were detected in bottom-sediment samples collected from 14 sites in the study area. Chlordane, DDT plus its metabolites, and dieldrin were detected at 11 or more of the sites. Other pesticides or metabolites detected included aldrin, endosulfan, and heptachlor epoxide. When normalized for organic-carbon concentrations, concentrations for most of the eight compounds were largest in drainwater and at the most downstream locations in the Owyhee and Vale project areas. All bottom-sediment samples analyzed for chlordane, DDT plus its metabolites, and heptachlor epoxide; about 50 percent of the endosulfan samples; and about 8 percent of the aldrin plus dieldrin samples contained interstitial-water concentrations that exceeded the "no-effect" (safe) criteria proposed for the protection of benthic fauna from chronic toxicity.

Concentrations of boron, mercury, selenium, cadmium, copper, lead, zinc, and some organochlorine pesticides (DDT and its metabolites, dieldrin, and toxaphene) in some biological tissues exceeded recommended guidelines or criteria for the protection of the health of humans, fish, or wildlife. However, these elevated concentrations were not consistently found in all sample media or at all sampling sites.

Chemical and biological data collected during this reconnaissance investigation was not conclusive as to whether irrigation drainage from the Owyhee and Vale project areas has caused or has the potential to cause harmful effects on human health, fish, and wildlife. Concentrations of total dissolved solids, major ions, nitrate plus nitrite, arsenic, boron, and selenium increased during the irrigation period. These increases were detected from above to below the irrigated areas in the Owyhee and Vale project areas, and may be the result of irrigation of the agricultural areas. Elevated pesticide concentrations detected in surface water and bottom sediment within agricultural drains and below the irrigated areas, in the project areas, further indicate that these concentrations result from current and (or) historical application of pesticides to the irrigated agricultural areas. However, results of the biological data collected during this investigation do not support the findings of the water-chemistry or bottom-sediment data. Contaminants in some of the biological tissues were sufficiently elevated to exceed recommended guidelines for the protection of human health, fish, and wildlife; however, these elevated concentrations were not consistently found in all sample media or at all sites.

INTRODUCTION

During the last several years, there has been increasing concern about the quality of irrigation drainage and its potentially harmful effects on human health, fish, and wildlife. Concentrations of selenium greater than water-quality criteria for the protection of aquatic life (U.S. Environmental Protection Agency, 1986a) have been detected in subsurface drainage from irrigated land in the western part of the San Joaquin Valley in California.

In 1983, incidences of mortality, birth defects, and reproductive failures in waterfowl were discovered by the U.S. Fish and Wildlife Service (USFWS) at the Kesterson National Wildlife Refuge in the western San Joaquin Valley where irrigation drainage was impounded. In addition, potentially toxic trace elements and pesticide residues have been detected in other areas in the Western United States that receive irrigation drainage (Feltz and others, 1991).

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

Initially, the Task Group identified 20 areas in 13 States that warranted reconnaissance-level investigations related to three specific activities: (1) irrigation or drainage facilities constructed or managed by the DOI, (2) national wildlife refuges managed by the DOI, and (3) other migratory bird or endangered species management areas that receive water from DOI-funded projects.

Nine of the 20 areas were selected for reconnaissance investigations during 1986–87. The nine areas are:

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

Reports for these nine reconnaissance investigations have been published. On the basis of the results of these investigations, four detailed studies were begun in 1988: Salton Sea area, Stillwater Wildlife Management area, Middle Green River Basin area, and the Kendrick Reclamation project area. Eleven more reconnaissance investigations were begun in 1988:

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

Evaluation of results for these investigations, and a continuing evaluation of all data for the Irrigation Drainage Program, led to the start of three more detailed studies in 1990–91:

California-Oregon:	Klamath Refuge Complex
Montana:	Sun River area
Colorado:	Gunnison River Basin/ Grand Valley project

In October 1990, four reconnaissance investigations were begun and another was started in October 1991. The study areas were:

Oregon-Idaho:	Owyhee and Vale projects
Nevada:	Humboldt Wildlife Management area
Colorado:	Dolores Project area
New Mexico:	San Juan River area
Washington:	Middle Columbia River Basin

All investigations were conducted by interbureau study teams composed of a scientist from the U.S. Geological Survey (USGS) as team leader, with additional scientists representing several different disciplines from USGS, USFWS, Bureau of Reclamation (BoR), and Bureau of Indian Affairs (BIA). The investigations are directed toward determining whether irrigation drainage has caused or has the potential to cause significant harmful effects on human health, fish, and wildlife, or may adversely affect the suitability of water for beneficial uses.

Purpose and Scope

This report presents results of a reconnaissance investigation to determine whether potentially toxic concentrations of selected trace elements or pesticides associated with irrigation drainage exist in surface water, bottom sediment, aquatic plants, aquatic insects, fish, and waterbirds in the Owyhee and Vale irrigation projects in eastern Oregon and southwestern Idaho. The Owyhee and Vale irrigation projects were selected for investigation, in part, because previous investigations have noted (1) elevated concentrations of arsenic, selenium, nitrate, and dacthal in area wells; (2) elevated concentrations of arsenic and boron in the Owyhee and Malheur Rivers; and (3) elevated concentrations of mercury and organochlorine compounds in fish from the Owyhee, Malheur, and Snake Rivers.

The objective of this reconnaissance investigation was to determine from previous studies and from new data-collection activities whether irrigation drainwater from the Owyhee and Vale irrigation projects has caused or has the potential to cause harmful effects on human health, fish and wildlife, or to impair other beneficial uses of water.

Samples of water, bottom sediment, aquatic plants, aquatic insects, fish, and waterbirds were collected from 13 sites in the Owyhee and Vale projects, as well as from 6 sites in the Snake River and tributaries to the Snake River in the area of study. These samples were analyzed for major and trace elements, pesticides, and other organochlorine compounds to determine whether known water-quality standards or other criteria have been exceeded.

Acknowledgments

Appreciation is extended to David Zimmer of the BoR, Pacific Northwest Office, for conducting a tour of the study area, assisting in the sampling efforts, and providing a detailed map of the surface-water movement through the Owyhee and Vale project areas. Appreciation is also extended to Douglas O. Cushman of the USGS for laboratory and field support; to Terry Holubetz and Clair Kofoed of the Idaho Department of Fish and Game; and to Edward Crateau, Stephen Duke, James Esch, Peggy Guillory, Alison Beck Haas, Richard Howard, Edward Koch, Charles Lobdell Jr., Charles Lobdell Sr., Katherine Looney, Elizabeth Materna, Helen Ulmschneider, Deanna Vinson, Barry Whitehill, Betsy Whitehill, Geraldine Williams, and Bruce Zoellick of the USFWS for assistance in collecting and processing biological samples. Kevin Ryan, Refuge Manager, and the staff of the Deer Flat National Wildlife Refuge provided facilities, equipment, and logistical support. Susan Burch and Bruce Zoellick of the USFWS assisted in data management. The authors also would like to acknowledge reviews of this report by members of the National Irrigation Water-Quality Program.

GENERAL DESCRIPTION OF THE STUDY AREA

The Owyhee and Vale projects are under the management and direction of the BoR, Pacific Northwest Regional Office, located in Boise, Idaho. Both projects are in east-central Oregon and southwest Idaho (figs. 1–3). The Owyhee project includes about 118,000 acres of irrigated lands, and is located in eastern Malheur County, Oregon, and northwestern Owyhee County, Idaho (fig. 2). The Vale project includes about 35,000 acres of irrigated land and is located in northeastern Malheur County, Oregon, along the lower Malheur River (fig. 3).

In order to store water necessary to sustain irrigation during the dry summer periods, several reservoirs were constructed and used to impound water during the winter season. This impounded water, along with direct diversions from the Malheur, Owyhee, and Snake Rivers, is delivered to irrigated areas through a series of diversion tunnels, siphons, canals, aqueducts, ditches, and drains (fig. 4). Willow Creek, Bully Creek, the Malheur River, and the respective tributaries of each make up the natural drainage system in the Vale irrigation project. Runoff from water in Bully Creek and Malheur River drainage basins is impounded in Warm Springs, Beulah, and Bully Creek Reservoirs (figs. 3 and 4). In the Owyhee irrigation project, the natural drainage streams include Jump Creek, Succor Creek, Alkali Creek, the Owyhee River, Cow Hollow, and the Snake River; several small streams, along the west side of the Snake River north of the Owyhee River, transport irrigation-return flow directly to the Snake River (figs. 2 and 4). Water in the Owyhee River is controlled by the Owyhee Dam. Water from the Snake River is pumped from several stations along the river (fig. 4).

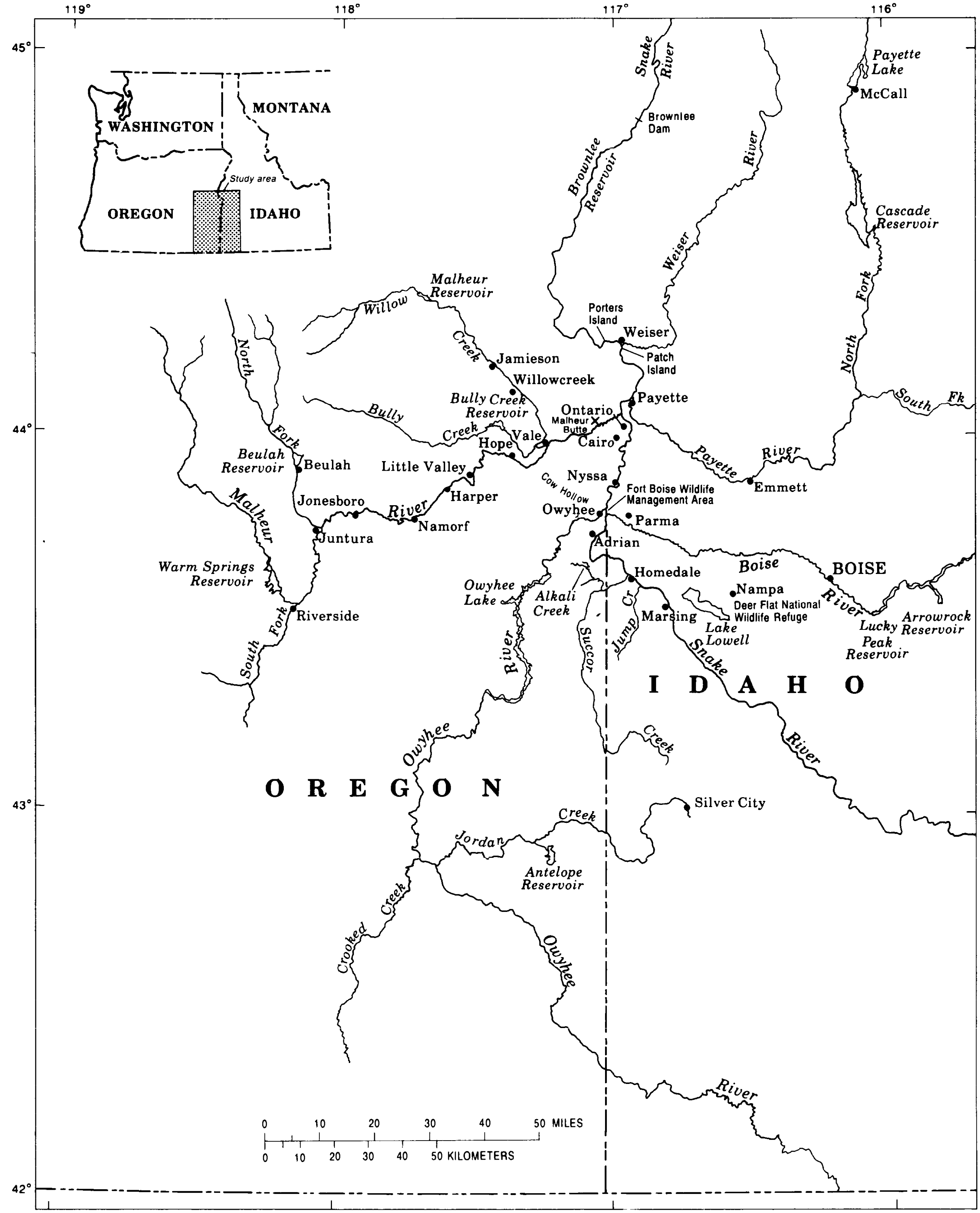


Figure 1. Location of the Malheur, Owyhee, and Snake Rivers in the study area, Oregon and Idaho, 1990–91.

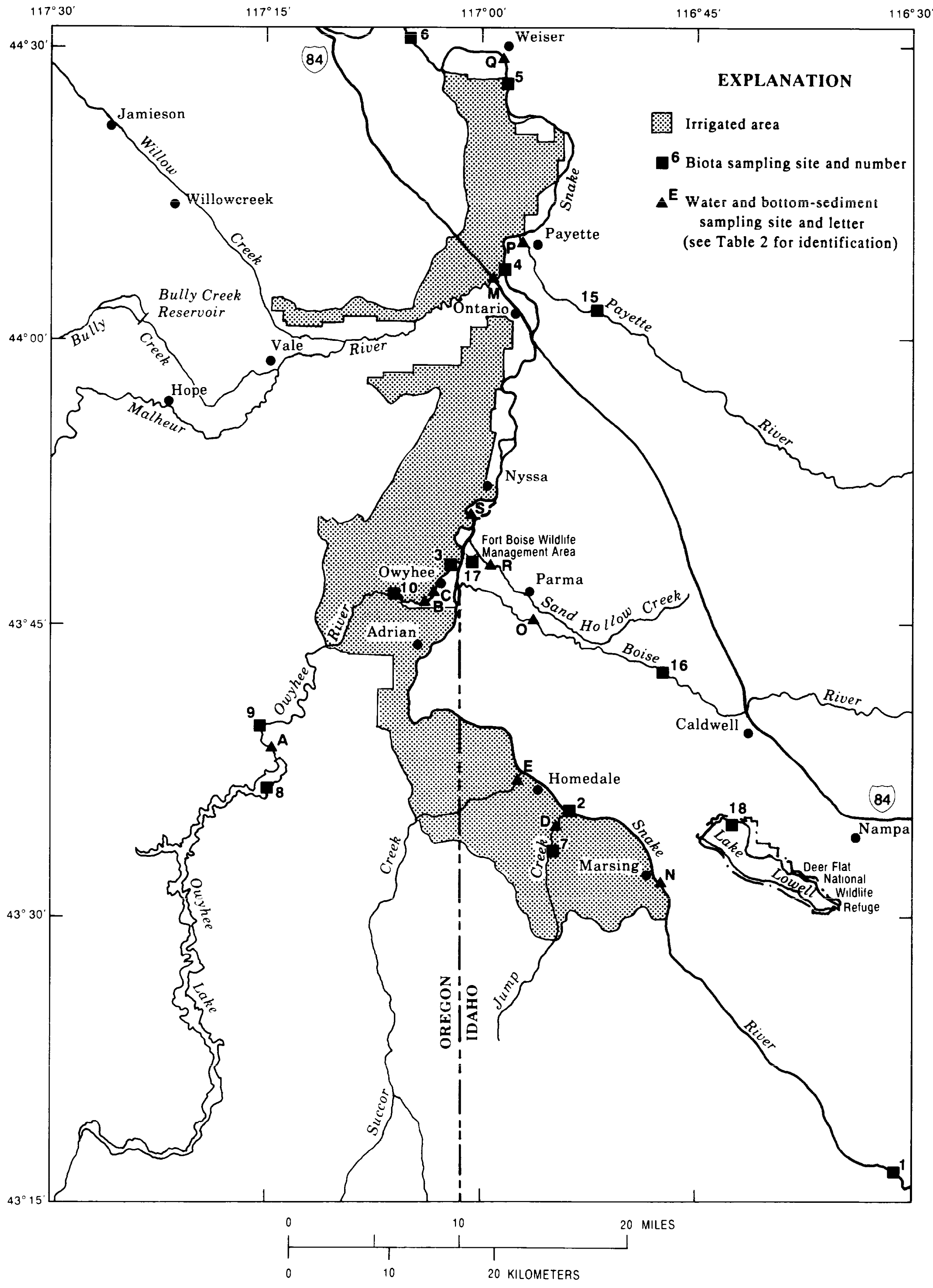


Figure 2. Location of the Owyhee project area, and Snake River system, Oregon and Idaho, 1990–91.

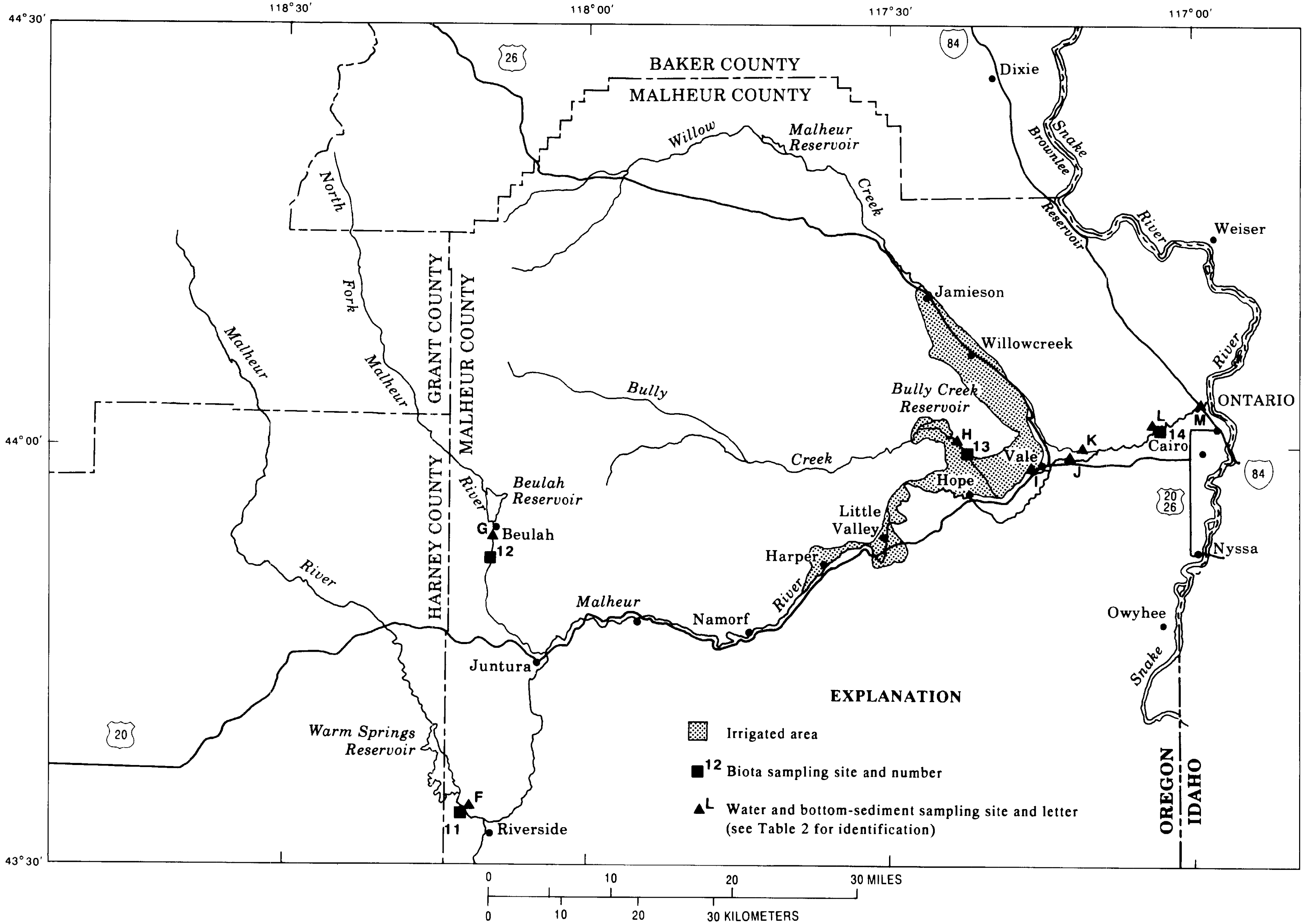


Figure 3. Location of the Vale project area, Oregon, 1990–91.

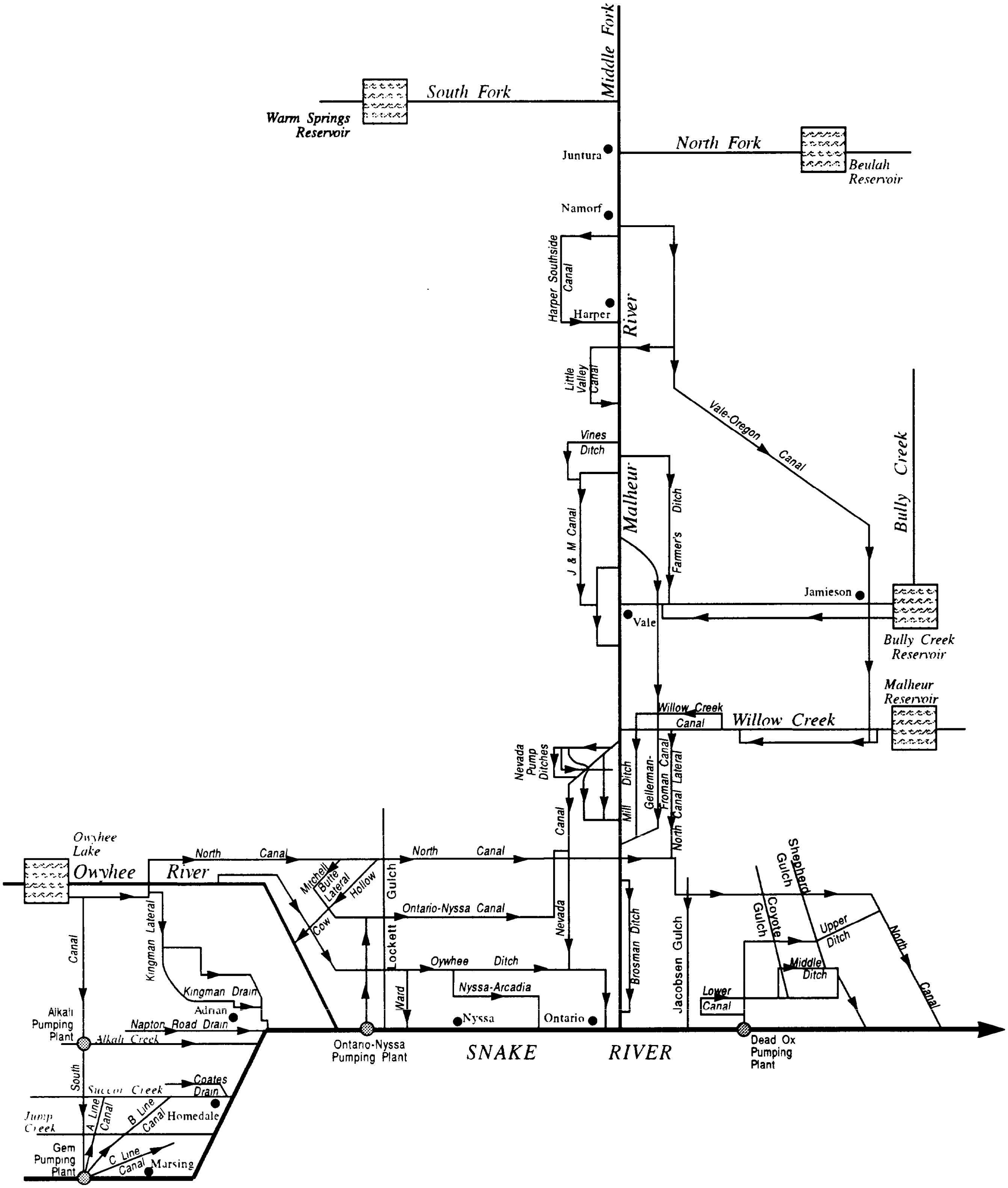


Figure 4. Surface-water movement through the Owyhee and Vale projects, Oregon and Idaho, 1990–91.

The climate of the Owyhee and Vale project areas is semiarid; annual precipitation ranges from 9 to 10 inches. Most precipitation occurs from November through February and from May through June. January and May have the most precipitation, averaging about 1 inch per month. The least precipitation occurs in July and August and is less than 0.3 inches per month. The Owyhee and Vale project areas have hot summers (temperatures at times rise to about 106°F [degrees Fahrenheit]) and cold winters (average temperatures at times fall to 19°F or lower). In the spring and fall, temperatures are moderate and mean temperatures are around 52°F. The growing season is about 159 days for the Vale project area and about 192 days for the Owyhee project area.

The Owyhee and Malheur River Basins occupy the Owyhee upland physiographic region (Malheur County, 1981). Gently sloping to rolling lava plateaus with elevations above 4,000 feet are the predominant land forms. Physiographic features vary widely in the area, ranging from rugged Owyhee breaks along the east side of the Owyhee Lake to broad flat expanses of the barren valley west-centrally located in the area. Soil and vegetation remain devoid in the central region, where lava flows occurred between 500 to 1,000 years ago. Basaltic and rhyolitic lava and tuffs, ranging in age from Miocene to Holocene, underlie extensive areas.

Soils in the Owyhee and Malheur project areas, where most of the cropland of the area is concentrated, consist of low-elevation terraces and flood plains that have been reworked by wind and water over the years (Oregon State University Extension Service, 1989a). The composition of the soil is 60-70 percent silt, 15-20 percent clay, and 5-10 percent sand. The irrigated areas generally are productive and high in potash, although these soils have become more acidic due to the heavy application of acid-residue fertilizers. Soils in the lower flood plains of the Owyhee River, Malheur River, Willow Creek, and Snake River tend to be more alkaline and require treatment to become more productive.

Elemental concentrations for soils in the study area could not be found, but generally are similar to those for soils collected farther south and west of the project areas, in Oregon. These soils have elemental concentrations that fell within a range of geochemical baseline concentrations for elements in soils west of the 97th Meridian of the conterminous United States (Rinella and Schuler, 1992).

These geochemical baseline concentrations would not be typical of elemental concentrations found in areas of the Owyhee and Vale project areas where contamination associated with mercury and gold mining operations has occurred.

Water from the project areas is used primarily for irrigation of agricultural crops. Large quantities of water are required because of the semiarid climate and relatively high rates of evaporation (a pan-evaporation rate of 50 inches per year). The normal irrigation season is usually from about mid-April to about mid-October. In drier years, such as 1990, irrigation in some areas (such as in the Malheur River system) start earlier and end earlier (fig. 5). Major crops grown in the area include sugar beets (15,000 acres), alfalfa hay (53,000 acres), other hay crops (33,000 acres), onions (9,300 acres), and winter wheat (30,800 acres) [Oregon State University Extension Service, 1989a]. In terms of Malheur County's agricultural income, cattle production is first, and onions are second. Minor crops include corn, potatoes, mint, various seed crops, apples, cherries, and peaches. About 10 percent of the land available for irrigation is not irrigated; this land is used for rangeland or dryland farming. Most irrigation in the project areas is by surface spreading methods. Surface spreading entails applying water to the ground in furrows or rills. Only about 10-15 percent of the area is irrigated by sprinklers. In 1987, it was estimated that the following amounts of pesticides were used in the project areas: 2,4-D (21,000 lbs), chlorpyrifos (1,000 lbs), dacthal (40,000 lbs), dicamba (320 lbs), endosulfan (2,500 lbs), ethion (11,000 lbs), malathion (24,000 lbs), parathion (5,000 lbs), and phorate (11,000 lbs) [Oregon State University Extension Service, 1989b].

Historically, the semiarid climate in the Owyhee and Vale project areas supported a native steppe and shrub-steppe vegetative community (Franklin and Dyrness, 1973). The present habitat within both project areas is primarily irrigated farmland and nonirrigated rangeland. Agricultural practices in the area limit quality wildlife habitat. Farm fields encroaching on streambanks have significantly reduced riparian vegetation. Wetland habitats are limited to narrow riparian strips along major watercourses, and populations of nesting aquatic birds are scattered and sparse throughout both project areas. High-quality wildlife habitat is found primarily along the banks and islands of the Snake River, near the mouths of major river systems, and at the Fort Boise Wildlife Management Area.

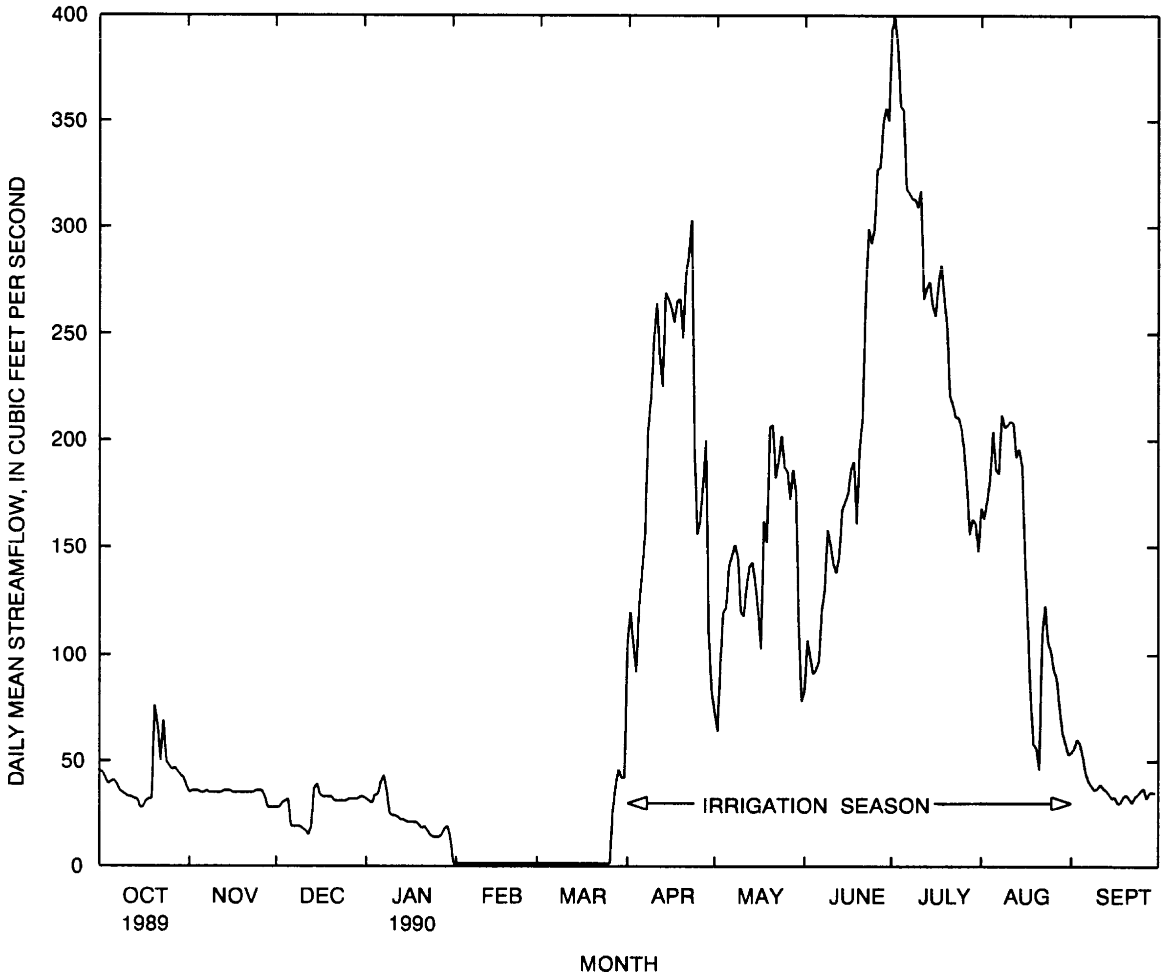


Figure 5. Daily mean streamflow of the Malheur River near Namorf, Oregon, water year 1990.

The Owyhee, Malheur, Boise, and Payette Rivers, as well as return flow from the Vale and Owyhee projects and the Boise project, drain into the Snake River that forms the Oregon-Idaho border about 8 miles downstream of Homedale, Idaho. Thirty islands in this reach of the Snake River, downstream to Rock Island (immediately above Brownlee Reservoir), are part of the Deer Flat National Wildlife Refuge. The Owyhee and Boise Rivers empty into the Snake River, just upstream of the 1,500-acre Fort Boise Wildlife Management Area that is managed by the Idaho Department of Fish and Game (IDFG). The Oregon Department of Fish and Wildlife (ODFW) also manages two islands that are located in the Snake River above Brownlee Reservoir, Patch Island and Porter Island.

The study area contains habitat for two federally listed endangered species, the bald eagle (*Haliaeetus leucocephalus*) and the peregrine falcon (*Falco peregrinus*). The Snake River and parts of the irrigation projects provide important wintering habitat for bald eagles. Bald eagles also nest and winter at Lake Lowell, a BoR reservoir located in the Boise project and a component of Deer Flat National Wildlife Refuge. A peregrine falcon released at Fort Boise Wildlife Management Area in 1987 was observed in the area for about 1 month following its release. Although only one pair of peregrine falcons nest near Nampa, Idaho, peregrines may potentially breed and winter throughout the study area.

The Snake River and adjacent areas provide important breeding and wintering habitat for migratory waterfowl. The Snake River, from Fort Boise Wildlife Management Area downstream to Brownlee Reservoir, supports a nesting population of about 125 pair of Canada geese (*Branta canadensis*) that annually produce approximately 600 goslings. The wintering duck population in this reach averages about 3,300, and consists primarily of mallards (*Anas platyrynchos)* [Todd Fenzl, Deer Flat National Wildlife Refuge, oral commun., 1989]. Fort Boise Wildlife Management Area, which supports a large breeding population of waterfowl and shorebirds, is the most significant area of bird production within the study area.

The Snake River islands and riparian zones adjacent to the Snake, Owyhee, and Malheur Rivers provide important habitat for a large variety of wildlife species. Several Snake River islands provide habitat for breeding colonies of California gulls (*Larus californicus*), black-crowned night herons (*Nycticorax nycticorax*), snowy egrets (*Egretta thula*), and double-crested cormorants (*Phalacrocorax auritus*). Populations of turkeys (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*) recently have been established in, and adjacent to, the Fort Boise Wildlife Management Area. Mule deer (*Odocoileus hemionus*) are yearlong residents on the Snake River islands and riparian corridor. Ring-necked pheasants (*Phasianus colchicus*) and California quail (*Callipepla californica*) are important upland game species found in agricultural lands and riparian zones throughout the study area. Common raptor species that breed in the area include red-tailed hawks (*Buteo jamaicensis*), northern harriers (*Circus cyaneus*), American kestrels (*Falco sparverius*), and short-eared owls (*Asio flammeus*).

The upper reaches of the Malheur River, and Warm Springs, Beulah, and Bully Creek Reservoirs support significant resident fisheries. Warm Springs Reservoir contains large populations of white crappie (*Pomoxis annularis*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*), and bluegill (*Lepomis macrochirus*); and a few channel catfish (*Ictalurus punctatus*), yellow bullheads (*Ictalurus natalis*), yellow perch (*Perca flavescens*), and rainbow trout (*Oncorhynchus mykiss*). Beulah Reservoir supports an excellent rainbow trout fishery, but must be routinely restocked because it is frequently drained during those water years with below-normal precipitation. Bully Creek Reservoir is a popular fishery for white crappie and bass (William Hosford, Oregon Department of Fish and Wildlife, oral commun., 1990).

The Malheur River, above the Namorf diversion, is managed by the ODFW as a cold-water trout fishery. This fishery is periodically treated with rotenone to kill all fish, and then restocked with 80,000-100,000 rainbow trout fingerlings. This reach was last treated in 1987. The Malheur River, below the Namorf diversion, supports few fish because irrigation results in low flows, and water quality is unsuitable for most species. Less than 5 percent of the total fishery consists of game species. The reach from Vale to the mouth supports channel catfish (William Hosford, oral commun., 1990).

Owyhee Lake supports 16 species of fish. Important game-fish species include largemouth and smallmouth bass, white and black crappie (*Pomoxis nigromaculatus*), channel catfish, brown bullheads (*Ictaluris nebulosus*), yellow perch, and rainbow trout (William Hosford, oral commun., 1990).

The first 10-mile reach, downstream of the Owyhee Dam, is managed as a cold-water trout fishery. The lower reaches of the Owyhee River support small numbers of fish because water quality is unsuitable for most species. The species included are largemouth and smallmouth bass, yellow perch, crappie, brown bullheads, and channel catfish (William Hosford, oral commun., 1990).

PREVIOUS STUDIES

Ground Water

Several water-resources studies on ground-water quality have been done in the study area since the late 1970's. On the basis of earlier studies and current work, Collins (1979) summarized water-quality data obtained from analyses of samples collected at a number of wells in Malheur County. Concentrations of nitrate plus nitrite as nitrogen, arsenic, and boron in well water ranged from 0.02 to 2.4 mg/L, 1 to 180 μg/L, and 20 to 4,400 μg/L, respectively.

In a study done by the Oregon State Health Division (1980), analyses of 14 of 95 water samples collected from wells and springs in Malheur County during 1978–79 indicated arsenic concentrations above the maximum U.S. Environmental Protection Agency (USEPA) limit of 50 μg/L established for potable water. The highest number of water-quality exceedances were found in the area near Vale, Oregon.

Between 1983 and 1986, the USEPA (U.S. Environmental Protection Agency, 1986b) investigated the agricultural area south and west of Ontario, Oregon. Samples from 50 wells (depth to water was 10-30 feet) had nitrate plus nitrite as nitrogen concentrations as large as 49 mg/L and dacthal concentrations as large as 290 μg/L.

Dacthal is an effective preemergent herbicide used on onions in Malheur County. The USEPA drinking-water standard for nitrate as nitrogen (N) is 10 mg/L, and the health advisory level for dacthal is 3,500 μg/L. A relation was inferred that the presence of nitrates in ground water could connote pesticide contamination. The USEPA determined that a linear correlation coefficient of 0.7 between nitrate as nitrogen concentrations in milligrams per liter, and dacthal concentrations in micrograms per liter existed in ground water in the Vale-Ontario area. During the same investigation, arsenic concentrations in 4 of 31 wells sampled (13 percent), and selenium concentrations in 3 of 31 wells sampled (10 percent), exceeded drinking-water standards for arsenic of 50 μg/L and for selenium of 10 μg/L (U.S. Environmental Protection Agency, 1986c).

In 1988, the Oregon Department of Environmental Quality (ODEQ) began the Northern Malheur County Water-Quality Project in response to the USEPA 1983–86 study (Oregon Department of Environmental Quality, 1990). Approximately 107 wells in the study area have been tested (with routine bimonthly water collection from 35 wells since August 1988). Approximately 30 percent of the samples had nitrate levels exceeding the USEPA criterion; the largest concentration was 32 mg/L. Approximately 45 percent of the wells had detectable amounts of dacthal; the largest concentration was 986 μg/L (Oregon Department of Environmental Quality, 1990).

Smyth and Istok (1989) quantified the association between the presence of nitrates from nitrate fertilizers and dacthal for 42 wells in the Vale-Ontario area. The correlation coefficient between log of nitrate as N and log of dacthal was 0.74.

Between 1985 and 1987, ODEQ conducted a multi-agency project to assess contamination by agricultural chemicals, including nitrates and pesticides, of ground-water quality in the State of Oregon (Pettit, 1991). A large percentage of wells in the Ontario area were found to contain nitrates and dacthal. The correlation coefficient between nitrates and dacthal was 0.845 in this study (Pettit, 1991).

In a study done in the Ontario-Vale area, Gannett (1990) determined that the most severe ground-water contamination by nitrates and dacthal occurred in a small agricultural area between Nyssa and Ontario, near Cairo Junction. Although contaminants sorbed to aquifer material could still contaminate any new water entering the system, Gannett suggested the water quality of the aquifer would improve if the sources of the contamination were removed. Gannett (1990) estimated it would take 5 to 11 years for water in the Cairo Junction area to migrate to discharge areas along the Malheur or Snake Rivers (a distance of 2 to 4.5 miles).

Surface Water and Bottom Sediment

Several studies and data-collection activities have been conducted in the study area since the late 1970's. An ODEQ nonpoint-source water-quality-management study was done in Malheur County in 1978–80 (Malheur County, 1981). More than 47 stations were sampled for field water-quality measurements, major ions, nutrients, suspended solids, and bacteria. In the Owyhee and Malheur Rivers, the largest concentrations of nitrate plus nitrite as N and of total phosphorus as phosphorus (P) were 3.4 and 1.4 mg/L, respectively. Drainwater concentrations of nitrate plus nitrite as N and total phosphorus as P were even larger at 18.2 and 1.6 mg/L, respectively. The largest observed boron concentration of 890 μg/L also occurred at a drainwater site.

The USGS in Oregon operated a water-quality monitoring site near the mouth of the Owyhee River as part of the National Stream Quality Accounting Network (NASQAN) program (U.S. Geological Survey, 1988). The Owyhee River station at Owyhee, Oregon (station no. 13184000) was operated from June 1979 to August 1986. More than 47 samples were collected over this period for field water-quality measurements and analysis of major ions, nutrients, bacteria, suspended sediment, and trace elements. The following are the maximum concentrations observed for select dissolved constituents at this site: arsenic (60 μg/L), cadmium (3 μg/L), chromium (<1 μg/L), copper (11 μg/L), lead (4 μg/L), mercury (0.4 μg/L), selenium (6 μg/L), zinc (120 μg/L), nitrate plus nitrite as N (4.1 mg/L), and orthophosphorus as P (0.19 mg/L). Maximum concentrations for arsenic, cadmium, mercury, selenium, zinc, and nitrate exceeded the 75th percentile concentrations for these same constituents compiled from 388 stations nationwide that were part of the NASQAN program and the National Water-Quality Surveillance System (NWQSS) [Smith and others, 1987]. Element concentrations exceeding the 75th percentile values are considered elevated relative to the national database.

ODEQ, in cooperation with the BoR, has operated eight water-quality sampling sites in the Owyhee and Malheur River Basins since 1986. Water from these stations is collected each year from May through December, primarily during the irrigation season. In 1990, ODEQ reported the following element concentration ranges: total-recoverable arsenic (4 to 150 μg/L), dissolved boron (90 to 1,070 μg/L), total-recoverable cadmium (<2 to 2 μg/L), total-recoverable chromium (<2 to 36 μg/L), total-recoverable copper (3 to 53 μg/L), total-recoverable lead (<2 to 6 μg/L), total-recoverable mercury (<0.2 to 0.3 μg/L), total-recoverable selenium (<2 to 5 μg/L), total-recoverable zinc (2 to 204 μg/L), dissolved nitrate plus nitrite (0.04 to 6.2 mg/L), and dissolved orthophosphorus (0.025 to 0.520 mg/L). The largest concentrations of arsenic and boron in 1990 were from samples collected at a site on the Malheur River located near Little Valley. The largest concentrations of Cd, Cr, Cu, Pb, Hg, Se, Zn, and orthophosphorus were from samples collected at a site on Willow Creek located east of Vale (a Malheur River tributary). The largest nitrate-plus-nitrite concentration was from a sample collected on Bully Creek (also a Malheur River tributary) at a site located near Vale. Concentrations of a number of constituents, such as arsenic and boron, showed an increasing trend with time. Arsenic increased in concentration from May to December 1990 at the most downstream locations in the Owyhee and Malheur Rivers, from 25 to 53 μg/L and from 38 to 52 μg/L, respectively. During the same period, boron increased in concentration at these same sites from 190 to 360 μg/L and from 450 to 750 μg/L, respectively.

In 1985, Fuste' and McKenzie (1987) did a study to assess current water-quality conditions of the Malheur River. Dissolved ions (such as sodium, calcium, magnesium, and chloride) and trace elements (such as total-recoverable arsenic and dissolved boron) generally increased in concentration in a downstream direction with time. Arsenic and boron increased in concentration from 35 to 54 μg/L and from 270 to 590 μg/L, respectively, at the most downstream sampling location in the Malheur River near Ontario from July through October 1985. Elevated concentrations of 85 μg/L arsenic and 810 μg/L boron were observed at a location on the Malheur River at Little Valley, possibly as a result of geothermal water seepage into the river. Two samples were collected at the Malheur River near the Ontario site in August and October for analyses of select trace elements. The largest total-recoverable concentrations observed were cadmium (1 μg/L), chromium (15 μg/L), copper (6 μg/L), nickel (8 μg/L), selenium (3 μg/L), and zinc (20 μg/L). Bottom-sediment samples were collected at a location on the Malheur River near Ontario. Bottom-sediment concentrations for trace elements were typical of concentrations found in soils in and near the Malheur River Basin (Fuste' and McKenzie, 1987).

In 1988, USEPA conducted a nationwide investigation of the bioaccumulation of select toxic pollutants in fish and shellfish (U.S. Environmental Protection Agency, 1990a). The focus of the investigation was on a variety of organic pollutants that could have potentially harmful effects, primarily on humans. These pollutants tend to bioaccumulate in fish and shellfish tissues. In addition to the collection of the biological samples, a number of bottom-sediment samples were collected. Bottom-sediment samples were collected at four locations in the Owyhee and Vale study areas: one sample was collected in the Owyhee River (Owyhee River at Owyhee) and three samples were collected in the Malheur River (Malheur River at Harper, Malheur River at Vale, and Malheur River at Ontario). The bottom-sediment sample collected from the Malheur River at Harper site contained 0.387 pg/g (picograms per gram) of 2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD, a suspected carcinogen which is extremely toxic to humans and aquatic life). The compound 2,3,7,8-TCDD is also a known impurity in the production of technical dacthal (U.S. Environmental Protection Agency, 1988b). As previously mentioned, dacthal is used extensively as a preemergent herbicide on onions in the study area. DDE was detected in bottom-sediment samples collected from the Owyhee River at the Owyhee location (average concentration 42.2 μg/kg) and from the Malheur River at the Vale location (12.6 μg/kg).

The USGS District in Idaho operates a water-quality monitoring station on the Snake River at Weiser, Idaho (station no. 13269000; water years 1968–1986 and October 1989 to present). Water samples were collected bimonthly in 1990 and analyzed for major ions, nutrients, suspended sediment, bacteria, and selected trace elements. Ranges in concentration for the following dissolved constituents were reported: arsenic (4 to 7 μg/L), cadmium (all <1 μg/L), chromium (1 to 4 μg/L), copper (1 to 3 μg/L), lead (<1 to 3 μg/L), mercury (all <0.1 μg/L), selenium (all <1 μg/L), zinc (<3 to 5 μg/L), nitrate plus nitrite (0.20 to 1.7 mg/L), and orthophosphorus (<0.01 to 0.07 mg/L).

Biota

Elevated mercury concentrations have been detected in fish for several years in the Owyhee and Malheur Rivers. During 1970–71, the Idaho Department of Fish and Game collected samples of water, sediment, and fish from sites throughout Idaho to determine the occurrence of mercury in aquatic ecosystems (Gebhards and others, 1971, 1973). In 1970, 98 percent of all samples tested positive for mercury, and 19 percent of the fish tissue tested equaled or exceeded the 0.5 μg/g (wet weight) Food and Drug Administration (FDA) guideline for mercury residues in human foods. Fish from Snake River reservoirs, including Brownlee Reservoir (located downstream of the study area), had elevated mercury concentrations. Fish from Jordan Creek, a headwater tributary to the Owyhee River, had elevated mercury levels (10 fish had a range of 0.24 to 1.18 μg/g wet weight with a mean of 0.55 μg/g; 60 percent exceeded the FDA standard of 0.5 μg/g). A probable source of this mercury is from historic mining activities in the Owyhee Mountains during the 1860's and from natural geologic formations. Elemental mercury was used in stamp milling, dredge mining, and to a lesser degree in placer mining for gold. It has been estimated by the Idaho Historical Society that one mill in Silver City (located near the headwater of Jordan Creek) contributed 2.5 tons of mercury during 1866–68 (Gebhards and others, 1973). Buhler and others (1973) citing Rose (1915) reported that between 1/4 to 1 ounce of quicksilver was discharged in the waste water per ton of gold ore processed, suggesting that enormous quantities of the metal were lost during processing. Cooper (1983) estimated that 1.5 lbs of mercury was lost to the environment for each ton of ore milled.

Fish collected in 1971 from Antelope Reservoir, located on Jordan Creek about 30 miles above the Owyhee River, contained higher mercury residues than those collected in the streams above the reservoir (Gebhards and others, 1973; Hill and others, 1975). Mercury concentrations in five suckers (*Catostomus* species) from Antelope Reservoir averaged 0.74 μg/g wet weight and in five rainbow trout averaged 0.91 μg/g wet weight (Gebhards and others, 1973). Hill and others (1975) reported mercury concentrations of 17 μg/g in Antelope Reservoir sediment. Mercury concentrations in seven species of fish collected from Brownlee Reservoir ranged from 0.24 μg/g wet weight in a common carp (*Cyprinus carpio*) to 0.73 μg/g wet weight in a northern squawfish (*Ptychocheilus oregonensis*) [Gebhards and others, 1973]. Three potential sources of mercury in fish were hypothesized: (1) past mining activities (as discussed above), (2) natural occurrence from cinnabar ore (mercuric sulfide) found in two locations in Idaho, and (3) agricultural sources. In 1971, an estimated 720 pounds of mercury were used in fungicides for winter and spring wheat. These fungicides may have been a possible source of mercury contamination to the biota through irrigation return flows (Gebhards and others, 1973).

In 1969 and 1970, fish were collected from 42 sites in Idaho, Oregon, Washington, and northern California and analyzed for mercury (Buhler and others, 1973). Fish from Antelope Reservoir in Oregon, and the Snake River in Idaho, Oregon, and Washington contained especially high mercury levels. Mercury concentrations in channel catfish muscle tissue exceeded the FDA guideline of 0.5 μg/g wet weight in 33 percent of the fish collected in the Owyhee River near Mitchell Butte (below Owyhee Lake); 50 percent of the fish collected in the Snake River near Adrian, Oregon (above the Owyhee River confluence); 75 percent of the fish collected in the Snake River near Nyssa (below the Owyhee River confluence); and 100 percent of the fish collected from the Snake River at the upper end of Brownlee Reservoir. The mean value for mercury was 1.28 μg/g wet weight in three rainbow trout collected from Antelope Reservoir, and 0.50 μg/g wet weight in nine black crappie collected from Owyhee Lake.

Observations made by Buhler and others (1973), Gebhards and others (1973), and Hill and others (1975) indicated fish from the different reservoirs had larger mercury concentrations than fish collected in streams above the reservoirs. Buhler and others (1973) noted that the deposition of mercury-rich sediment in reservoirs, "*** provides an opportunity for maximum bacterial formation of methylmercury (Jensen and Jernelov, 1969) which is then readily accumulated by fish."

In 1987, seven species of game and nongame fish were collected from Owyhee and Malheur Reservoirs and Upper Cow Lake by ODFW. These species were analyzed by ODEQ for cadmium, lead, and mercury. Lead was not detected in any of the 11 samples analyzed, and cadmium was detected in only 1 sample (0.04 μg/g dry weight). Mercury was detected in all samples and ranged from 1.4 μg/g to 8.7 μg/g dry weight (geometric mean of 4.9 μg/g).

Fish and sediment samples were collected in 1987 from various sites in the project areas along the Owyhee and Malheur Rivers for the National Bioaccumulation Study (U.S. Environmental Protection Agency, 1987). Those samples were analyzed for a large number of organic and inorganic contaminants. Elevated concentrations of chlordane and DDT and its metabolites were found in fish collected from the Malheur River (Gene Foster, Oregon Department of Environmental Quality, oral commun., 1990). Examples of elevated concentrations include 1,530 µg/kg p,p'DDE in a sucker, 1,300 µg/kg p,p'DDE in a channel catfish fillet, and 371 µg/kg oxychlordane in a common carp (whole body) collected in the Malheur River. The organochlorine compound 2,3,7,8-TCDD was also detected in common carp in the Owyhee River (0.70 to 0.87 pg/g) and in bottom sediment from the Malheur River (0.39 pg/g).

In 1979, the Idaho Department of Health and Welfare analyzed several species of fish collected from Lake Lowell (Deer Flat National Wildlife Refuge) for organic and inorganic compounds. Several compounds were detected, including total polychlorinated biphenyls (PCBs), dieldrin, DDT and its metabolites, nonachlor, pentachlorophenol, and dacthal. Small concentrations of mercury were detected in common carp and yellow perch.

SAMPLE COLLECTION AND ANALYSIS

The primary objective of the sampling plan of this study was to determine whether irrigation drainage from the Owyhee and Vale project areas has caused or could result in acute or chronic toxicity to fish, wildlife, or humans. Chemical concentrations measured in water, bottom sediment, and biota samples were compared with water-quality standards established by the State of Oregon, water-quality criteria determined by the USEPA, and contaminant concentrations that have been reported in the literature to cause adverse biological effects. When standards or criteria were unavailable, the sample concentrations were compared with baseline values thought to be representative of natural conditions. A secondary objective was to determine the relative toxicity of drainwater samples using Microtox bioassays as a screening tool, and additional acute toxicity tests on *Daphnia magna* and *Chironomus tentans* if the Microtox tests demonstrated a high degree of toxicity in drainwater samples.

A core list of major ions and trace elements was designated for analysis by the DOI Task Group on Irrigation Drainage for all irrigation drainage studies. Organochlorine compounds analyzed in the water, bottom sediment, and biota samples represented a group of compounds with known potential for toxicity or were known to have been used in the study area. Major ions, trace elements, and organochlorine compounds analyzed are listed in table 1.

Sampling Sites

A total of 19 sites were selected for collection of water samples, 14 sites were selected for collection of bottom-sediment samples, and 18 sites were selected for biota sampling (table 2 and figs. 2-3). Biological sampling site 1 (Snake River above study area) and water and bottom-sediment sampling site N (Snake River at Marsing, Idaho) represent reference sites that are not influenced by irrigation drainwater from either the Owyhee or Vale projects. However, these sites are influenced by agricultural drainage from other points in the Snake River Basin above the site study area. Locations of biological sampling sites were not as clearly defined as those determined for collection of water and bottom sediment because of the mobility of fish and wildlife, scarcity of desired organisms, and locations of suitable habitat. Therefore, success was not always achieved in matching identical sampling locations for biota to those established for water and bottom-sediment collection.

One of the sampling areas, Fort Boise Wildlife Management Area (represented in table 2 by water and bottom-sediment sites R and S, and biota sampling site 17), is located adjacent to the Snake River near the mouths of the Boise and Owyhee Rivers. It is an important waterfowl and waterbird production area and one of the few areas in the study area with a population of sufficient density for sampling. The ponds and wetlands in the area are supplied entirely by agricultural drainwater from the BoR Boise Project via Sand Hollow Drain. Because there is a dense breeding population of waterfowl and shorebirds within this area of the study that is heavily influenced by irrigation drainwater, it was an important site to sample to determine the potential for elevated concentrations of inorganic and organic constituents in water, bottom sediment, waterfowl, and waterbirds.

Table 1. Chemical constituents analyzed in water, bottom sediment, and biota, Owyhee and Vale project areas, and Snake River system, 1990–91

[2,4-D = 2,4-dichlorophenoxyacetic acid; 2,4-DP = dichlorprop; 2,4,5-trichlorophenoxyacetic acid; DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane; PCB = polychlorinated biphenyl; PCN = polychlorinated napthalene; HCB = hexachlorobenzene]

Water (dissolved concentrations except where noted)					Bottom sediment		Biota	
General water-quality characteristics	Major ions	Nutrients	Trace elements	Organochlorine compounds (whole water)	Elements	Organochlorine compounds	Elements	Organochlorine compounds
Discharge	Alkalinity	Silica	Aluminum	2,4-D	Aluminum	Aldrin	Aluminum	Chlordane
Dissolved oxygen	Calcium	Ammonia as N	Arsenic	2,4-DP	Arsenic	Chlordane	Antimony	DDD
Dissolved solids	Chloride	Nitrate plus Nitrite as N	Barium	2,4,5-T	Barium	DDD	Arsenic	DDE
pH	Fluoride	Orthophosphorus as P	Boron	Aldrin	Beryllium	DDE	Barium	DDT
Specific conductance	Magnesium		Cadmium	Chlordane	Bismuth	DDT	Beryllium	Dieldrin
Suspended sediment	Potassium		Chromium	Chlorpyrifos	Boron	Dieldrin	Boron	Endrin
Temperature	Sodium		Copper	Dacthal	Cadmium	Endosulfan	Cadmium	HCB
	Sulfate		Iron	DDD	Calcium	Endrin	Chromium	Heptachlor epoxide
			Lead	DDE	Cerium	Heptachlor	Cobalt	Lindane(BHC)
			Lithium	DDT	Chromium	Heptachlor epoxide	Copper	Mirex
			Manganese	Diazinon	Cobalt	Lindane (BHC)	Iron	Nonachlor
			Mercury	Dicamba	Copper	Methoxychlor	Lead	PCBs (total)
			Molybdenum	Dieldrin	Europium	Mirex	Magnesium	Toxaphene
			Selenium	Disyston	Gallium	PCB	Manganese	
			Strontium	Endosulfan	Gold	PCN	Mercury	
			Vanadium	Endrin	Holmium	Perthane	Molybdenum	
			Zinc	Ethion	Iron	Toxaphene	Nickel	
				Fonofos	Lanthanum		Selenium	
				Heptachlor	Lead		Silver	
				Heptachlor epoxide	Lithium		Strontium	
				Lindane (BHC)	Magnesium		Tin	
				Malathion	Manganese		Vanadium	
				Methoxychlor	Mercury		Zinc	
				Methyl parathion	Molybdenum			
				Methyl trithion	Neodymium			
				Mirex	Nickel			
				Parathion	Niobium			
				PCB	Phosphorus			
				PCN	Potassium			
				Perthane	Scandium			
				Phorate	Selenium			
				Picloram	Silver			
				Silvex	Sodium			
				Toxaphene	Strontium			
				Trithion	Tantalum			
					Thorium			
					Tin			
					Titanium			
					Uranium			
					Vanadium			
					Yttrium			
					Ytterbium			
					Zinc			

Table 2. Sampling sites and site descriptions for collection of water, bottom sediment, and biota from the Owyhee and Vale project areas, and Snake River system, 1990–91

[ID = Idaho; OR = Oregon; US = upstream of an agricultural area; R = River; blw = below; Cr = Creek; Res = Reservoir; nr = near; WA = within an agricultural area; DS = downstream of an agricultural area; DR = agricultural drain area; WMA = Wildlife Management Area; A = above Fort Boise WMA; B = below Fort Boise WMA; WS = water samples; BS = bottom-sediment samples; I = aquatic insects; P = aquatic plants; F = fish; E = eggs; B = birds]

Water and bottom-sediment sampling sites

Figures 2 and 3 identifications	Site name	Station number	Type of sample collected	Site type
Owyhee Project				
A	Owyhee R blw Owyhee Lake, OR	13183000	WS	US
B	Overstreet Drain, OR	434705117065200	WS, BS	DR
C	Owyhee R at Owyhee, OR	13184000	WS, BS	DS
D	Jump Cr near Homedale, ID	13172890	WS	DS
E	Succor Cr near Homedale, ID	13173500	WS, BS	DS
Vale Project				
F	Malheur R blw Warmsprings Res nr Riverside, OR	13215000	WS	US
G	North Fork Malheur R at Beulah, OR	13217500	WS	US
H	Bully Cr blw Bully Cr Res, OR	440104117230400	WS	US
I	Bully Cr near Vale, OR	435802117161600	WS, BS	DS
J	Malheur R at Vale, OR	435844117141100	WS, BS	WA
K	Willow Cr at Vale, OR	435917117134500	WS, BS	DS
L	D Drain, OR	435945117065300	WS, BS	DR
M	Malheur R near Ontario, OR	440312116585100	WS, BS	DS
Snake River System				
N	Snake R at Marsing, ID	13172850	WS, BS	US
O	Boise R near Parma, ID	13213000	WS, BS	DS
P	Payette R near Payette, ID	13251000	WS, BS	DS
Q	Snake R at Weiser, ID	13269000	WS, BS	DS
R	Sand Hollow Cr inflow to Fort Boise WMA, ID	434759116582800	WS, BS	A,DR
S	Sand Hollow Cr outflow from Fort Boise WMA, ID	434919117003200	WS, BS	B,DR

Biota sampling sites

Figures 2 and 3 identifications	Site name	Type of sample collected	Site type
Snake River			
1.	Snake River above study area	I, P, F, E, B	US
2.	Snake River; mouth of Jump Creek	I, P, F E, B	WA
3.	Snake River; mouth of Owyhee River	I, P, F, B	WA
4.	Snake River; mouth of Malheur River	I, P, F	WA
5.	Snake River at Weiser	I, P, F, E	DS
6.	Snake River below study area (Brownlee Reservoir)	F	DS
Owyhee Project			
7.	Jump Creek	I, P	WA
8.	Owyhee Reservoir	F	US
9.	Owyhee River below Owyhee Reservoir	I, P, F	US
10.	Owyhee River in agriculture area	I, P, F	WA
Vale Project			
11.	Middle Fork Malheur River below Warm Springs Reservoir	I, P, F	US
12.	North Fork Malheur River below Beulah Reservoir	I, P, F	US
13.	Bully Creek below Bully Creek Reservoir	I, P, F	US
14.	Malheur River in agriculture area	I, P, F	WA
Sites Adjacent to the Owyhee and Vale Projects			
15.	Payette River	I, P, F	WA
16.	Boise River	I, P, F	WA
17.	Fort Boise Wildlife Management Area	I, P, E, F,B	DS
18.	Lake Lowell	I, P, B	WA

Waterbird eggs were collected from sites along the Snake River and from the Fort Boise Wildlife Management Area. Other sample sites that are listed in table 2 had a low density of nesting target species, and little effort was made to sample these sites. Adult and juvenile waterbirds were collected along the Snake River, at Fort Boise Wildlife Management Area, and at Lake Lowell. Although not located within or affected by either the Owyhee or Vale projects, Lake Lowell was sampled because of the influence of irrigation drainage in the lake, the lake's role as a component of Deer Flat National Wildlife Refuge, and the lake's support of a variety of fish and wildlife species—including migratory birds and the endangered bald eagle. Fish, aquatic plants, and aquatic insects were collected from all sampling sites.

Field Collection and Analytical Techniques

Water

Sampling times for collection of water samples included early April 1990 (pre-irrigation or minimal irrigation period), July through August 1990 (during irrigation period), and October 1990 (post-irrigation or minimal irrigation period).

Field measurements of dissolved oxygen, pH, specific conductance, and temperature were made near center of flow at 0.6 of depth from water surface. Discharge was measured at all sites using a Price AA type current meter or a Price pygmy meter and appropriate support equipment. Discharge measurements were considered to have an accuracy of ±10 percent (Rantz, 1982).

Water samples, analyzed for major and minor elements, nutrients, and pesticides, were collected using a D-76Q depth-integrating sampler specially fitted with a Teflon nozzle and gasket to minimize contamination. Water from 20 to 30 "equal-width interval" (EWI) verticals in the cross section were collected and composited through a Teflon decaport splitter into individual sample bottles for the organic analyses, a churn splitter for the inorganic analyses, or a quart-size glass bottle for suspended-sediment analysis. Before using the D-76Q sampler, the widemouth, quart-size, glass sample bottles were washed thoroughly with a phosphate-free detergent in hot water, rinsed with tap and distilled water, oven-baked at 300 to 325°C for 8 hours, and then sealed in baked aluminum foil. All remaining sampling and processing equipment was washed thoroughly with the phosphate-free detergent in hot water, rinsed with tap and distilled water, and then sealed in baked aluminum foil. The Teflon decaport splitter along with its Teflon tubing underwent an additional rinsing with pesticide-free methanol and was allowed to air dry before being sealed in baked aluminum foil. The water, composited in the churn splitter, was filtered through a plastic filtration assembly (previously acid- and distilled-water rinsed) containing a 0.45 µm pore-size cellulose-acetate membrane filter.

The resulting filtrate was placed into appropriately labeled bottles, then preserved and (or) chilled on ice according to the suite of chemical constituents to be analyzed. Whole-water samples designated for organic analysis also were chilled on ice. An incremental alkalinity titration was performed on a portion of filtered water from each field site.

Analytical determinations for the water samples were made by the USGS, National Water Quality Laboratory, in Arvada, Colorado. Analyses were done according to procedures described by Fishman and Friedman (1989) and Wershaw and others (1987). Determination of suspended-sediment concentrations were performed at the USGS Sediment Laboratory in Vancouver, Washington, according to the procedure described by Guy (1969).

Bottom Sediment

Bottom-sediment samples were collected from late July to early August 1990 from most of the sites in the study area. Samples were collected at the Fort Boise Wildlife Management Area in early July 1990 because creek- and pond-dredging operations were scheduled to begin in mid-July.

Bottom-sediment samples were collected using a stainless-steel Ponar sampler, lowered by hand to the stream bottom. Because of sampler design and river-bottom conditions, depth of sediment penetration tended to be only a few inches. A minimum of 10 subsamples was collected in each cross section. The subsamples were composited and mixed thoroughly in a stainless-steel pan with a stainless-steel spoon. Samples collected for inorganic analyses were placed into pint-sized plastic shipping containers. Samples collected for organic analysis were first sieved through a stainless-steel sieve with a 2 mm (millimeter) mesh screen and then placed into baked, 500 milliliter, widemouth-glass shipping containers. All samples were iced to below 4°C in the field and shipped to the respective analytical laboratories. Samples collected for total digestion determinations of major and trace elements and organic carbon were sent to the USGS Environmental Geochemistry Laboratory in Denver, Colorado, and were analyzed by methods described by Severson and others (1987). Samples collected for determination of organochlorine compounds were sent to the USGS National Water Quality Laboratory in Arvada, Colorado, and were analyzed according to procedures detailed by Wershaw and others (1987).

Detailed interpretation of the elemental data was limited to the <63-µm-size fraction because material <88 µm has been shown to be more readily ingested by some bottom-feeding benthic organisms (Luoma, 1983). Although only the <63-µm-size fraction elemental data were interpreted, few differences were observed between the two fractions.

Some elements did show some enrichment in the <63-µm-size fraction when compared to concentrations in the <2-mm-size fraction.

Biota

Biota samples (eggs, waterbirds, fish, aquatic plants, and aquatic insects) from Fort Boise Wildlife Management Area and fish samples from Brownlee Reservoir were collected by USFWS personnel, with assistance from the IDFG.

Except for samples of large fish and bird carcasses, which were wrapped in aluminum foil and placed in plastic bags, all other samples were placed in chemically cleansed jars. Immediately after collection, samples were chilled and later frozen to -13°C, then stored frozen at -13°C for 3 to 8 months prior to chemical analysis.

Egg collections were made during April and May. An attempt was made to collect eggs from nests of mallards, American avocets (*Recurvirostra americana*), and American coots (*Fulica americana*). However, nesting populations of these species were limited within the study area and were not available at most sampling sites. In order to increase the sample size, cinnamon teal (*Anas cyanoptera*) eggs were collected at Fort Boise Wildlife Management Area, and black-crowned night heron and California gull eggs were collected from nesting colonies located on a Snake River island near Weiser, Idaho. Eggs were immediately chilled in the field and returned to the laboratory in Boise, Idaho. Eggs were then weighed and measured, the contents removed and placed in chemically cleansed glass jars, and frozen. Egg volumes were calculated by multiplying 0.51 times the length (L) times the square of the width (W) [$0.51 \times L \times W^2$] (O'Malley and Evans, 1980; Stickel and others, 1973). Egg contents were analyzed for both organochlorine compounds and trace elements. After a drying period of about 1 year and 6 months, eggshell thicknesses (including membranes) were measured using a Starrett micrometer graduated in units of 0.001 mm. Measurements were made at three locations around the equator and were averaged to determine a mean thickness for each eggshell. Average eggshell thickness was compared with measurements made on pre-1947 dated eggs of the same species.

Mallards, American coots, and American avocets were collected for tissue analysis from Fort Boise Wildlife Management Area in August, and western grebes (*Aechmophorus occidentalis*) and American coots were collected from Lake Lowell and sites along the Snake River in August and September, 1990. An extensive effort was made to collect mallards from Snake River and Lake Lowell sites, but mallards were not available in sufficient numbers during the collection period. Western grebes, which are piscivorous (fish eating), were collected because they are a high trophic-level species. All birds were collected with a shotgun and steel shot.

After the waterbirds were collected, livers were excised, placed in chemically cleansed jars, weighed, and frozen. Mallard and western grebe carcasses were prepared for analysis by removing feathers, feet, bills, and gastrointestinal tracts, and then were frozen. Livers were analyzed for trace elements, and carcasses were analyzed for organochlorine compounds.

Fish were collected by a combination of hook and line, electroshocking, gill netting, and seining. Species included primarily common carp and channel catfish, with smaller samples of yellow and brown bullheads, smallmouth bass, largemouth bass, black crappie, redear sunfish (*Lepomis microlophus*), pumpkinseeds (*Lepomis gibbosus*), bluegill, mountain whitefish (*Prosopium williamsoni*), and northern squawfish. Fish were weighed, wrapped in aluminum foil, triple wrapped in plastic bags, and frozen. All fish samples, except carp, were composites of two or three fish. Carp samples were packaged individually because of their large size. Whole-body samples of all fish were analyzed for trace elements, and samples of channel catfish and bullheads were analyzed for organochlorine compounds.

Aquatic plants and aquatic insects were collected from all sites. Plant samples were collected by hand, and insect samples were collected using kick nets and tweezers to separate insects from vegetation. Aquatic-plant species collected included filamentous green algae (*Thallophyta*), sago pondweed (*Potamogeton pectinatus*), and horned pondweed (*Zannichellia palustris*). Aquatic invertebrates collected included mayfly nymphs (order Ephemeroptera), water boatman (family Corixidae), creeping water bugs (family Naucoridae), and damselfly and dragonfly nymphs (order Odonata). Invertebrate samples consisted of a composite of individuals. Samples of aquatic plants and invertebrates were analyzed for trace elements.

Biota samples were packed in dry ice and shipped to analytical laboratories by overnight courier.

Trace elements were analyzed by the Research Triangle Institute, Research Triangle Park, North Carolina, and the Environmental Trace Substances Research Center, Columbia, Missouri. Organochlorine compounds were analyzed by the Mississippi State University Chemical Laboratory, Mississippi State, Mississippi. Arsenic and selenium were analyzed by the graphite furnace atomic absorption method, mercury by the cold vapor atomic absorption method, and other trace elements by the "inductively coupled plasma" (ICP) scan with preconcentration to enhance detection levels. Boron concentrations were measured without preconcentration. Organochlorine compounds were analyzed by electron-capture gas chromatography.

Quality control and quality assurance of all analytical data were reviewed by the Patuxent Analytical Control Facility (PACF) of USFWS. Acceptable performance (recovery variation averaged less than 20 percent for all chemicals detected) on spikes, blanks, and duplicates was documented in laboratory, quality-control reports.

Trace-element concentrations in biota are expressed in micrograms per gram on a dry weight basis to eliminate the variability of moisture content, to facilitate comparability within and between different taxa, and to be consistent with the other DOI irrigation drainage studies. Comparison with other toxicological data may require that the concentrations be expressed in wet weight, which can be obtained by multiplying the dry weight concentration by a factor of 1 minus the percentage of moisture content, expressed as a decimal.

Organochlorine compounds in biota are expressed in micrograms per gram on a wet-weight basis for comparability within and between different taxa and for consistency with other DOI irrigation drainage studies.

The microbial luminescence bioassay, Microtox, was used in this study to determine the relative toxicity of water samples. Water samples were collected monthly from May through October from 18 sites in the Owyhee and Vale projects. Sampling was designed to provide a relative measure of toxicity before the beginning of the irrigation season, during periods of intensive irrigation, and after completion of the irrigation season. The assay was used to attempt to address potential short-term toxic conditions from frequent application of a variety of pesticides.

The Microtox bioassay is a rapid screening test based on toxicant-induced reductions in bioluminescence in the bacterium *Photobacterium phosphoreum*. When metabolic processes of the bacterium are inhibited or damaged, a reduction in light output occurs. The decline in light emitted indicates the presence of a toxic substance. The degree of the decline in light intensity after exposure to a toxic substance is directly proportional to the concentration of the toxic substance in the sample. The bacteria's reaction to a substance is quantified by measuring the amount of light produced before and after a substance is added. The percent of light that decreases after 5 and 15 minutes is plotted against the sample concentration. The "effective concentration" (EC) of sample which diminishes the light by 50 percent is designated as the EC_{50}.

The 100-percent assay procedure is used to measure the toxicity of water samples. This assay provides a maximum testing concentration of approximately 91 percent of the sample. Two replications were tested for every sample. All Microtox assays were conducted within 48 hours of sample collection.

DISCUSSION OF RESULTS

Field Water-Quality Measurements

Field measurements were summarized according to whether they were made from the Owyhee River system (includes most of the Owyhee project sampling sites), the Malheur River system (includes all of the Vale project sampling sites), or the Snake River system (includes sampling sites in the Snake River and other major tributaries to the Snake River in the study area). Water-quality data pertaining to individual sites is in supplemental data table 19 (located at back of report).

Water temperatures ranged from 6.0°C in the Owyhee River below Owyhee Lake in April 1990, to 25.0°C in the Owyhee River at Owyhee in August 1990 (fig. 6; table 19 at back of report). River temperatures generally increased from the April to the August samplings, then decreased in October. Dissolved-oxygen (DO) concentrations ranged from 6.4 to 12.9 mg/L with sites in the Malheur River system showing the widest range (6.4 to 12.8 mg/L) and from 60 to 156 percent of DO saturation (fig. 6; table 19 at back of report). No temporal pattern was observed in the DO concentrations measured during the study.

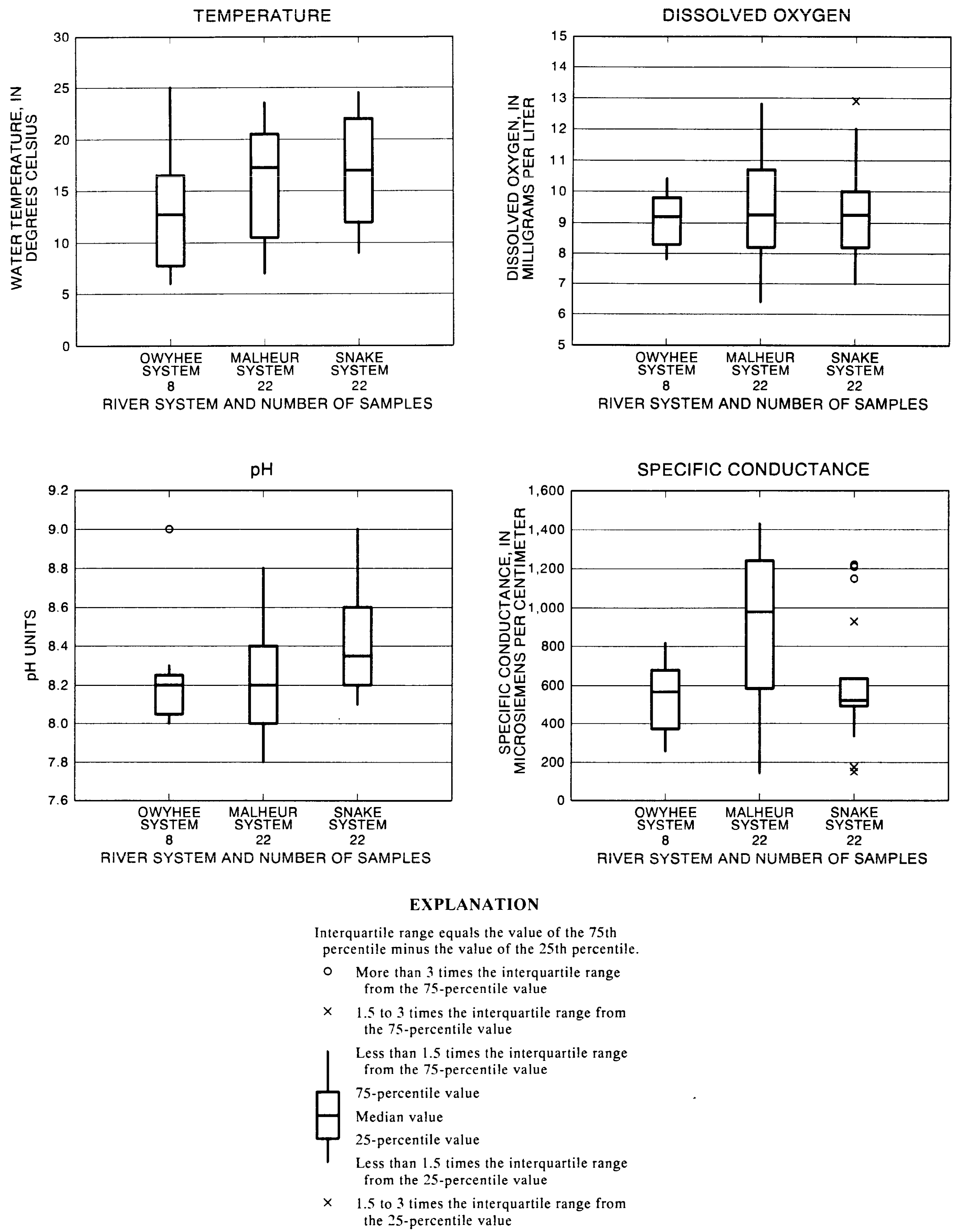


Figure 6. Distribution of temperature, dissolved oxygen, pH, and specific conductance in water, Owyhee, Malheur, and Snake River systems, April-October 1990.

A dissolved-oxygen saturation (60 percent) in Bully Creek on Highway 20 near Vale during October 1990 was below the ODEQ minimum standard of 75 percent of saturation established for the Malheur River Basin (Oregon Department of Environmental Quality, 1988). River pH ranged from 7.8 to 9.0 (fig. 6; table 19 at back of report). The values of pH in the Owyhee River below Owyhee Dam in April 1990 and at Sand Hollow Creek outflow from the Fort Boise Wildlife Management Area in July 1990 equaled the maximum criterion of 9.0 established for the protection of freshwater aquatic life from chronic toxicity (U.S. Environmental Protection Agency, 1986a). Specific-conductance values (a measure of the total dissolved solids concentration) ranged from 143 to 1,430 μS/cm (microsiemens per centimeter at 25°C) [fig. 6; table 19 at back of report]. Specific-conductance values in the Malheur River system tended to be larger and had a median value of 979 μS/cm, when compared with median values of 568 μS/cm in the Owyhee River system and 523 μS/cm in the Snake River system. Specific-conductance values generally increased from April to August 1990 samplings and remained elevated to October 1990. During the August 1990 sampling, specific-conductance measurements made at sites below the irrigated areas in both the Owyhee and Malheur River systems were more than 2.5 times those values taken at sites located above these areas. The exception was 1,430 μS/cm, measured at an upstream site in the Malheur River below Warm Springs Reservoir that was probably affected by local springs. Specific-conductance values measured in agricultural drains in both the Owyhee and Malheur River systems were elevated when compared with measurements taken at sites above the irrigated areas. Depending on the time of year, specific-conductance values of drainwater approached or exceeded specific-conductance values taken at sites located below the irrigated areas.

Major Ions

Concentrations of major ions in water are listed in table 19 at the back of this report. The proportion of major ions for each water sample collected during the three samplings are shown in table 3 and in figure 7. Table 3 is a summary, by site, of the major ions that constituted 20 percent or more of either the cation or anion composition. For example, analyses of a water sample collected in April 1990 from the Owyhee River at the Owyhee site showed sodium and calcium to be the dominant cations (accounting for over 40 percent of the total cation composition); conversely, bicarbonate and sulfate were shown to be the dominant anions (accounting for over 40 percent of the total anion composition). During the 1990 irrigation season, there was little change in the ionic composition (fig. 7) of water collected at all sites. Downstream sites in the Owyhee and Malheur River systems tended to make larger sulfate contributions than sites located upstream of the irrigated areas. Water collected from the Malheur River below Warm Springs Reservoir was the exception and seemed to have its own unique chemistry, possibly due to seepage from localized springs. Scarcely any change was noted in the ionic composition between the most upstream and the most downstream sites in the Snake River. Magnesium, which was not a dominant constituent in the Owyhee and Malheur River Basins, was dominant at the two main stem Snake River sites.

Agricultural uses of water can be limited by elevated concentrations of dissolved solids; by the fraction of sodium ions, in relation to calcium and magnesium ions, that are expressed as a "sodium adsorption ratio" (SAR); and by the alkalinity of the water, which indirectly affects SAR (U.S. Environmental Protection Agency, 1986a). Total dissolved solids, alkalinity, SAR, and hardness generally increased in concentration from the April to August 1990 sampling, and remained elevated through October 1990 (table 19 at back of report). Median values for total dissolved solids, alkalinity, SAR, and hardness in the Malheur River system were over 1.5 times those observed in the Owyhee and Snake River systems (fig. 8). Concentrations of total dissolved solids ranged from 91 to 1,010 mg/L. Eighteen water samples from the Owyhee and Vale projects had concentrations of dissolved solids in the 500 to 1,000 mg/L range, considered to have detrimental effects if applied to sensitive crops (U.S. Environmental Protection Agency, 1986a). Only one concentration of total dissolved solids (1,010 mg/L), for a sample from the Malheur River below Warm Springs Reservoir during August 1990, exceeded the 1,000 mg/L irrigation-hazard concentration known to have detrimental effects on many crops and whose use requires careful management practices (U.S. Environmental Protection Agency, 1986a); the source of that water is probably influenced by geothermal springs in the area.

Table 3. Major ions in water, with 20 percent or more of the milliequivalent ionic composition (in order of percentage of either total cation or total anion contribution), Owyhee, Malheur, and Snake River systems, April-October 1990

[ID = Idaho; OR = Oregon; Ca = calcium; Mg = magnesium; Na = sodium; HCO3 = bicarbonate; SO4 = sulfate; Cl = chloride; "--" = not analyzed; R = River; blw = below; nr = near; Cr = Creek; Res = Reservoir]

Figures 2 and 3 identification	Site	Major ions, Months: April	July-August	October
		Owyhee River System		
A	Owyhee R blw Owyhee Lake, OR	--	Na/Ca/HCO3	--
B	Overstreet Drain, OR	--	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4
C	Owyhee River at Owyhee, OR	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4
		Malheur River System		
F	Malheur R blw Warmsprings Res, OR	--	Na/Ca/Mg/SO4/HCO3/CL	--
G	N Fk Malheur R at Beulah, OR	--	Ca/Na/Mg/HCO3	--
H	Bully Cr blw Bully Cr Res, OR	--	Na/Ca/HCO3	--
I	Bully Creek nr Vale, OR	--	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4
J	Malheur River nr Vale, OR	--	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4
K	Willow Creek at Vale, OR	--	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4
L	D Drain, OR	--	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4
M	Malheur River nr Ontario, OR	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4	Na/Ca/HCO3/SO4
		Snake River System		
N	Snake River at Marsing, ID	--	Ca/Mg/Na/HCO3/SO4	Ca/Mg/Na/HCO3
D	Jump Cr nr Homedale, ID	--	Ca/Na/SO4/HCO3	Ca/Na/SO4/HCO3
E	Succor Cr nr Homedale, ID	Na/Ca/SO4/HCO3	Na/Ca/SO4/HCO3	Na/Ca/SO4/HCO3
O	Boise River nr Parma, ID	Na/Ca/HCO3	Na/Ca/HCO3	Na/Ca/HCO3
P	Payette R nr Payette, ID	Ca/Na/HCO3	Na/Ca/HCO3	Ca/Na/HCO3
Q	Snake River at Weiser, ID	Na/Ca/Mg/HCO3/SO4	Na/Ca/Mg/HCO3/SO4	Ca/Na/Mg/HCO3/SO4
R	Sand Hollow Cr inflow, ID	--	Na/Ca/HCO3	Na/Ca/HCO3
S	Sand Hollow Cr outflow, ID	--	Na/Ca/HCO3	Na/Ca/HCO3/SO4

SAR values in samples from four sites in the Malheur River Basin exceeded 4, which is considered the upper range of tolerance for sodium application to sensitive fruits. No water samples exceeded the SAR tolerance range of 8 to 18, which is considered acceptable for irrigation of general crops and forages.

Water hardness indirectly affects the toxicity of some trace elements to freshwater fish and other aquatic life. As water hardness decreases, the toxicity of some trace elements can increase. Hardness (as calcium carbonate [$CaCO_3$]) ranged from 60 to 230 mg/L in the Owyhee River; from 67 to 390 mg/L in the Malheur River; and from 44 to 450 mg/L in the Snake River system (fig. 8; and table 19 at back of report).

During the August 1990 sampling, total dissolved solids, alkalinity, SAR, and hardness values in water collected at the Owyhee River at Owyhee site (located below the irrigated areas) were from 1.7 to 2.8 times the values in water samples collected at Owyhee River below Owyhee Dam site (a site located above the irrigated areas in the Owyhee River system). During the August 1990 sampling, values for total dissolved solids, alkalinity, SAR, and hardness in water collected at the Malheur River at Ontario site, downstream of the irrigated areas, were from 1.6 to 5.4 times the values in water samples collected at two sites located above the irrigated areas (North Fork Malheur River at Beulah and Bully Creek below Bully Creek Reservoir). Total dissolved solids, alkalinity, SAR, and hardness values in agricultural drains in both the Owyhee and Malheur River systems were larger than values in water samples collected at sites above the irrigated areas. Depending on the time of year, drainwater values either approached or exceeded those values in water samples collected at sites below the irrigated areas.

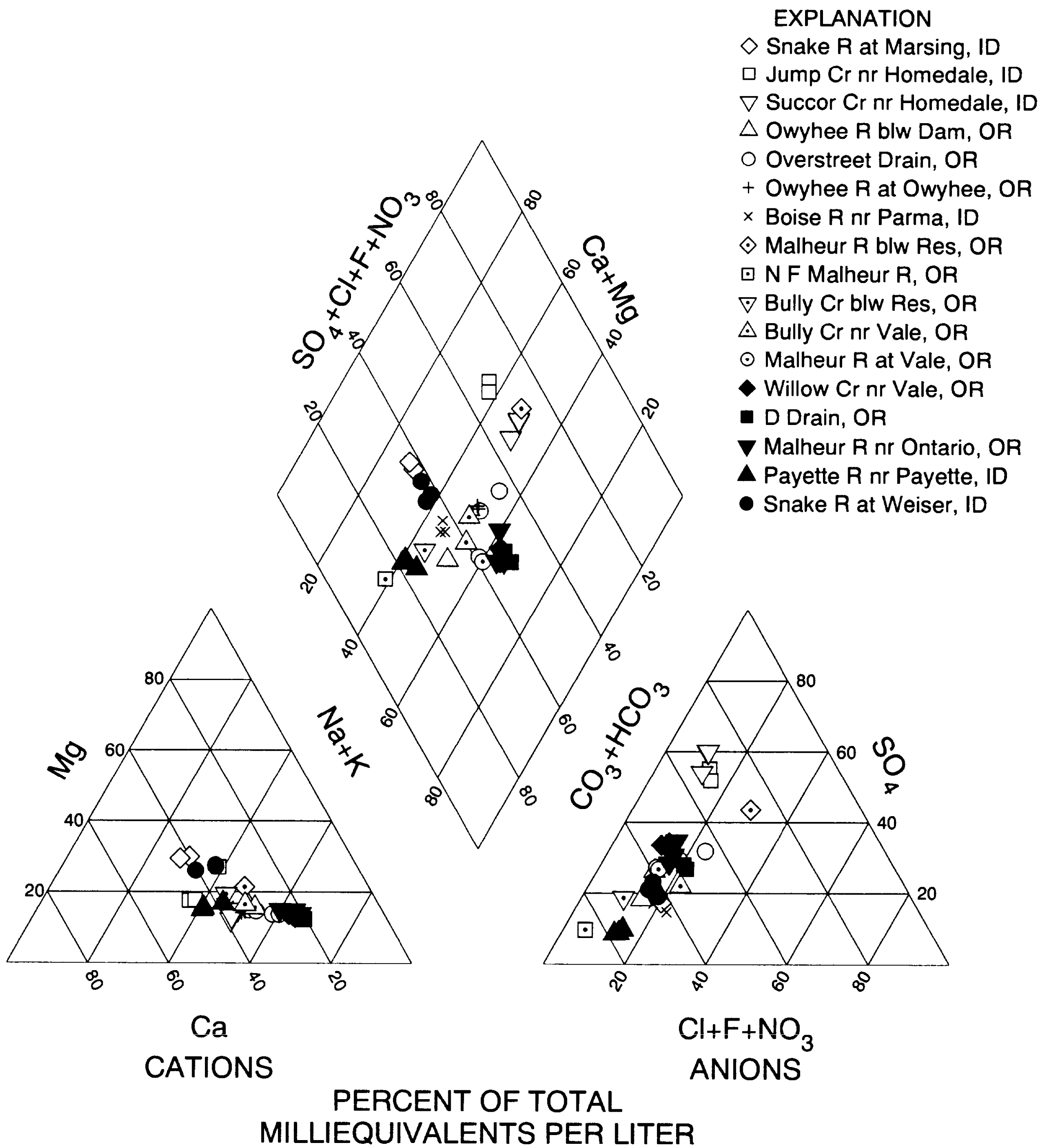
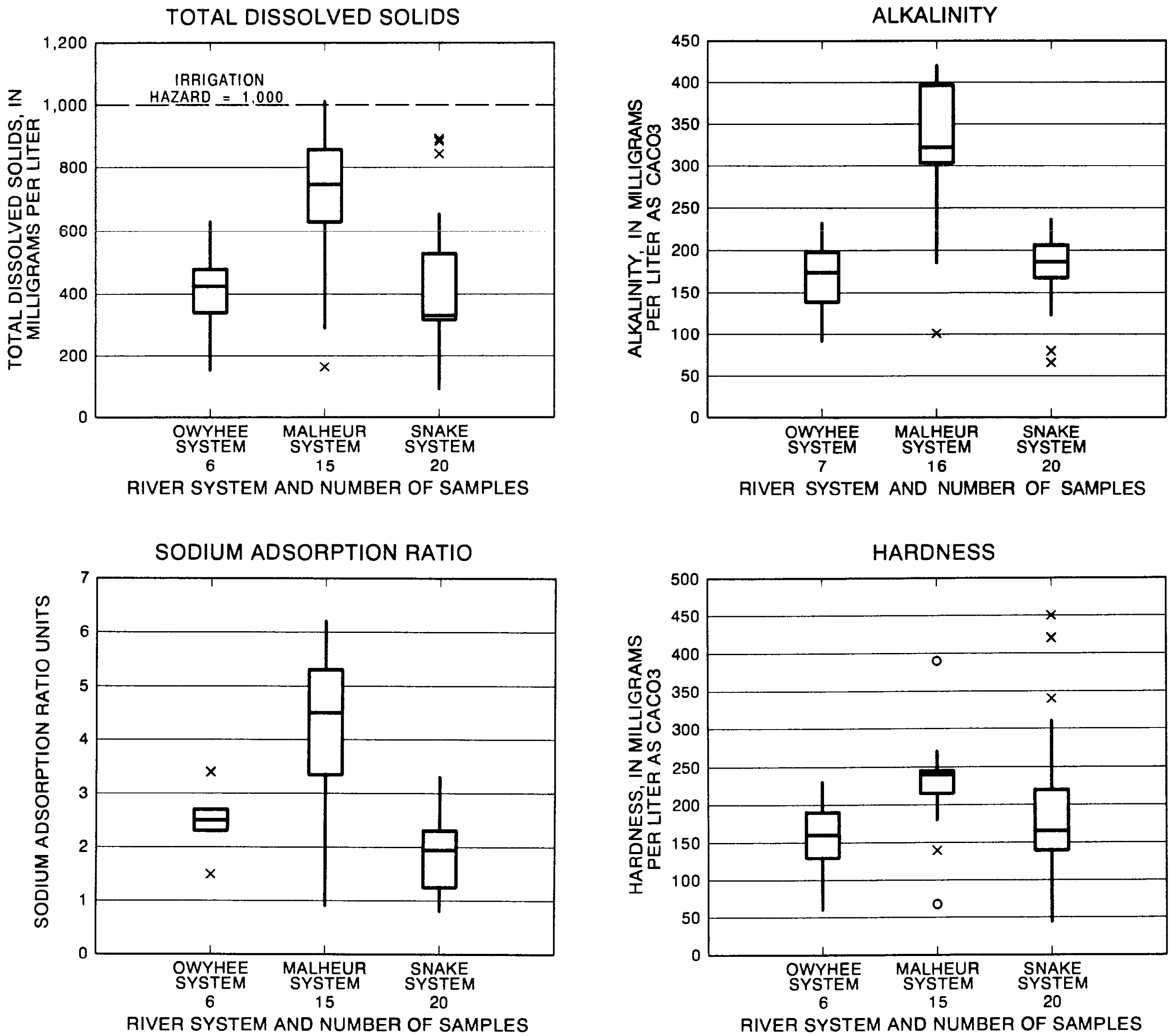


Figure 7. Dissolved major ions in water, Owyhee, Malheur, and Snake River systems, April-October 1990.

Dissolved Nutrients

Nitrogen and phosphorus are essential elements for aquatic-plant growth and, in sufficiently large concentrations, can alter the water quality of a stream or a lake. Nutrient concentrations can affect water quality by causing excessive algal or aquatic vegetation growth, and by causing chronic or acute toxicity to aquatic plants, fish, or animal life. Readily bioavailable forms of these nutrients include ammonia, nitrate plus nitrite, and orthophosphorus. Irrigation-return flow containing nutrients from fertilizers applied to agricultural land has been shown to affect downstream water quality (Wittenberg and McKenzie, 1980).



EXPLANATION

Interquartile range equals the value of the 75th percentile minus the value of the 25th percentile.

o More than 3 times the interquartile range from the 75-percentile value

× 1.5 to 3 times the interquartile range from the 75-percentile value

Less than 1.5 times the interquartile range from the 75-percentile value

75-percentile value

Median value

25-percentile value

Less than 1.5 times the interquartile range from the 25-percentile value

× 1.5 to 3 times the interquartile range from the 25-percentile value

o More than 3 times the interquartile range from the 25-percentile value

Figure 8. Distribution of total dissolved solids, alkalinity, sodium adsorption ratio, and hardness in water, Owyhee, Malheur, and Snake River systems, April-October 1990.

Concentrations of dissolved ammonia, nitrate plus nitrite, and orthophosphorus in water from the study area are listed by individual sampling sites in table 19 (located at back of report) and have been grouped by river basin location in figure 9. Nutrient concentrations in Malheur River tended to be larger, with median values more than 1.5 times those observed in Owyhee and Snake Rivers. On the basis of data collected during October 1990 for pH values, temperature values, and concentrations of dissolved ammonia, no water samples contained concentrations of free ammonia (NH_3) that exceeded levels considered to be toxic to aquatic fish (U.S. Environmental Protection Agency, 1986a). Nitrate-plus-nitrite concentrations in water collected from April through October 1990 ranged from <0.10 to 7.8 mg/L. The “maximum contaminant level” (MCL) for nitrate as N for domestic-drinking water is 10 mg/L. Orthophosphorus concentrations were largest in the Malheur River Basin and ranged from 0.24 to 0.39 mg/L. All orthophosphorus values for the Malheur River system exceeded the 0.10 mg/L desired limit for total phosphorus considered necessary for the prevention of nuisance plant growth in streams or other flowing water that does not discharge directly to lakes or impoundments (Mackenthun, 1973).

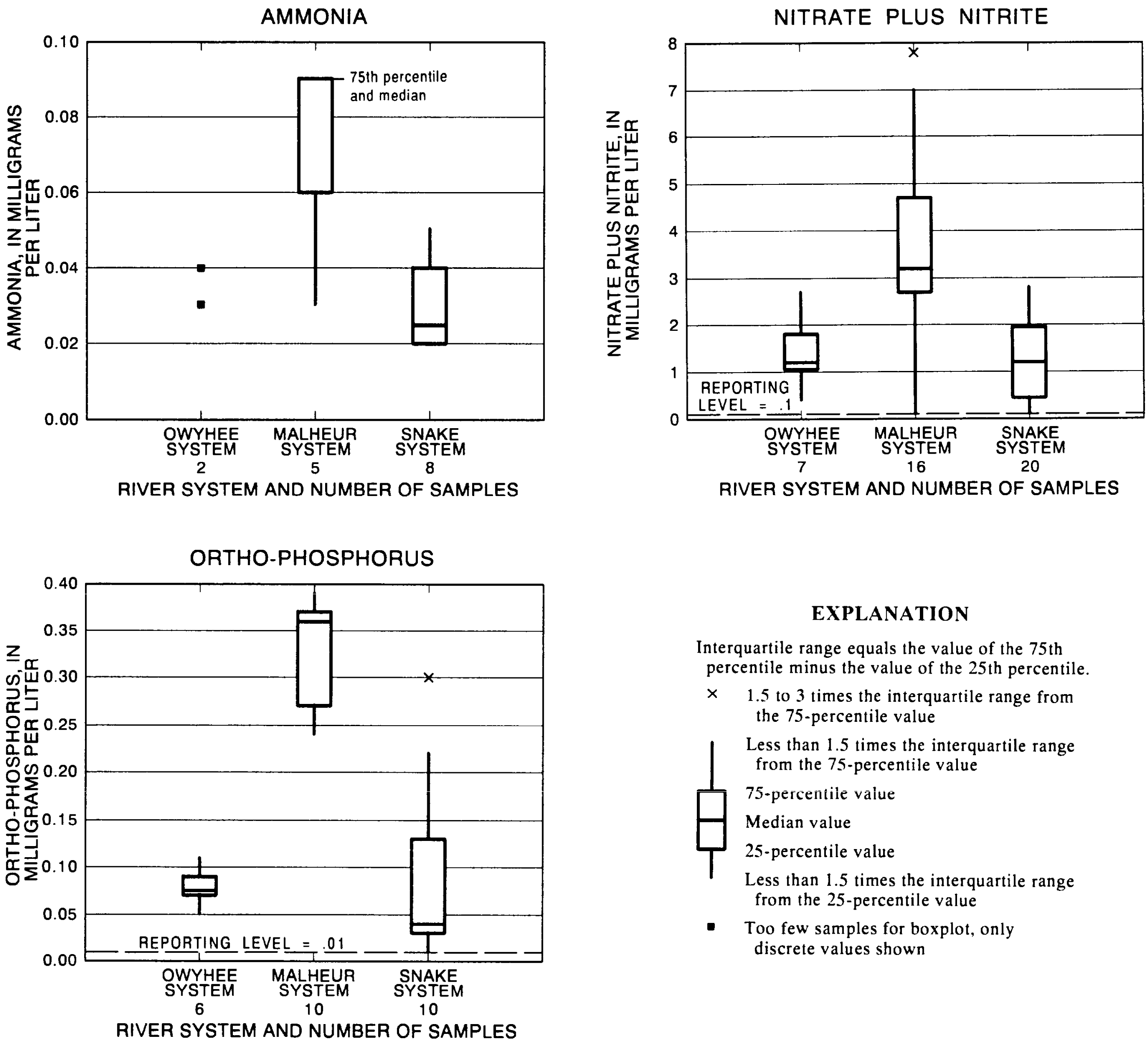


Figure 9. Distribution of dissolved ammonia, nitrate plus nitrite, and orthophosphorus in water, Owyhee, Malheur, and Snake River systems, April-October 1990.

Water collected from one site in the Owyhee River system (Overstreet Drain) and from three sites in the Snake River system (Sand Hollow Creek inflow and outflow to the Fort Boise Wildlife Management Area, and the Boise River near Parma) had orthophosphorus concentrations that also exceeded 0.10 mg/L.

During the August 1990 sampling, the nitrate-plus-nitrite concentration in a water sample collected at the Owyhee River at Owyhee site below the irrigated areas was over 4 times the concentration in a water sample collected at Owyhee River below Owyhee Dam site above the irrigated areas in the Owyhee River system. In the Malheur River system, during the August 1990 sampling, the nitrate-plus-nitrite concentration from water samples collected at the Malheur River at Ontario site downstream of the irrigated areas was over 40 times the concentrations in water samples collected at two sites above the irrigated areas (North Fork Malheur River at Beulah and Bully Creek below Bully Creek Reservoir). Nitrate-plus-nitrite concentrations found in agricultural drains from the Owyhee and Malheur River systems were larger than values in water samples collected at sites above the irrigated areas. Depending on the time of year and the river system sampled, drainwater values either approached or exceeded values in water samples collected at sites below the irrigated areas.

Trace Elements

Concentrations of trace elements dissolved in water and in bottom-sediment samples from sites in the study area are listed in tables 20-22 (at back of report). Concentrations of trace elements in biota are listed in tables 23-27 (at back of report). The trace elements of greatest concern, in areas that receive irrigation drainwater, typically include arsenic, boron, selenium (Hoffman and others, 1991; Ohlendorf, 1989; Hothem and Ohlendorf, 1989; Saiki, 1986; U.S. Fish and Wildlife Service, 1987), and in some cases mercury (Hoffman and others, 1990). These elements are discussed in detail in the proceeding sections. Other trace elements that are known for their toxicity to animals include cadmium, copper, lead, and zinc (Eisler, 1988b; Gasaway and Buss, 1972; White and Finley, 1978). These elements are discussed under the section "Other Elements." Many of the remaining elements analyzed (aluminum, antimony, barium, beryllium, chromium, cobalt, iron, magnesium, manganese, molybdenum, nickel, silver, strontium, tin, and vanadium) were either at concentrations below the analytical reporting limits or at concentrations below levels of biological concern.

Arsenic

Water and Bottom Sediment

Concentrations of dissolved arsenic are summarized and shown in table 4 and in figure 10. Arsenic concentrations for the study area ranged from 1 to 62 µg/L, with a median value of 22 µg/L. The median arsenic concentration in the Malheur River Basin was 37 µg/L; whereas median values in the Owyhee and Snake River Basins were 26 and 9 µg/L, respectively. Arsenic concentrations at Malheur River near Vale (56 µg/ L), Willow Creek near Vale (54 and 62 µg/L), and D Drain (55 µg/L) exceeded the MCL of 50 µg/L for drinking water supplies (U.S. Environmental Protection Agency, 1986a). Concentrations of total arsenic in samples collected by ODEQ in 1990 ranged from 4 to 150 µg/L, with a median value of 36 µg/L. Arsenic concentrations in this study generally increased in a downstream manner, but did not increase at sampling sites during the water year as was observed in the Malheur River in 1985 by Fuste' and McKenzie (1987) and the 1990 ODEQ collection of monthly samples (May-December).

During the August 1990 sampling, arsenic concentration in a water sample collected at the Owyhee River at Owyhee site below the irrigated area was about 5 times the concentration in a water sample collected at Owyhee River below Owyhee Dam site located above the irrigated areas in the Owyhee River system. In the Malheur River system, during the August 1990 sampling, the arsenic concentration in a water sample collected at the Malheur River at Ontario site downstream of the irrigated areas was from 5 to 37 times the concentrations in water samples collected at two sites located above the irrigated areas (North Fork Malheur River at Beulah and Bully Creek below Bully Creek Reservoir). Arsenic concentrations in water samples from agricultural drains from both the Owyhee and Malheur River systems were larger than concentrations in water samples collected at sites above the irrigated areas. Depending on the time of year and the river system sampled, drainwater concentrations approached or exceeded concentrations in water samples collected at sites below the irrigated areas.

Table 4. Arsenic, boron, mercury, and selenium concentrations in water and bottom sediment (less than 63-micrometer-size fraction) for all project areas (Owyhee, Malheur, and Snake River systems), April-October 1990
[N = number of samples; < = less than]

Element	Water, dissolved (micrograms per liter)				Bottom sediment (micrograms per gram)			
	N	Minimum	Median	Maximum	N	Minimum	Median	Maximum
Arsenic	41	1	22	62	17	2.6	6.4	79
Boron	41	20	180	2,200	16	.5	2	3
Mercury	41	<.1	<.1	<.1	18	<.02	.02	.76
Selenium	41	<1	<1	5	17	.2	.4	.6

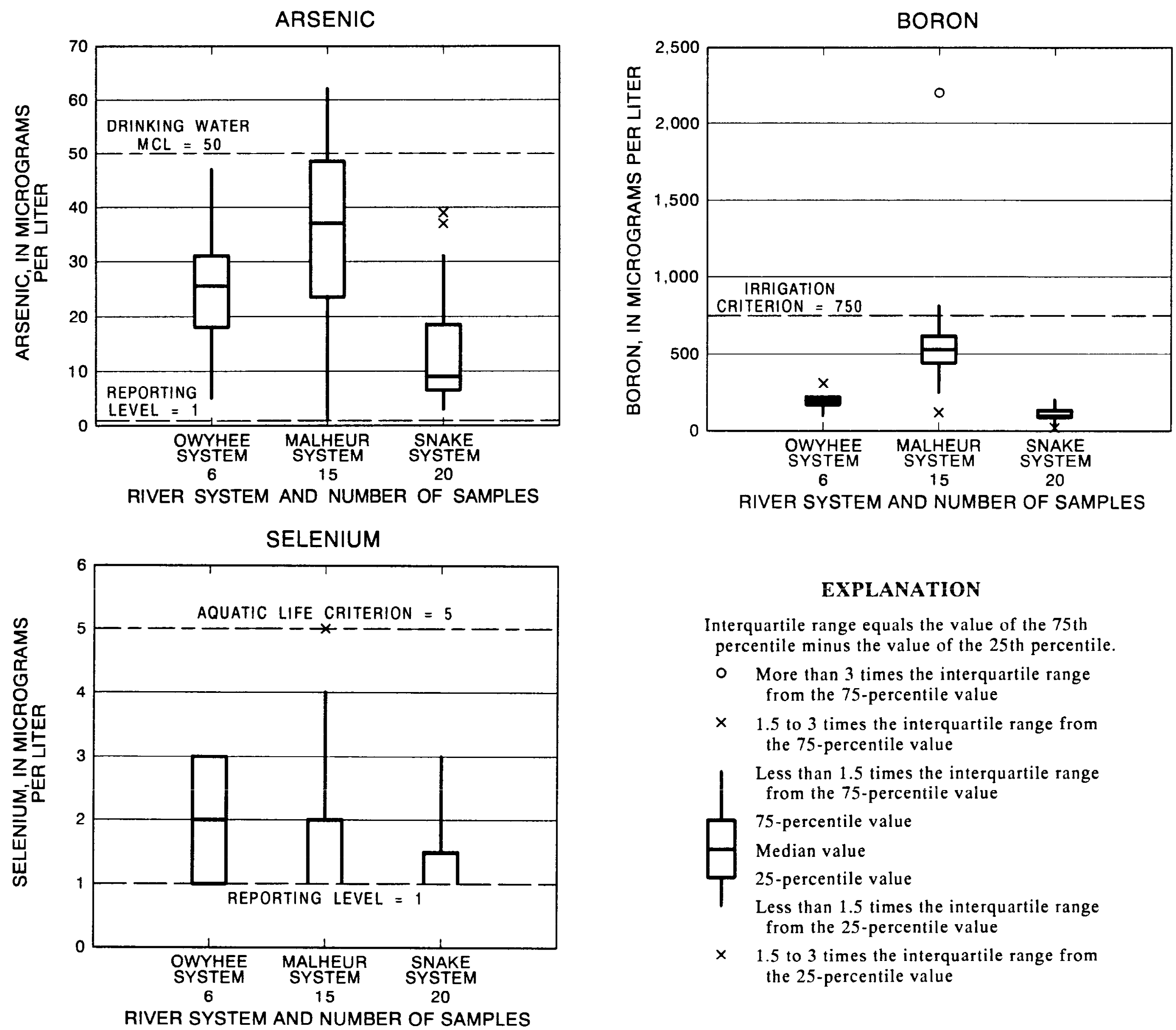


Figure 10. Distribution of dissolved arsenic, boron, and selenium in water, Owyhee, Malheur, and Snake River systems, April-October 1990.

A comparison was made between arsenic concentrations in bottom sediment (<63-mm-size fraction) collected at 17 sites in the study area (table 21, at back of report), and the expected 95-percent baseline range for soils from the Western United States (table 5). Bottom-sediment arsenic concentrations were within this baseline range, with the exception of the concentration measured at the Malheur River below Warm Springs Reservoir site. The bottom-sediment concentration of arsenic at that site (79 μg/g) was over 3 times the upper 95-percent baseline range for soils from the Western United States (22 μg/g). Table 22 (at back of report) lists arsenic and other element concentrations in bottom sediment for the <2-mm-size fraction.

Biota

Arsenic concentrations in biota are presented in table 6, and in tables 23-27 (at back of report). Background arsenic concentrations in living organisms are usually <1 μg/g wet weight in terrestrial flora and fauna (including birds) and freshwater biota (Eisler, 1988a).

Arsenic was detected in all aquatic-plant samples, and concentrations generally were larger in algae than in sago or horned pondweed (table 6). Arsenic concentrations generally were larger in Owyhee project samples (range 3.02 to 29.3 μg/g) than in Vale project samples (range 1.87 to 19.8 μg/g) or Snake River samples (range 2.6 to 12.3 μg/g). Laboratory studies by the USFWS have indicated that arsenic concentrations of 30 μg/g dry weight or more, found in aquatic vegetation associated with irrigation drainwater, could alter the growth, development, and physiology of mallard ducklings (Camardese and others, 1990). While none of the samples collected in this study exceeded this threshold, one algae sample from Jump Creek (29.3 μg/g) [Owyhee project] approached it. The large arsenic concentration of 79 μg/g, found in bottom sediment from the Malheur River below Warm Springs Reservoir, was not reflected in the biota samples collected from that site (table 21, at back of report).

Arsenic in aquatic invertebrates was detected in all but one sample; however, concentrations were not elevated (table 6). Arsenic concentrations generally were larger in Owyhee project samples (range 1.58 to 7.55 μg/g) than in the Vale project samples (range less than analytical reporting limit to 5.7 μg/g) or Snake River samples (range 0.30 to 1.20 μg/g). The largest arsenic concentration of 7.55 μg/g was found at Jump Creek in damselfly/dragonfly nymphs (Odonata). None of the samples approached the 30 μg/g wet-weight concentrations of arsenic associated with effects on growth, development, and physiology of mallard ducklings (Camardese and others, 1990).

Arsenic concentrations in fish generally were small (table 6). Only 9 percent of all fish sampled, (16 percent of Snake River and 14 percent of Owyhee project fish) exceeded the 1980–81 National Contaminant Biomonitoring Program (NCBP) 85th percentile concentration of 0.88 μg/g dry weight (Lowe and others, 1985) [fig. 11]. Gilderhus (1966) reported that an arsenic concentration of 4.68 μg/g dry weight in whole juvenile bluegills was associated with poor growth and survival. No fish-tissue samples from this study approached this level (the largest concentration was 1.2 μg/g in a common carp collected in the Snake River above the study area).

Arsenic was not detected in any bird eggs from Snake River sites, but was detected at small concentrations in 3 of 9 bird eggs collected at Fort Boise Wildlife Management Area (table 26, at back of report). Arsenic was detected in only two (20 percent) of the bird livers sampled in American coots from adjacent sites (1.05 μg/g) and from Snake River (1.32 μg/g) [table 6]. Those arsenic concentrations are below concentrations in birds considered to be elevated (2 to 10 μg/g) [Goede, 1985].

Boron

Water and Bottom Sediment

Concentrations of dissolved boron are summarized in table 4 and in figure 10. Boron concentrations in the study area ranged from 20 to 2,200 μg/L, with a median value of 180 μg/L. The median boron concentration in the Malheur River system was 530 μg/L; whereas median values in the Owyhee and Snake River systems were 195 and 100 μg/L, respectively. Boron concentrations at Malheur River below Warm Springs Reservoir (2,200 μg/L) and D Drain (810 μg/L) exceeded the USEPA criteria of 750 μg/L for irrigation of sensitive crops. Concentrations of boron collected by ODEQ in 1990 for the study area ranged from 90 to 1,070 μg/L, with a median value of 405 μg/L.

Table 5. Bottom-sediment concentrations (less than 63-micrometer-size fraction) of major and trace elements from the Owyhee and Vale project areas, and Snake River system, and the expected 95-percent baseline range for element concentrations in soils from the Western United States
[na = data not available; < = less than]

	Owyhee-Vale bed sediment								Western United States 1/	
		Value at indicated percentile								
Chemical	Number of samples	Minimum	10	25	50	75	90	Maximum	Number of samples	Expected 95-percent range
Major elements, in units of percent										
Aluminum	18	4.60	5.39	6.68	7.16	7.40	7.99	8.15	770	1.5 - 23
Calcium	18	1.92	2.14	2.51	2.86	3.62	9.81	9.85	777	.19 - 17
Carbon,										
inorganic	18	<.01	.02	.05	.24	.55	2.55	2.62	na	na
organic	18	.24	.25	.68	1.01	1.42	1.78	2.01	na	na
Iron	18	2.03	2.35	2.82	3.50	4.05	4.30	4.45	777	.55 - 8.0
Magnesium	18	.79	.81	.90	1.09	1.27	1.48	1.60	778	.15 - 3.6
Phosphorus	18	.06	.08	.09	.10	.10	.12	.14	524	.006 - .17
Potassium	18	.97	1.09	1.44	1.61	1.74	2.10	2.13	777	.38 - 3.2
Sodium	18	.94	1.10	1.27	1.48	1.75	2.00	2.33	774	.26 - 3.7
Titanium	18	.28	.32	.38	.45	.54	.60	.64	777	.069 .70
Minor elements, in units of micrograms per gram										
Arsenic	17	2.6	2.8	4.2	6.4	10	25	79	730	1.2 - 22
Barium	18	606	624	656	679	805	1,110	1,110	778	200 - 1,700
Beryllium	18	1	1	2	2	2	2	2	778	.13 - 3.6
Bismuth	18	<10	<10	<10	<10	<10	<10	<30	na	na
Boron	16	.5	.6	.9	2	2	3	3	778	5.8 - 91
Cadmium	18	< 2	< 2	< 2	< 2	< 2	< 2	< 5	na	na
Cerium	18	42	47	49	55	66	92	150	683	22 - 190
Chromium	18	47	53	61	68	86	108	114	778	8.5 - 200
Cobalt	18	8	10	12	15	19	19	22	778	1.8 - 28
Copper	18	16	16	18	26	33	36	39	778	4.9 - 90
Europium	18	< 2	< 2	< 2	< 2	< 2	< 2	< 5	na	na
Gallium	18	10	12	15	16	17	20	20	776	5.7 - 45
Gold	18	< 8	< 8	< 8	< 8	< 8	< 8	<20	na	na
Lanthanum	18	23	27	29	32	40	52	88	777	8.4 - 110
Lead	18	10	11	12	14	17	100	470	778	5.2 - 55
Lithium	18	20	20	24	26	31	35	36	731	8.8 - 55
Manganese	18	378	435	600	684	1,006	3,100	3,280	777	97 - 1,500
Mercury	18	<.02	<.02	.02	.02	.04	.18	.76	733	.008 - .25
Molybdenum	18	<2	<2	<2	<2	<2	<2	<5	774	.18 - 4.0
Neodymium	18	24	26	27	28	32	38	60	538	12 - 110
Nickel	18	14	16	21	26	30	38	41	778	3.4 - 66
Niobium	18	< 4	< 4	8	10	13	25	30	na	na
Scandium	18	6	7	8	12	14	15	16	778	2.7 - 25
Selenium	17	.2	.2	.2	.4	.5	.6	.6	773	.04 1.4
Silver	18	<2	<2	<2	<2	<2	<2	<5	na	na
Strontium	18	238	249	265	320	344	398	402	778	43 - 930
Thorium	16	4.7	4.9	6.1	7.6	9.6	13.3	13.4	195	4.1 - 20
Tin	18	<10	<10	<10	<10	<10	<10	680	na	na
Uranium	16	1.7	1.8	2.0	2.5	3.2	4.1	4.8	224	1.2 - 5.3
Vanadium	18	52	54	62	90	112	124	131	778	18 - 270
Ytterbium	18	2	2	2	3	3	3	3	764	.98 - 6.9
Yttrium	18	16	18	22	24	28	29	30	778	8.0 - 60
Zinc	18	53	59	72	82	88	110	112	766	17 - 180

1/ R.C. Severson, U.S. Geological Survey, written commun., 1987, based on data from Shacklette and Boerngen, 1984.

Table 6. Concentrations of arsenic in biota collected from the Snake River, Owyhee and Vale project areas, and adjacent sites, 1990

[Concentrations in micrograms per gram on a dry weight basis; ranges are the minimum and maximum concentrations; < = less than values; number in parentheses ( ) equals the number of samples collected; "--" not analyzed; *includes bass and crappie]

Matrix	Snake River	Owyhee project	Vale project	Adjacent sites
Aquatic plants				
Algae	6.20-12.3 (2)	12.3-29.3 (4)	7.71-19.8 (5)	4.80-13.8 (4)
Sago pondweed	2.60-3.06 (2)	3.02-21.0 (4)	3.75-5.60 (3)	1.50-5.90 (4)
Horned pondweed	--	--	1.87-6.10 (3)	--
Aquatic invertebrates				
Corixidae	0.30-0.98 (2)	1.58-4.17 (2)	<0.60-5.70 (4)	0.48-0.91 (4)
Ephemeroptera	0.94	3.11	--	--
Hemiptera	1.20	--	<0.60	--
Odonata	0.59	4.18-7.55 (2)	0.77-1.27 (3)	1.41-1.60 (2)
Fish				
Carp	0.50-1.20 (6)	0.50-1.04 (2)	--	<0.30-0.80 (3)
Channel catfish	<0.20-0.20 (6)	0.44-0.72 (2)	<0.30 (1)	<0.30-0.49 (2)
Bullhead	--	--	<0.30-0.60 (2)	0.20-0.72 (3)
Sunfish*	<0.30-0.69 (6)	<0.20-0.40 (3)	<0.20-0.30 (3)	<0.20-0.60 (4)
Mountain whitefish	0.40 (1)	--	--	--
Waterbird eggs				
Mallard	<0.30 (6)	--	--	<0.30 (1)
Cinnamon teal	--	--	--	<0.30 (1)
Black-crowned night heron	<0.30 (2)	--	--	--
California gull	<0.30 (2)	--	--	--
American avocet	--	--	--	<0.30-0.39 (3)
Black-necked stilt	--	--	--	<0.30 (1)
American coot	--	--	--	<0.30-0.31 (3)
Waterbird livers				
Mallard	--	--	--	<0.30 (1)
American avocet	--	--	--	<0.30 (2)
American coot	1.32	--	--	<0.30-1.05 (2)
Western grebe	<0.45 (3)	--	--	<0.30 (1)

In this study, boron concentrations generally increased in a downstream manner in the river basins (with the possible exception of the elevated boron concentration of Malheur River below Warm Springs Reservoir). Boron did not demonstrate increases in concentrations during a water year, as observed in both the Malheur River in 1985 by Fuste' and McKenzie (1987), and in the 1990 ODEQ collection of monthly samples (May-December). During the August 1990 sampling, boron concentrations in a water sample collected at the Owyhee River at Owyhee site below the irrigated areas was 1.9 times the concentration in a water sample collected at Owyhee River below Owyhee Dam site above the irrigated areas in the Owyhee River system.

In the Malheur River Basin during the August 1990 sampling, the boron concentration in a water sample collected at the Malheur River at Ontario site downstream of the irrigated areas was from 2 to more than 4 times those concentrations in water samples collected at two sites above the irrigated areas (North Fork Malheur River at Beulah and Bully Creek below Bully Creek Reservoir). Concentrations of boron in water sampled from agricultural drains from both the Owyhee and Malheur River systems were larger than concentrations in water samples collected at sites above the irrigated areas. Depending on the time of year and the river system sampled, drainwater concentrations either approached or exceeded concentrations in water

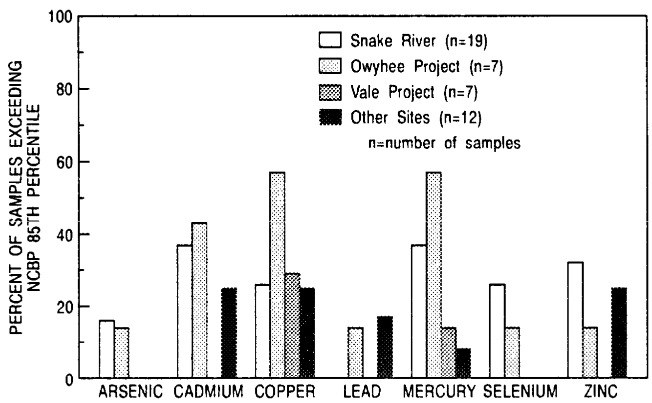


Figure 11. Percentage of fish sampled from the Owyhee and Vale projects, and Snake River system, 1990, that exceeded the National Contaminant Biomonitoring Program (NCBP) 85th percentile for trace elements.

samples collected at sites below the irrigated areas. Bottom-sediment concentrations of boron (<63-μm-size fraction) were within the expected 95-percent baseline range for soils from the Western United States (table 5).

Biota

Concentrations of boron in biota are presented in table 7, and in tables 23-27 (at back of report). The biological effects of boron on aquatic organisms are poorly understood. Laboratory studies by the USFWS have demonstrated that embryo toxicity effects occur in mallards fed a diet containing 1,000 μg/g dry weight boron, and that the adverse dietary-effects level is between 300 and 1,000 μg/g dry weight (U.S. Fish and Wildlife Service, 1987; Smith and Anders, 1989).

Concentrations of boron in aquatic plants ranged from 13.0 μg/g to 402 μg/g (maximum concentration found in sago pondweed that was located in an agricultural area of the lower Vale project) [table 7]. Sago pondweed is a major food item for waterfowl. Two sago pondweed samples (402 μg/g from the Vale project, and 377 μg/g from the Snake River above the study area) exceeded the 300 μg/g dry weight dietary-threshold level (U.S. Fish and Wildlife Service, 1987; Smith and Anders, 1989). However, most boron concentrations in aquatic plants were below levels reported to cause mortality or reproductive impairment in mallards.

Concentrations of boron in aquatic invertebrates generally were small, and ranged from below analytical reporting limits to 19 μg/g in Odonata from the Malheur River below Warm Springs Reservoir (table 7, Vale project), which correlates with elevated boron concentrations detected in water at this site (table 20). No samples were near the 300 μg/g dry weight, dietary-threshold level for mallards (U.S. Fish and Wildlife Service, 1987; Smith and Anders, 1989).

Concentrations of boron in fish were small (table 7). Boron was detected in only 27 percent of all the fish sampled; and in 5 percent of Snake River fish, in 29 percent of Owyhee project fish, and in 43 percent of Vale project fish (table 7, sites adjacent to the projects). The largest concentration of boron was 3.48 μg/g in a channel catfish from the Boise River (table 7, adjacent sites).

Concentrations of boron in bird eggs were small, and ranged from undetected to 1.46 μg/g dry weight in a black-crowned night heron egg collected from an island on the Snake River near Weiser, Idaho (table 7). Fifty-eight percent of the eggs analyzed had detectable concentrations of boron. Detectable concentrations were well below concentrations believed to cause reproductive impairment in birds (Smith and Anders, 1989).

Concentrations of boron in bird livers also were small, and ranged from undetected to 2.89 μg/g in an American coot liver from Lake Lowell (table 7; and table 27 at back of report). Forty percent of the bird livers analyzed contained detectable concentrations of boron. Detectable concentrations were well below concentrations believed to cause reproductive impairment in birds (Smith and Anders, 1989).

Mercury

Water and Bottom Sediment

Concentrations of dissolved mercury are summarized in table 4. All dissolved-mercury concentrations were <0.1 μg/L. However, no assessment of mercury toxicity in water can be made because the analytical reporting level was above the 4-day average concentration criterion of 0.012 μg/L (not to be exceeded more than once in a 3-year period) established by the USEPA (U.S. Environmental Protection Agency, 1986a) for the protection of freshwater aquatic organisms. Concentrations of mercury, found in samples collected by ODEQ in 1990 from the study area, ranged from <0.2 to 0.3 μg/L with a median value of <0.2 μg/L that exceeds the USEPA criterion.

Table 7. Concentrations of boron in biota collected from the Snake River, Owyhee and Vale project areas, and adjacent sites, 1990

[Concentrations in micrograms per gram on a dry weight basis; ranges are the minimum and maximum concentrations; < = less than values; number in parentheses ( ) equals the number of samples collected; "--" not analyzed; *includes bass and crappie; because different detection limits were reported by different analytical laboratories, some "less than"values exceed reported values]

Matrix	Snake River	Owyhee project	Vale project	Adjacent sites
Aquatic plants				
Algae	52.5-69.0 (2)	24.0-133 (4)	45.5-249 (5)	13.0-180 (4)
Sago pondweed	185-377 (2)	22.4-249 (4)	184-402 (3)	121-295 (4)
Horned pondweed	--	--	13.4-126 (3)	--
Aquatic invertebrates				
Corixidae	<2.00-5.55 (2)	2.15-8.30(2)	1.95-14.0(4)	<1.00-3.00(4)
Ephemeroptera	6.00	4.20	--	--
Hemiptera	2.93	--	6.77	--
Odonata	3.00	8.64-10.5 (2)	6.00-19.0(3)	4.83-7.70(2)
Fish				
Carp	<2.00-0.54 (6)	<2.00-1.56 (2)	--	<2.00-1.38(3)
Channel catfish	<2.00 (6)	<0.50-3.00 (2)	<0.50 (1)	<0.50-3.48(2)
Bullhead	--	--	1.17-1.52(2)	<2.00-2.00(3)
Sunfish*	<2.00 (6)	<2.00 (3)	<2.00-1.16(3)	<0.50-0.52(4)
Mountain whitefish	<2.00 (1)	--	--	--
Waterbird eggs				
Mallard	<0.50-1.15 (6)	--	--	<0.50 (1)
Cinnamon tea	--	--	--	<0.50 (1)
Black-crowned night heron	<0.50-1.46 (2)	--	--	--
California gull	<0.50 (2)	--	--	--
American avocet	--	--	--	0.51-0.78(3)
Black-necked stilt	--	--	--	0.72
American coot	--	--	--	0.73-0.92(3)
Waterbird livers				
Mallard	--	--	--	<0.50 (1)
American avocet	--	--	--	<0.50-1.33(2)
American coot	.85 (1)	--	--	<0.50-2.89(2)
Western grebe	<.50 (3)	--	--	2.02

A comparison was made between mercury concentrations in bottom sediment (<63-μm-size fraction) collected at 18 sites in the study area and the expected 95-percent baseline range (0.008 to 0. 25 μg/g) for soils from the Western United States (table 5). Bottom-sediment mercury concentrations were within this baseline range with the exception of the concentration of 0.76 μg/g measured at the Sand Hollow Creek inflow to the Fort Boise Wildlife Management Area. The bottom-sediment concentration of mercury at that site was over 3 times the upper 95-percent baseline range for soils from the Western United States (0.25 μg/g). The second largest concentration of mercury (0.12 μg/g) found in the study area occurred at an Owyhee River site located below Owyhee Lake.

Biota

Concentrations of mercury in biota are presented in table 8, and in tables 23-27 (at back of report). Past studies indicate potentially elevated concentrations of mercury in fish. Mercury is known to bioconcentrate in organisms, and can biomagnify through the food chain (Eisler, 1987).

Table 8. Concentrations of mercury in biota collected from the Snake River, Owyhee, and Vale project areas, and adjacent sites, 1990

[Concentrations in micrograms per gram on a dry weight basis; ranges are the minimum and maximum concentrations; < = less than values; number in parentheses ( ) equals the number of samples collected; "--" not analyzed; * includes bass and crappie; because different detection limits were reported by different analytical laboratories, some "less than" values exceed reported values]

Matrix	Snake River	Owyhee project	Vale project	Adjacent sites
Aquatic plants				
Algae	<0.10-0.01 (2)	<0.10-0.03(4)	<0.10-0.07(5)	<0.25-0.05(4)
Sago pondweed	<0.10-0.02 (2)	<0.10-0.02(4)	<0.10-0.01(3)	<0.25-0.03(4)
Horned pondweed	0.02	--	<0.01-0.04(3)	--
Aquatic invertebrates				
Corixidae	<0.10-0.05 (2)	<0.10 (2)	<0.10-0.36(4)	<0.10-0.16(2)
Ephemeroptera	0.03	<0.10 (1)	--	--
Hemiptera	<0.10 (1)	--	0.34	--
Odonata	0.06	<0.10 (2)	<0.10-0.41(3)	<0.10-0.16(2)
Fish				
Carp	0.45-1.40 (6)	0.22-2.52(2)	--	0.31-1.22(3)
Channel catfish	0.33-1.10 (6)	0.75-1.98(2)	0.19	0.28-0.55(2)
Bullhead	--	--	0.26-0.47(2)	0.23-0.34(3)
Sunfish*	0.42-0.78 (6)	0.34-1.05(3)	0.36-0.96(3)	0.23-0.37(4)
Mountain whitefish	0.05 (1)	--	--	--
Waterbird eggs				
Mallard	<0.05 (6)	--	--	<0.05 (1)
Cinnamon teal	--	--	--	0.19
Black-crowned night heron	0.74-5.90 (2)	--	--	--
California gull	0.10-0.19 (2)	--	--	--
American avocet	--	--	--	0.18-0.80(3)
Black-necked stilt	--	--	--	2.15
American coot	--	--	--	0.12-0.37(3)
Waterbird livers				
Mallard	--	--	--	0.54
American avocet	--	--	--	1.15-3.75(2)
American coot	0.59	--	--	0.55-1.74(2)
Western grebe	9.08-9.56 (3)	--	--	7.65

Mercury was detected in 45 percent of the total aquatic-plant samples taken from the study areas: 50 percent of Snake River samples, 25 percent of Owyhee project samples, and 36 percent of Vale project samples (table 8; and table 23 at back of report). Detectable concentrations were small and ranged from 0.01 to 0.07 µg/g (table 8; table 23 at back of report).

Mercury also was detected in 54 percent of the total aquatic-invertebrate samples taken from the study areas: 60 percent of Snake River samples, 17 percent of Owyhee project samples, and 38 percent of Vale project samples (table 24, at back of report). Two of the largest mercury concentrations were found in samples collected from the Vale project area at the Bully Creek Dam site (Corixidae, 0.36 µg/g, and Odonata, 0.41 µg/g). Little is known about mercury concentrations in invertebrates and how these levels relate to invertebrate productivity and bioaccumulation in the food chain. However, mercury concentrations found in invertebrates from uncontaminated areas are generally below 0.2 µg/g wet weight (0.7 µg/g dry weight) [Powell, 1983; Eisler, 1987], which is above mercury concentrations found during this study.

Mercury was detected in all fish samples, and ranged from 0.05 µg/g (mountain whitefish, Snake River at mouth of Jump Creek) to 2.52 µg/g (common carp, Owyhee Lake) [table 8]. Fish from Owyhee Lake contained the largest concentrations of mercury, ranging from 1.05 to 2.52 µg/g. Mercury concentrations in fish exceeded the 1980–81 NCBP 85th percentile concentration (Lowe and others, 1985) in 29 percent of all fish samples taken from the study area: 37 percent of Snake River samples, 57 percent of Owyhee project samples, and 14 percent of Vale project samples (fig. 11).

Nationwide, background mercury concentrations in freshwater fish generally range from 0.01 to 0.2 μg/g wet weight (approximately 0.04 to 0.8 μg/g dry weight) [National Academy of Sciences, 1973]. Mercury concentrations in fish proposed safe for human consumption should not exceed 0.25 μg/g wet weight for pregnant women and 0.40 to 1.00 μg/g wet weight for other adults (Khera, 1979; National Academy of Sciences, 1978; U.S. Environmental Protection Agency, 1980, 1985; Eisler, 1987). The proposed USEPA criteria for mercury for the protection of human health is 0.5 μg/g wet weight (U.S. Environmental Protection Agency, 1980, 1985). In this study, six fish samples (13 percent of the total sample size) exceeded the 0.25 μg/g wet weight (1 μg/g dry weight) proposed human health criteria for pregnant women, and three fish samples (7 percent of the total sample size) exceeded the USEPA 0.5 μg/g wet weight protection level for human health (table 9). However, the criteria cited above are for edible fillets (muscle tissue), while data presented in this study are for whole fish which contain larger mercury concentrations than individual edible portions.

Toxicity to fish-eating birds occurs if the total body burden of mercury in fish exceeds 0.5 μg/g wet weight (National Academy of Sciences, 1978); only carp and channel catfish samples from Owyhee Lake exceeded this criterion (table 9).

Table 9. Concentrations of mercury in whole fish from the Owyhee and Vale project areas and the Snake River system that exceeded proposed human-health criteria (0.25 μg/g wet weight for pregnant women; 0.50 μg/g wet weight for general human health)
[μg/g = micrograms per gram]

Sample site	Species	Concentration of mercury (μg/g wet weight)
Snake River above study area	Common carp	0.32
Snake River below study area	Common carp	.45
Owyhee Lake	Common carp	.76
	Channel catfish	.58
	Largemouth bass	.32
Lake Lowell	Common carp	.29

Mercury was detected in all waterbird eggs except mallards (table 8; and table 26 at back of report). Measurable concentrations of mercury ranged from 0.10 μg/g in a California gull egg to 5.9 μg/g in a black-crowned night heron egg. Only the black-crowned night heron egg (5.9 μg/g dry weight, 1.2 μg/g wet weight) exceeded the 0.86 μg/g wet-weight concentration reported to cause reproductive problems in mallards (Heinz, 1979), and no eggs exceeded the 1.3 to 2.0 μg/g wet-weight sensitivity level reported for various avian species (Fimreite, 1979). Effects of mercury on reproduction of fish-eating aquatic birds is unclear because sensitivity to mercury varies between species (Haseltine and others, 1983).

Mercury was detected in all waterbird livers, and concentrations were largest in fish-eating species (western grebes) [table 8]. This is consistent with observations made by Eisler (1987) that mercury concentrations are generally largest in birds that consume fish or other birds. Concentrations of mercury in western grebe livers ranged from 7.65 to 9.56 μg/g. These concentrations were lower than the 16-21 μg/g dry weight observed in western grebes from Malheur National Wildlife Refuge in 1988 (Rinella and Schuler, 1992), but exceeded the mean liver residue concentration of mercury in female mallards (4.3 μg/g dry weight) associated with reduced reproductive success (Heinz, 1979). Concentrations of mercury in American avocet, American coot, and mallard livers also were below the effect level for mallards reported by Heinz (1979).

Selenium

Water and Bottom Sediment

Concentrations of dissolved selenium are summarized in table 4 and in figure 10. Selenium concentrations for the study area ranged from <1 to 5 μg/L, with a median value of <1 μg/L. The median selenium concentration in the Malheur River Basin was 2 μg/L; whereas, median values in the Owyhee and Snake River Basins were 2 μg/L and <1 μg/L, respectively. The selenium concentration of 5 μg/L at the Willow Creek near Vale site in the Vale project area equaled the 4-day average concentration established for the protection of freshwater aquatic life (U.S. Environmental Protection Agency, 1986a). Concentrations of selenium collected by ODEQ in 1990 ranged from <2 to 5 μg/L, with a median value of <2 μg/L. In this study, selenium concentrations in the main stem Malheur and Owyhee Rivers generally increased in a downstream manner. During the 1990 water year, no increases in selenium concentrations were observed at any sites in either this study or the ODEQ data.

During the August 1990 sampling, selenium concentration in a water sample collected at the Owyhee River at Owyhee site below the irrigated areas was greater than 2 times the concentration in a water sample collected at Owyhee River below Owyhee Dam located above the irrigated areas in the Owyhee River Basin. During the August 1990 sampling, the selenium concentration in a water sample collected from the Malheur River at Ontario – downstream of the irrigated areas – also was greater than 2 times the concentrations in water samples collected at two sites above the irrigated areas (North Fork Malheur River at Beulah and Bully Creek below Bully Creek Reservoir). Selenium concentrations in water sampled from agricultural drains from both the Owyhee and Malheur River Basins were larger than concentrations in water samples collected at sites above the irrigated areas. Depending on the time of year and the river system sampled, concentrations of selenium in drainwater were nearly equivalent to concentrations of selenium in water samples collected at sites below the irrigated areas. All bottom-sediment concentrations of selenium (<63-mm-size fraction) were within the expected 95-percent baseline range (0.04 to 1.4 μg/g) for soils from the Western United States (table 5).

Biota

Selenium concentrations in biota are presented in table 10, and in tables 23-27 at the back of this report. Elevated concentrations of selenium have been linked directly to mortality and reproductive failures in fish and wildlife in areas that receive agricultural drainwater (Ohlendorf and others, 1986a, 1987).

Several dietary-effect criteria are used to define selenium concentrations of concern in food items. Lemly and Smith (1987) identified 5 μg/g dry weight as a level of concern for selenium in fish food. Heinz and others (1987, 1989) and Hoffman and Heinz (1988) reported that as little as 7 μg/g dry weight selenium as selenomethionine in the diet decreases hatching success and is teratogenic to mallards. In 1986, the USFWS recommended safe target levels for cleanup of Kesterson Reservoir and the San Luis Drain (Moore and others, 1990). These recommendations included 5 μg/g dry weight for food for warm-water fish and 3 μg/g dry weight for food for waterfowl. Hamilton and others (1990) suggested that dietary concentrations of selenium should be <3 μg/g dry weight to protect certain fish.

Selenium was detected in 84 percent of the total aquatic-plant samples taken from the study areas: 75 percent of Snake River samples, 100 percent of Owyhee project area samples, and 82 percent of Vale project area samples (table 23 at back of report). The largest selenium concentration detected in algae (2.21 μg/g dry weight) was from the Owyhee River below Owyhee Lake; that site is located above any irrigation drainwater influence. No concentrations of selenium exceeded the 5 μg/g dry-weight-effect level for fish food, the 7 μg/g dry-weight-effect level for mallard food, or the 3 μg/g dry weight to protect waterfowl and fish.

Selenium was detected in all aquatic invertebrates, and the largest concentrations generally were found in Owyhee project samples (table 10). Concentrations ranged from 0.84 μg/g in a water-boatman (Corixidae) sample from Lake Lowell to 9.65 μg/g in mayfly larvae (Ephemeroptera) from the Owyhee River below Owyhee Lake. Both mayfly samples collected had larger selenium concentrations than other aquatic invertebrates. The Owyhee River mayfly sample (9.65 μg/g) was the only sample that exceeded the 5 μg/g dry-weight-effect level for fish food (Lemly and Smith, 1987) or the 7 μg/g dry-weight-effect level for mallard food (Heinz and others, 1987, 1989; Hoffman and Heinz, 1988). Selenium concentrations in aquatic invertebrates exceeded the 3 μg/g dry weight to protect waterfowl (Moore and others, 1990) and fish (Hamilton and others, 1990) in 16 percent of all samples (20 percent of Snake River and 60 percent of Owyhee project samples) [table 24 at back of report]. No other samples exceeded this threshold value.

Selenium concentrations in fish generally were small (table 10), but exceeded the 1980–81 NCBP 85th percentile concentration (2.84 μg/g wet weight) [Lowe and others, 1985] in 13 percent of all fish sampled (26 percent of Snake River and 14 percent of Owyhee project fish) [fig. 11].

Selenium was detected in all waterbird eggs, ranging from 0.96 μg/g (mallard, Snake River near Jump Creek) to 4.54 μg/g (mallard, Snake River above study area) [table 10]. In 26 percent of the samples, selenium concentrations were only slightly above the 3 μg/g dry-weight-indicator threshold for avian contamination in nonmarine environments (Skorupa and Ohlendorf, 1991), and were below the 6 to 70 μg/g dry weight concentrations that have been found in selenium-contaminated sites associated

Table 10. Concentrations of selenium in biota collected from the Snake River, Owyhee and Vale project areas, and adjacent sites, 1990

[Concentrations in micrograms per gram on a dry weight basis; ranges are the minimum and maximum concentrations; < = less than values; number in parentheses ( ) equals the number of samples collected; "--" not analyzed; *includes bass and crappie; because different detection limits were reported by different analytical laboratories, some "less than" values exceed reported values]

Matrix	Snake River	Owyhee project	Vale project	Adjacent sites
Aquatic plants				
Algae	0.95-1.42(2)	0.81-2.21(4)	0.66-1.40 (5)	<0.70-0.98 (4)
Sago pondweed	<0.60-1.20(2)	0.77-1.19(4)	<0.60-0.72 (3)	<0.70-0.57 (4)
Horned pondweed	--	--	<0.60-0.70 (3)	--
Aquatic invertebrates				
Corixidae	2.00-2.90(2)	1.66-2.98(2)	0.88-1.84 (4)	0.84-1.30 (4)
Ephemeroptera	4.40	9.65	--	--
Hemiptera	2.71	--	1.65	--
Odonata	2.70	3.23-3.47(2)	1.40-1.57 (3)	1.02-1.30 (2)
Fish				
Carp	0.90-2.60(6)	2.19-2.20(2)	--	0.97-1.22 (3)
Channel catfish	1.40-2.90(6)	1.11-1.90(2)	1.92	0.89-1.53 (2)
Bullhead	--	--	1.32-2.50 (2)	1.47-2.00 (3)
Bass/crappie	0.95-4.70(6)	1.67-3.00(3)	0.82-1.60 (3)	1.20-1.70 (4)
Mountain whitefish	4.5 (1)	--	--	--
Waterbird eggs				
Mallard	0.96-4.54(6)	--	--	1.50
Cinnamon teal	--	--	--	1.75
Black-crowned night heron	2.98-3.60(2)	--	--	--
California gull	2.28-3.33(2)	--	--	--
American avocet	--	--	--	2.80-3.15 (3)
Black-necked stilt	--	--	--	3.95
American coot	--	--	--	1.73-1.85 (3)
Waterbird livers				
Mallard	--	--	--	19.5
American avocet	--	--	--	13.6-14.3 (2)
American coot	3.83	--	--	2.58-3.50 (2)
Western grebe	10.9-17.3(3)	--	--	10.2

with reduced hatching success and high rates of embryo mortality and teratogenicity (Ohlendorf and others, 1986a; Hoffman and others, 1988).

Selenium was detected in all waterbird livers, ranging from 2.58 µg/g (American coot, Fort Boise Wildlife Management Area) to 19.5 µg/g (mallard, Fort Boise Wildlife Management Area) [table 10, and table 27 at back of report]. Background selenium concentrations in wild birds from uncontaminated habitats average between 4 and 10 µg/g dry weight (Koranda and others, 1979; Ohlendorf and others, 1986a, 1988a; Presser and Ohlendorf, 1987). Concentrations from 15 to 26 µg/g dry weight have been associated with reduced hatching success and cause embryonic deformities (Ohlendorf and others, 1986b; Heinz and others, 1989; Ohlendorf, 1989). One western grebe (17.3 µg/g) from the Snake River near the mouth of Jump Creek and one mallard (19.5 µg/g) from Fort Boise Wildlife Management Area were within this lower threshold range.

Concentrations of selenium in livers of coots, mallards, and avocets closely corresponded to concentrations reported in coots, gadwalls, and avocets from the Malheur National Wildlife Refuge in eastern Oregon (Rinella and Schuler, 1992), and to concentrations reported in coots and mallards from American Falls Reservoir on the Snake River in eastern Idaho (Low and Mullins, 1990). Although selenium concentrations in bird livers from all three sites were within the range that may cause reproductive impairment, no problems have been observed at any of these sites and concentrations in food items were below threshold levels.

Rinella and Schuler (1992) concluded that evaluation of selenium hazards based solely on liver concentrations may be misleading, because birds may be accumulating selenium from other sites. In addition, the toxic effects of selenium may be altered by synergistic or antagonistic effects with other trace elements such as mercury (Eisler, 1985b, 1987).

Other Elements

Water and Bottom Sediment

Dissolved concentrations of cadmium, chromium, copper, lead, molybdenum, vanadium, and zinc in water were compared with State and Federal water-quality standards and criteria. Based on USEPA formulations (U.S. Environmental Protection Agency, 1986a) that take into consideration element concentrations and hardness values, some concentrations of cadmium, copper, and lead exceeded the USEPA criteria for the protection of freshwater aquatic life at four sites (table 11). Concentrations of cadmium in water exceeded the criterion at one location (Payette River near Payette, Idaho [1 µg/L at hardness of 44 mg/L]); concentrations of copper in water exceeded the criterion at one site (Owyhee River below Owyhee Lake, Oregon [21 µg/L at hardness of 60 mg/L]); and concentrations of lead in water exceeded the criterion at three sites: Snake River at Marsing, Idaho (10 µg/L at hardness of 190 mg/L); Owyhee River below Owyhee Lake, Oregon (16 µg/L at hardness of 60 mg/L); and Sand Hollow Creek outflow from the Fort Boise Wildlife Management Area (6 µg/L at hardness of 130 mg/L).

Concentrations of lead and manganese in bottom sediment (<63-µm-size fraction) at four sites were greater than the 95-percent baseline range for soils from the Western United States (table 11). Although no expected 95-percent baseline range in concentration was available for tin, the concentration of tin

Table 11. Locations in the Owyhee and Vale project areas, and Snake River system, where element concentrations in water exceeded the U.S. Environmental Protection Agency criteria for the protection of freshwater aquatic life or where element concentrations in bottom sediment (less than 63-micrometer-size fraction) were larger than the expected 95-percent baseline range for element concentrations in soils from the Western United States

[ID = Idaho; OR = Oregon; WMA = Wildlife Management Area; W = water; S = bottom sediment; X = exceedance of water-quality criteria; E = sediment enrichment; * = does not show exceedance of water-quality criteria or sediment enrichment; "--" = not analyzed]

Sampling sites (figures 2 and 3)	Date	Medium	Element: Arsenic	Cadmium	Copper	Lead	Manganese	Mercury	Tin
Snake River at Marsing, ID	07-31-90	W	*	*	*	X	--	*	--
Owyhee River below Owyhee Lake, OR	08-03-90	W	*	*	X	X	--	*	--
Malheur River below Warmsprings, OR	08-21-90	S	E	*	*	E	*	*	*
Bully Creek near Vale, OR	08-22-90	S	*	*	*	*	E	*	*
Payette River near Payette, ID	04-18-90	W	*	X	*	*	--	*	--
Sand Hollow Creek inflow to the Fort Boise WMA, ID	07-06-90	S	*	*	*	E	E	E	E
Sand Hollow Creek drain from the Fort Boise WMA	07-06-90	W	*	*	*	X	--	*	--
	07-06-90	S	*	*	*	*	E	*	*

(680 μg/g) in bed sediment at the Sand Hollow Creek inflow to the Fort Boise Wildlife Management Area was considerably larger than the maximum concentration for tin (7.4 μg/g) observed in soils from the Western United States (Shacklette and Boerngen, 1984) and the analytical reporting limit (10 μg/g).

Biota

Cadmium was detected in all but one aquatic-plant sample, at concentrations ranging from <0.15 to 3.03 μg/g. The maximum concentration was found in horned pondweed from the North Fork Malheur River below Beulah Reservoir (table 23 at back of report). Most concentrations were under 1 μg/g. Cadmium also was detected in almost all aquatic invertebrates except those from Lake Lowell and Owyhee River below Owyhee Lake (table 24 at back of report). The largest concentration of cadmium was 2.29 μg/g in water-boatman samples from the North Fork Malheur River below Beulah Reservoir. These concentrations were less than dietary levels shown to be toxic to adult or juvenile mallards in experimental feeding studies (Cain and others, 1983; White and Finley, 1978). Concentrations of cadmium in fish exceeded the 1980–81 NCBP 85th percentile concentration (0.24 μg/g dry weight) [Lowe and others, 1985] in 29 percent of the total fish samples taken from the study areas: 37 percent of Snake River samples, and 43 percent of Owyhee project area samples (fig. 11). Cadmium concentrations in a common carp from Owyhee Lake (6.19 μg/g dry weight; 1.86 μg/g wet weight) was 31 times greater than the 1980–81 NCBP 85th percentile of 0.06 μg/g wet weight (Lowe and others, 1985). Concentrations of cadmium in fish ranged from being slightly greater than and up to 4 times the 1980–81 NCBP 85th percentile concentration of 0.06 μg/g (table 25 back of report). Cadmium was not detected in waterbird eggs, and concentrations in bird livers were below levels believed to be toxic to birds (tables 26 and 27 at back of report) [Eisler, 1985a; White and Finley, 1978].

Copper concentrations exceeded the 1980–81 NCBP 85th percentile concentration (Lowe and others, 1985) in 31 percent of the total fish samples taken from the study areas; and in 26 percent of Snake River fish samples, in 57 percent of Owyhee fish samples, and in 29 percent of Vale fish samples (fig. 11). Most NCBP exceedance values were more than 3 times the 0.90 μg/g wet weight 85th percentile value, but a channel catfish from the lower Owyhee River (58.7 μg/g dry weight; 14.7 μg/g wet weight) exceeded this value more than 16 times. Copper concentrations in waterbird livers were comparable to concentrations found at the Malheur National Wildlife Refuge (Rinella and Schuler, 1992).

Lead was detected in 13 percent of the fish sampled, and exceeded the 1980–81 NCBP 85th percentile concentration (Lowe and others, 1985) in 7 percent of the fish sampled (fig. 11). No lead was detected in fish from the Snake River or the Vale project (table 25 at back of report). A common carp collected at Fort Boise Wildlife Management Area had a lead concentration of 21.2 μg/g dry weight (6.04 μg/g wet weight), more than 24 times the 1980–81 NCBP 85th percentile value of 0.25 μg/g wet weight. Because this area is popular for upland bird and waterfowl hunting, it is possible that this carp ingested lead shot. Further evidence supporting this possibility is that the concentration of lead in the bottom sediment (<63-μm-size fraction) collected at the inflow point to the Fort Boise Wildlife Management Area (470 μg/g) greatly exceeds the 95-percent baseline range for soils from the Western United States (55 μg/g). Lead was detected in 10 percent of the aquatic-plant samples and ranged up to 14.6 μg/g dry weight in algae from the lower Malheur River (table 23 at back of report). In 29 percent of the aquatic-invertebrate samples, lead also was detected and ranged up to 10.7 μg/g in water boatman (Corixidae) from the Snake River near Weiser, Idaho (table 24 at back of report). No lead was detected in any waterbird livers (detection limit of 1.5 μg/g dry weight) [table 27 at back of report]. Lead does not tend to biomagnify in food chains (Eisler, 1988b).

Zinc was detected in all fish samples ranging from 28.7 μg/g in a mountain whitefish from the Snake River near the mouth of Jump Creek to 412 μg/g in a common carp from Owyhee Lake (table 25 at back of report). Zinc concentrations in fish exceeded the 1980–81 NCBP 85th percentile concentration (160 μg/g dry weight) [Lowe and others, 1985] in 22 percent of all fish sampled (19 percent of Snake River and 7 percent of Owyhee project fish) [fig. 11]. Concentrations of zinc were largest in carp, and all fish that exceeded the NCBP 85th percentile were carp. The biological implications of these levels are unknown, but it has been reported that common carp have a tendency to accumulate more zinc than other fish species (Lowe and others, 1985).

Organic Compounds

Water

Concentrations of organic compounds detected in whole-water samples are summarized in table 12, and tabulated in table 28 (at back of report). A total of 35 different compounds were analyzed in samples collected in 1990 (table 1). Fifteen compounds (including two metabolites of DDT) were detected at one or more of the 11 sites sampled. DDT and its metabolites (DDE and DDD), dieldrin, endrin, 2,4-D, dicamba, and dacthal were detected at seven or more sites. Chlorpyrifos, endosulfan, ethion, malathion, parathion, phorate, and lindane were detected at one to four sites. Concentrations of DDT and its metabolites, dieldrin, endrin, 2,4-D, dicamba, dacthal, and parathion generally were largest at four sites: Overstreet Drain, Owyhee River at Owyhee, D Drain, and Malheur River near Ontario. Concentrations of 2,4-D and dacthal also were elevated at Boise River near Parma and Succor Creek near Homedale. No easily discernible temporal trends in concentration were observed during the three samplings completed in 1990. Eighty-six percent of the samples analyzed for DDT and its metabolites, 71 percent of the dieldrin samples, 14 percent of the endrin samples, and 10 percent of the parathion samples exceeded water-quality criteria established for the protection of freshwater aquatic life (table 12) [U.S. Environmental Protection Agency, 1986a].

Analysis of DDT and its metabolites in whole-water samples indicated that nearly 30 percent (median value) of the insecticide was still present as DDT (fig. 12), although the use of DDT in the United States has been banned by the USEPA since about 1972. Fifty percent of the insecticide was present as the aerobic metabolite (DDE), and the remaining 20 percent present in the anaerobic form (DDD). These percentages are consistent with values observed in a 1987–90 study done in the Yakima River Basin, Washington program (J.F. Rinella, U.S. Geological Survey, written commun., 1992). The percentage of DDT, DDE, and DDD in the Yakima River whole-water samples was about 30-40, 50, and 10-20 percent, respectively.

As noted in the "Previous Studies" section of this report, a strong correlation exists between dacthal and nitrate concentrations in ground water in the Vale-Ontario area. In this study area, an arithmetic correlation coefficient of 0.88 existed between concentrations of dacthal and nitrate plus nitrite (as N) [fig. 13] for surface-water samples collected in 1990.

Bottom Sediment

Results of bottom-sediment analysis for organochlorine compounds from 14 sites have been tabulated in table 29 (at back of report); the organochlorine compounds detected are summarized in table 13. The <2-mm-size fraction was analyzed for 17 different organochlorine compounds. Eight compounds (including two metabolites of DDT) were detected in the study area. Chlordane, DDT plus its metabolites (DDE and DDD), and dieldrin were detected at 11 or more sites. Aldrin, endosulfan, and heptachlor epoxide were detected at one to five sites. Concentrations of all eight compounds (when normalized for organic content) generally were largest at five sites: Overstreet Drain, Owyhee River at Owyhee, Bully Creek near Vale, D Drain, and Malheur River near Ontario. Succor Creek near Homedale had the largest normalized concentration for endosulfan. These sites were generally the same sites that had the largest concentrations of organochlorine compounds in whole-water samples, with the possible exception of Bully Creek near Vale. Because no water samples for organochlorine analysis were collected at the Bully Creek site near Vale, its ranking for whole-water concentrations of organochlorine compounds could not be determined.

Interstitial pore-water pesticide concentrations were computed for sampling sites where pesticide concentrations in bottom sediment exceeded analytical reporting limits. An "N" designation in table 13 refers to an interstitial-water concentration that will result in protection of benthic fauna from chronic toxicity with a 97.5 percent certainty; a "U" designation refers to an interstitial-water concentration that is between a level of no-effect ("N") and a level of effect ("E"); an "E" designation refers to an interstitial-water concentration that will result in a hazardous long-term effect on the benthic fauna with a 97.5 percent certainty. All of the detectable pesticide concentrations had computed interstitial pore-water concentrations for chlordane, DDT plus metabolites, and heptachlor epoxide that exceeded the "no-effect" criterion (a "U" or "E" designation in table 13) proposed for the protection of benthic fauna from chronic toxicity (U.S. Environmental Protection Agency, 1988a, 1990b). Fifty percent of the computed interstitial pore-water concentrations for endosulfan and about 8 percent of the aldrin plus dieldrin concentrations (aldrin metabolizes to dieldrin) also exceeded the proposed "no-effect" criterion.

Table 12. Summary of organic compounds detected in whole water and number of samples exceeding water-quality criteria for the protection of freshwater aquatic life, Owyhee and Vale project areas, and Snake River system, April-October 1990

[Concentrations in micrograms per liter; nc = no criteria available; DDT = dichlorodiphenyltrichloroethane; 2,4-D = 2,4-dichlorophenoxyacetic acid: < = less than]

Organic compound	Number of samples	Minimum reporting level	Number less than reporting level	Percentile distribution			Water-quality criteria 1/	Total number of samples per area			Number of samples exceeding criteria		
								Project			Project		
				Minimum	Median	Maximum		Owyhee	Vale	Snake River	Owyhee	Vale	Snake River
Chlorpyrifos	7	0.01	6	<0.01	<0.01	0.03	0.041	2	3	2	0	0	0
2,4-D	20	.01	1	< .01	.16	.67	2/ 4.0	5	5	10	0	0	0
Dacthal	21	.01	0	.04	2.2	19.4	nc	5	5	11	nc	nc	nc
DDT plus metabolites	21	.001	3	<.001	.008	.084	.001	5	5	11	5	5	8
Dicamba	20	.01	12	< .01	< .01	.10	2/200	5	5	10	0	0	0
Dieldrin	21	.001	3	< .001	.003	.053	.0019	5	5	11	5	5	5
Endrin	21	.001	12	< .001	< .001	.008	.0023	5	5	11	1	2	0
Endosulfan	21	.001	17	< .001	< .001	.003	.056	5	5	11	0	0	0
Ethion	21	.01	16	< .01	< .01	.02	2/ .02	5	5	11	0	0	0
Lindane (BHC)	21	.001	20	< .001	< .001	.002	.08	5	5	10	0	0	0
Malathion	21	.01	20	< .01	< .01	.07	.1	5	5	11	0	0	0
Parathion	21	.01	17	< .01	< .01	.06	.013	5	5	11	1	1	0
Phorate	21	.01	20	< .01	< .01	.05	nc	5	5	11	nc	nc	nc

1/ U.S. Environmental Protection Agency, 1986a.
2/ National Academy of Sciences, National Academy of Engineering, 1973.

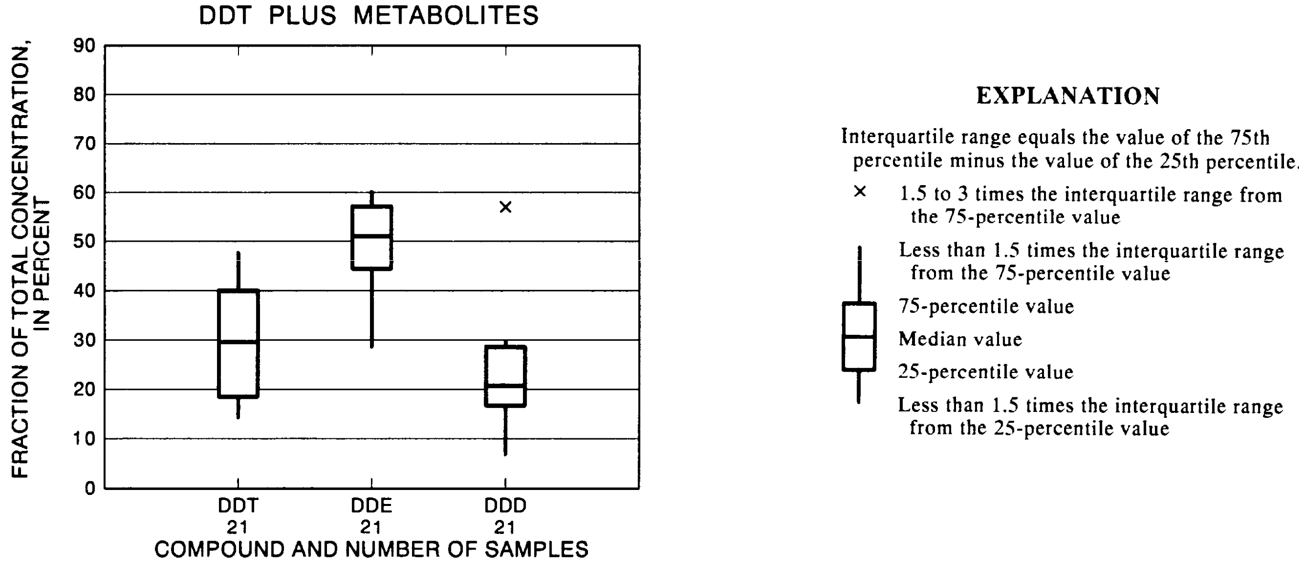


Figure 12. Distribution of the fraction of DDT, DDE, and DDD in water, Owyhee and Vale projects, and Snake River system, April-October 1990.

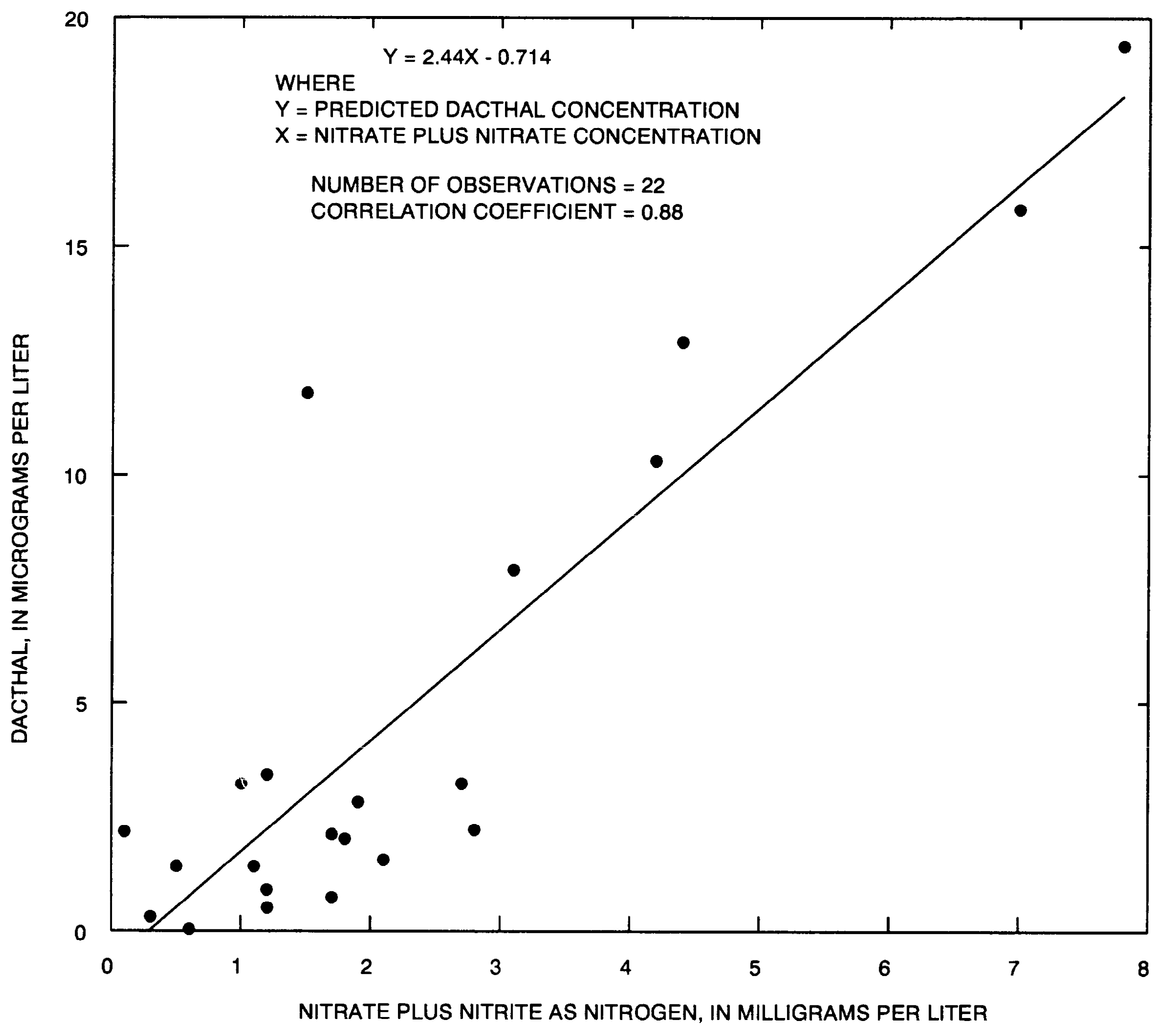


Figure 13. Relation between dacthal and nitrate-plus-nitrite concentrations in water, Owyhee and Vale projects, and Snake River system, April-October 1990.

Table 13. Summary of organochlorine compounds detected in bottom sediment (normalized to fraction organic carbon) and assessment of pesticide toxicity to benthic fauna, Owyhee and Vale project areas, and Snake River system, July-August 1990

[ID = Idaho; OR = Oregon; DDT = dichlorodiphenyltrichloroethane; WMA = Wildlife Management Area; N = no-effect concentration (represents concentration with a 97.5 percent certainty will result in protection from chronic effects to benthic fauna; U = unknown toxicity (represents concentration between no-effect [safe] and effect [hazardous] levels; E = effect concentration (represents concentration with a 97.5 percent certainty will result in hazardous long-term effects to benthic fauna; < = pesticide concentration less than analytical reporting limit; * = pesticide concentration detected but fraction organic carbon less than analytical reporting limit]

Sampling location (figures 2 and 3)	Date	Organochlorine compounds: Aldrin plus Dieldrin	Chlordane	DDT plus metabolites	Endosulfan	Heptachlor epoxide
Snake River at Marsing, ID	07-31-90	N	U	U	<	<
Succor Creek near Homedale, ID	08-01-90	N	U	E	U	<
Overstreet Drain, OR	08-03-90	N	U	E	<	<
Owyhee River at Owyhee, OR	08-01-90	N	U	E	N	<
Boise River near Parma, ID	08-01-90	N	<	U	<	<
Bully Creek near Vale, OR	08-22-90	U	E	E	<	U
Malheur River near Vale, OR	08-22-90	N	U	U	<	<
Willow Creek at Vale, OR	08-22-90	N	U	U	<	<
D Drain, OR	08-23-90	N	U	E	<	<
Malheur River near Ontario, OR	08-03-90	N	U	E	N	<
	08-03-90	N	U	E	U	<
Payette River near Payette, ID	08-02-90	N	U	U	<	<
Snake River at Weiser, ID	08-02-90	N	U	U	<	<
Sand Hollow Creek inflow to the Fort Boise WMA, ID	07-06-90	*	<	*	<	<
Sand Hollow Creek outflow to the Fort Boise WMA, ID	07-06-90	<	<	*	<	<
Percent of pesticide samples whose chronic toxicity to benthic fauna was unknown (U) or showed effect (E)		8	100	100	50	100

Fifty-four percent of the DDT plus metabolite samples and 8.3 percent of the chlordane samples in this study had interstitial-water concentrations that exceeded the criterion determined to have hazardous long-term effects on benthic fauna (an "E" designation in table 13).

Analysis of DDT plus metabolites in bottom sediment indicated about 15 percent (median value) of the insecticide was still present as DDT. However, samples collected from four sites (Succor Creek near Homedale, Willow Creek near Vale, Sand Hollow Creek inflow to the Fort Boise Wildlife Management Area, and Overstreet Drain) still had elevated DDT fractions ranging from 38.5 to 75.6 percent. More than 60 percent (median value) of the insecticide was present as DDE, and about 21 percent (median value) was present as DDD (fig. 14). Percentages of DDT, DDE, and DDD (median values) in bottom-sediment samples from the Yakima River Basin in Washington were about 20, 60, and 20 percent, respectively (J.F. Rinella, U.S. Geological Survey, written commun., 1992).

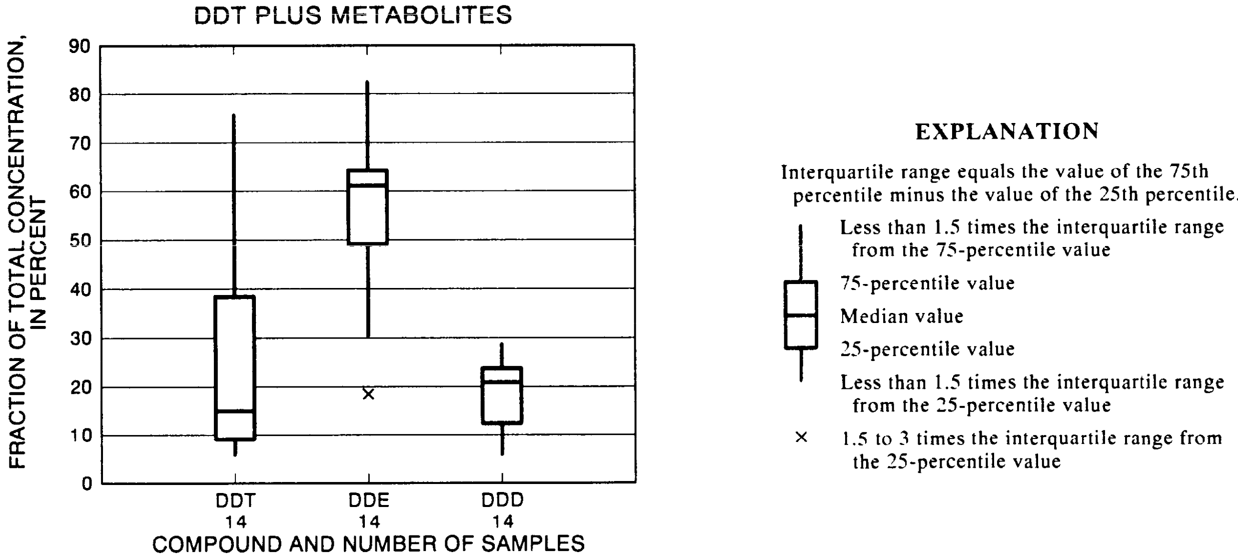


Figure 14. Distribution of the fraction of DDT, DDE, and DDD in bottom sediment, Owyhee and Vale projects, and Snake River system, April-October 1990.

Biota

Sixteen fish samples from 14 sites and 14 bird samples from 6 sites were analyzed for organochlorine compounds. Results of organochlorine pesticide and PCB analyses in biological samples are reported individually in tables 17 and 18, at back of report. As discussed in the previous section, several organochlorine compounds (notably aldrin and endosulfan) were not analyzed in biota; therefore, their concentrations in biota are unknown. Fourteen compounds (including two metabolites of DDT) were detected in fish, bird egg, and bird-tissue samples. Concentrations of most organic compounds were at or below the analytical reporting level (<0.01 µg/g), and concentrations generally were greater in biological samples from the Snake River and the Owyhee project area. Concentrations of DDT and its metabolites, dieldrin, and toxaphene were the only organochlorine compounds that were elevated in some samples of birds or fish. Concentrations of DDT, DDE, DDD, dieldrin, and toxaphene in fish samples (fig. 15) were elevated in relation to the 1980–81 baseline from the National Pesticide Monitoring Program (NPMP) [Schmitt and others, 1985], but all were less than dietary concentrations believed to impair reproductive success of avian predators.

DDT and its metabolites were detected in most fish samples collected from both the Owyhee project area and the Snake River (table 17, back of report). Residues of DDE and DDT also were found in some fish samples from the Vale project and from other sampling sites (table 17, back of report). Detectable concentrations of DDE occurred in 14 of the 16 fish samples analyzed, and ranged from less than the analytical reporting level to 1.5 µg/g. DDE concentrations in 50 percent or more of the fish samples exceeded the nationwide geometric mean (0.20 µg/g wet weight) from the NPMP (Schmitt and others, 1985) [fig. 15]. However, the concentrations were below dietary levels of 3 µg/g reported to threaten fish-eating wildlife (Lincer, 1975; McLane and Hall, 1972; Mendenhall and others, 1983; Wiemeyer and Porter, 1970). p,p'-DDE was detected in all bird eggs collected from the Snake River and Fort Boise Wildlife Management Area, and concentrations ranged from 0.13 to 2.8 µg/g (table 18, back of report).

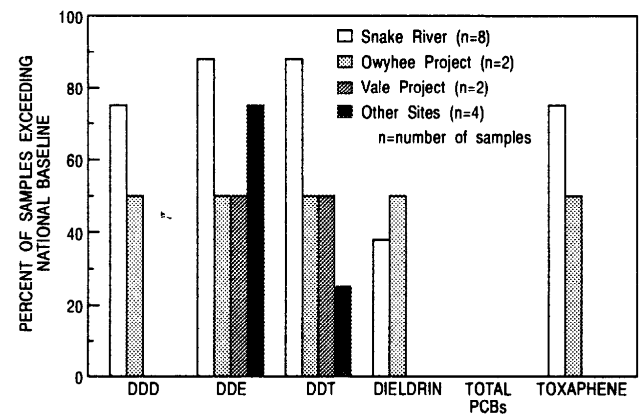


Figure 15. Percentage of fish sampled from the Owyhee and Vale projects, and Snake River system, 1990, that exceeded the National Pesticide Monitoring Program (NPMP) geometric mean for organochlorine pesticides and polychlorinated biphenyls (PCBs).

The largest concentration was found in a cinnamon teal egg collected from the Fort Boise Wildlife Management Area. DDE concentrations in bird eggs were below levels of 8 μg/g associated with impaired reproduction (Custer and others, 1983; Henny and others, 1984; Ohlendorf and others, 1988b). Much larger concentrations of DDE were observed in adult birds than in bird eggs collected from the Snake River, the Fort Boise Wildlife Management Area, or Lake Lowell. Concentrations ranged from 0.38 to 7.7 μg/g and were largest in the western grebe samples (table 18, at back of report).

None of the fish sampled had PCB concentrations that exceeded the national baseline for the NPMP of 0.53 μg/g wet weight (Schmitt and others, 1985) [fig. 15]. PCB concentrations in all the fish samples were below the analytical reporting levels (table 17, at back of report). Small concentrations of PCBs were detected in bird eggs sampled from the Snake River and Fort Boise Wildlife Management Area (table 18, back of report). In the nine eggs analyzed, total PCB concentrations ranged from <0.05 to 0.34 μg/g. These concentrations were below levels associated with lethal or sublethal effects in birds (Custer and Heinz, 1980; Eisler, 1986; Haseltine and Prouty, 1980; Heinz and others, 1984; Hoffman and others, 1986). Larger concentrations of PCBs were found in adult birds than were found in bird eggs collected from the Snake River and Lake Lowell (table 18, at back of report). Concentrations ranged from 2.6 to 7.8 μg/g in western grebes. Consistent with other studies, the largest PCB concentrations were found in western grebes, a fish-eating bird. Detectable PCB concentrations found in bird carcasses were still considerably below levels associated with mortality or reproductive problems in birds (Eisler, 1986; Lowe and Stendell, 1991).

Concentrations of dieldrin exceeded the national geometric mean of 0.04 μg/g from the NPMP (Schmitt and others, 1985) in 38 percent of the fish samples collected from the Snake River and in 50 percent of the fish samples collected from the Owyhee project area (fig. 15). None of the samples from the other sites exceeded this national geometric mean. Although dieldrin concentrations exceeded this national geometric mean in some fish samples, those concentrations (table 17, at back of report) were smaller than the concentrations present in dietary fish used in laboratory studies that did not inhibit the breeding success of avian predators (Dahlgren and Linder, 1974; Mendenhall and others, 1983).

Dieldrin was detected in all but one of the bird samples, but dieldrin concentrations were small (equal to or slightly more than the analytical reporting level; table 18, at back of report). The levels of dieldrin in birds were well below concentrations observed to affect bird survival or productivity (Heinz and Johnson, 1981; Mendenhall and others, 1983).

Concentrations of toxaphene were detected in 7 of the 16 fish samples analyzed and ranged from <0.05 to 1.9 μg/g (table 17, at back of report). Fifty and 75 percent of the fish from the Snake River and the Owyhee project area, respectively, contained toxaphene concentrations that exceeded the national baseline of 0.27 μg/g from the NPMP (Schmitt and others, 1985) [fig. 15]. Reduced growth, abnormal bone development, and reduced reproductive ability have been reported to occur in fish when residues of toxaphene in fish tissue exceed 0.4 μg/g (Eisler and Jacknow, 1985; Mayer and Mehrle, 1977). Six of the 10 fish samples from the Snake River and Owyhee project exceeded this value. All the fish samples with detectable concentrations of toxaphene surpassed criteria of 0.1 μg/g recommended by the National Academy of Sciences (1973) for the protection of fish-eating wildlife. Toxaphene was not detected in any of the bird egg or mallard carcass samples, but toxaphene was detected in all western grebe carcass samples (table 18, at back of report). Concentrations of toxaphene in carcass samples of western grebes ranged from 0.63 to 2.7 μg/g and were below concentrations reported to be associated with lethal or sublethal effects in birds (Eisler and Jacknow, 1985; Hoffman and Eastin, 1982).

Mean eggshell thickness measurements in the six bird species sampled are found in table 14. Mean thickness of eggshells ranged from 0.224 mm (millimeters) for American avocets to 0.322 mm for American coots. Eggshell thickness measurements were compared with pre-1947 eggshell thickness measurements (Blus and others, 1985; Henny and others, 1984). Mean percent thinning was 9 percent (range 0 to 15 percent) for mallards and 12 percent (range 4 to 22 percent) for black-crowned night herons. Eggshell thickness of pre-1947 eggs of cinnamon teal, California gulls, American coots, and American avocets was not available for comparison with eggshell measurements from this study (L. Kiff, Western Foundation for Vertebrate Zoology, Los Angeles, California, oral commun., 1992).

Table 14. Arithmetic mean eggshell thickness of eggs collected from the Snake River and Fort Boise Wildlife Management Area, 1990

[Eggshell thickness in millimeters; percent thinning is based on comparison to pre-1947 eggshell thickness; N = sample size; ND = no pre-1947 data available for comparison; SD = standard deviation]

Species	N	Eggshell thickness Mean	±SD	Pre-1947 Mean	±SD	Percent of eggshell thinning (range) 1/
Mallard	10	0.318	±0.025	2/0.349	±0.006	9 (0 - 15)
Cinnamon teal	2	.279	± .009	ND		ND
California gull	4	.307	± .017	ND		ND
Black-crowned night heron	3	.242	± .025	3/ .275	± .004	12 (4 - 22)
American coot	4	.322	± .008	ND		ND
American avocet	5	.224	± .020	ND		ND

1/ Comparison of 1990 eggshell thickness to pre-1947 thickness.
2/ Data from Blus and others (1985).
3/ Data from Henny and others (1984).

Egg contents for 9 of the 28 eggs collected were analyzed for organochlorine concentrations. No correlation was observed with either DDD, DDE, DDT, or dieldrin concentrations and eggshell thinning in mallards (table 15).

Table 15. Organochlorine concentrations and percent eggshell thinning in mallard eggs collected from Snake River and Fort Boise Wildlife Management Area, 1990

[Eggshell thinning from table 14; organochlorine concentrations in micrograms per gram on a wet-weight basis corrected for moisture loss by multiplying reported data by the whole egg weight divided by the egg volume (0.51 x L x W^2); DDD = dichlorodiphenyl-dichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane; ND = not detected]

Percent eggshell thinning	Selected organochlorine concentrations DDD	DDE	DDT	Dieldrin
6	0.03	2.34	0.10	0.01
10	.02	.50	.03	.02
15	ND	.13	.02	ND

Bioassessment Results

The 100-percent microbial bioluminescence bioassay procedure (Microtox) was used to measure the toxicity of water samples at 5- and 15-minute intervals. Water samples were collected each month from 18 sites from May through October 1990 during the agricultural growing season (figs. 2-3). Eleven of the sampling sites were in the Owyhee project area, 5 were in the Vale project area, and 2 were from the Fort Boise Wildlife Management Area (figs. 2-3). Irrigation drains and natural streams that convey irrigation drainwater were selected for sampling because they could serve as a migratory pathway for pesticides applied to agricultural fields. During the first month of sampling, water samples also were collected from all the reservoirs in the study area. No toxicity was found in these samples and they were eliminated from future sampling efforts.

Toxicity was observed at only two sites on two separate sampling dates (table 16). In May 1990, water collected from the Snake River at Walter's Ferry produced an EC_{50} value of 62 percent after 5 minutes (EC_{50} is the effective concentration of a water sample, either in terms of milligrams per liter or percentage of sample, that causes a 50 percent loss of light measured in a test bacteria). Toxicity was not evident after 15 minutes, however, nor did the replicate sample show any toxicity. Water samples collected from Succor Creek in July 1990 showed toxicity in both replications tested and at both time intervals. Replication 1 had an EC_{50} at 5 minutes of 78 percent and an EC_{50} at 15 minutes of 52 percent. Replication 2 showed similar results, with an EC_{50} at 5 minutes of 82 percent and an EC_{50} at 15 minutes of 30 percent. No toxicity was observed at either site during the other months in which water was sampled.

Table 16. Results of Microtox 100-percent microbial bioluminescence bioassays on water samples collected from the Owyhee and Vale project areas, and adjacent sites, 1990

[Measurable results are in a percent of the EC_{50} (the effective concentration of a water sample – either in terms of milligrams per liter or percentage of sample – that causes a 50 percent loss of light measured in a test bacteria); NT indicates samples that were not toxic; both replications are shown at 5- and 15-minute intervals when a toxic reaction was measured]

	EC_{50} (Percent)					
Sites	May	June	July	August	September	October
Owyhee Project						
Owyhee River	NT	NT	NT	NT	NT	NT
Jump Creek	NT	NT	NT	NT	NT	NT
Succor Creek	NT	NT	78,52 82,30	NT	NT	NT
Alkali Creek	NT	NT	NT	NT	NT	NT
Mesquite Road Drain	NT	NT	NT	NT	NT	NT
Grove Road Drain	NT	NT	NT	NT	NT	NT
Horstman Drain	NT	NT	NT	NT	NT	NT
Thompson Road Drain	NT	NT	NT	NT	NT	NT
Overstreet Drain	NT	NT	NT	NT	NT	NT
Arcadia Drain	NT	NT	NT	NT	NT	NT
Railroad Drain	NT	NT	NT	NT	NT	NT
Walter's Ferry	62,NT NT	NT	NT	NT	NT	NT
Vale Project						
Malheur River-Ontario	NT	NT	NT	NT	NT	NT
Malheur River-Vale	NT	NT	NT	NT	NT	NT
Mallet Drain	NT	NT	NT	NT	NT	NT
Airport Road Drain	NT	NT	NT	NT	NT	NT
Valeview Road Drain	NT	NT	NT	NT	NT	NT
Adjacent Sites						
Fort Boise WMA-outflow	NT	NT	NT	NT	NT	NT
Fort Boise WMA-diversion	NT	NT	NT	NT	NT	NT

Results of this assay indicate only that toxicity was not found on the day of collections. Many of the pesticides used in Idaho and Oregon are organophosphate, carbamate, or pyrethroid-based pesticides that break down rapidly. Consequently, toxic effects would not be observed unless samples were collected shortly after the pesticides were applied. Although short-lived, these pesticides could still have a substantial effect on aquatic insects. To adequately determine if these types of pesticides could have an effect on aquatic insects would require an intensive sampling effort, including daily collection and daily testing of water samples from numerous drain sites.

Biological Observations

Limited biological observations were made of the study area with the exception of the Snake River islands above the Oregon border and the Fort Boise Wildlife Management Area. The USFWS was involved in extensive field studies of predation on waterfowl nests on Snake River islands during the summers of 1990–91. During this time, about 150 Canada goose goslings were observed per year. One gosling with a missing upper mandible was found in 1991 on Cigar Island, which is located a few miles downstream of Marsing, Idaho (Helen Ulmschneider, U.S. Fish and Wildlife Service, oral commun., 1991). No other birth defects were noted.

No significant bird mortalities, birth defects, or other biological anomalies were observed at Fort Boise Wildlife Management Area (Clair Kofoed, Idaho Department of Fish and Game, oral commun., 1992) or at any of the other biota-collection sites during the course of the study.

Several pesticide-induced kills of Canada geese on the Snake River (within the study area) have been observed. The most recent pesticide-induced kill occurred in 1988, when an estimated 160 Canada geese were killed on Westlake Island near Weiser, Idaho, after the application of one carbamate and two organophosphate pesticides on an alfalfa field (Blus and others, 1991). A kill of Canada geese, suspected of being pesticide induced, occurred on the Snake River near Marsing, Idaho, in 1991; then carcasses were decomposed and unsuitable for sampling.

SUMMARY

As part of a DOI program to identify the nature and extent of irrigation-induced, water-quality problems in the Western United States, water samples were collected from 19 sites in the Owyhee and Vale project areas, as well as at a number of sites in the Snake River and tributaries to the Snake River. Samples were collected during pre-irrigation (April 1990), irrigation (July-August 1990), and post-irrigation (October 1990) periods and analyzed for major ions, nutrients, and trace elements. Samples collected from 11 of the 19 sites were analyzed for pesticides and other organochlorine compounds. Bottom-sediment samples were collected from 18 sites in the study area from late July to early August 1990 and were analyzed for trace elements. Samples collected from 14 of those 18 sites were analyzed for pesticides and other organochlorine compounds. Biota samples (eggs, waterbirds, fish, aquatic plants, and aquatic insects) were collected from 19 sites in the study area; select samples were analyzed for trace elements, pesticides, and other organochlorine compounds.

The dominant major ions in water were sodium, calcium, bicarbonate, and sulfate. The largest concentration of "total dissolved solids" (TDS) was 1,010 mg/L at a site located above the irrigated areas in the Malheur River system that probably was influenced by local springs during summer low flows. The median TDS concentration in the Malheur River system was more than 1.5 times the median values observed in the Owyhee River and Snake River systems. TDS, alkalinity, SAR, and hardness increased in concentration during August 1990 irrigation, from above the irrigated areas to below the irrigated areas in the Owyhee and Malheur River systems; however, these concentrations did not increase in the Malheur River below Warm Springs Reservoir, which appears to be influenced by local springs. TDS, alkalinity, SAR, and hardness in agricultural drains from both river systems were either comparable or slightly exceeded concentrations found in water samples collected at sites below the irrigated areas. Nitrate-plus-nitrite concentrations in water samples collected throughout the study area ranged from <0.10 at a number of sites to 7.8 mg/L at D Drain. During the August 1990 sampling, nitrate-plus-nitrite concentrations also increased from above to below the irrigated areas in the Owyhee and Malheur River systems. Nitrate-plus-nitrite concentrations in agricultural drains from both river systems also were similar or slightly exceeded concentrations at sites below the irrigated areas.

Trace-element concentrations of arsenic, boron, copper, molybdenum, vanadium, and zinc were detected in most water samples; cadmium, chromium, lead, and selenium were detected in some water samples, generally at concentrations near the analytical reporting limit; mercury was not detected in any samples. Concentrations of arsenic, boron, cadmium, copper, and lead in some water samples exceeded State or Federal water-quality standards or criteria. During the August 1990 sampling, arsenic, boron, and selenium concentrations increased from above to below the irrigated areas in the Owyhee and Malheur River systems, similar to increases in concentrations observed for TDS, major ions, and nitrate plus nitrite. Concentrations of arsenic, boron, and selenium in agricultural drains for the two river systems also were comparable or slightly exceeded the concentrations found in water samples collected at sites below the irrigated areas.

Most trace elements in bottom sediment were detected at concentrations within the expected 95-percent baseline range for soils from the Western United States. The following concentrations exceeded the 95-percent baseline range for soils from the Western United States: arsenic (79 μg/g) and lead (59 μg/g) in one sample from a site in the Malheur River system; mercury (0.67 μg/g), lead (470 μg/g), and tin (680 μg/g) in one sample from a site in the Snake River system; manganese in two samples from two sites in the Snake River system (3,080 and

3,280 μg/g) and from 1,630 μg/g in one sample from a site in the Malheur River system.

Although some water samples contained elevated concentrations of arsenic, none of the arsenic concentrations in aquatic plants or aquatic insects exceeded dietary-threshold concentrations. Arsenic concentrations in fish were below those reported to affect growth and survival in bluegills, and were not elevated in birds or in bird eggs.

Boron in two sago pondweed samples (Snake River above study area and lower Malheur River) exceeded the dietary-threshold concentration of 300 μg/g dry weight for waterfowl. No other aquatic-plant or aquatic-insect samples exceeded this threshold. Boron was not elevated in fish, birds, or bird eggs.

Mercury was not elevated in aquatic-plant or aquatic-insect samples. Six fish samples exceeded USEPA protection levels for pregnant women, and three fish samples exceeded USEPA protection levels for human health. Study samples were whole fish, however, while USEPA criteria are based on edible fillets that would contain lower mercury concentrations. Fish from Owyhee Lake contained the largest concentrations of mercury. Mercury was detected in all waterbird eggs except mallards, but only one black-crowned night heron egg exceeded a concentration reported to cause reproductive problems in mallards. Mercury was detected in all bird livers, and concentrations were largest in fish-eating species (western grebes). Concentrations of mercury in American avocets, American coots, and mallards were below effect levels reported for mallards.

Selenium was not elevated in aquatic-plant samples, but concentrations in aquatic insects exceeded the waterfowl-dietary criterion in 20 percent of the Snake River samples and in 60 percent of the Owyhee River samples. Selenium concentrations in fish generally were small, and were not considered elevated in waterbird eggs. Selenium in some waterbird livers were in the lower threshold-effects range reported from other studies, but no effects were observed. At other sites in Oregon and Idaho, where similar concentrations of selenium have been reported, no effects have been observed.

Cadmium concentrations were elevated in 29 percent of the fish samples. Cadmium in a common carp from Owyhee Lake was 31 times greater than the 1980–81 NCBP 85th percentile. Copper concentrations were elevated in approximately 33 percent of the fish samples, lead was elevated in 7 percent of the fish samples, and zinc was elevated in 22 percent of the fish samples. Zinc concentrations were largest in carp, which is consistent with findings of other studies.

Fifteen pesticides and metabolites were detected in whole-water samples collected from 11 sites in the study area. DDT plus its metabolites (DDE and DDD) [<0.001 to 0.084 μg/L], dieldrin (<0.001 to 0.053 μg/L), endrin (<0.001 to 0.008 μg/L), 2,4-D (<0.01 to 0.67 μg/L), dicamba (<0.01 to 0.10 μg/L), and dacthal (0.04 to 19.4 μg/L) were detected in samples collected from 7 or more sites. Other pesticides detected included chlorpyrifos (<0.01 to 0.03 μg/L), endosulfan (<0.001 to 0.003 μg/L), ethion (<0.01 to 0.02 μg/L), malathion (<0.01 to 0.07 μg/L), parathion (<0.01 to 0.06 μg/L), phorate (<0.01 to 0.05 μg/L), and lindane (<0.001 to 0.002 μg/L). Most of the concentrations of pesticides detected generally were largest in drainwater and at sites below the irrigated areas in the Owyhee and Malheur Rivers. Eighty-six percent of the whole-water samples analyzed for DDT plus its metabolites, 71 percent of the dieldrin samples, 14 percent of the endrin samples, and 10 percent of the parathion samples had concentrations that exceeded water-quality criteria established for the protection of freshwater aquatic life.

Eight pesticides and metabolites were detected in bottom sediment collected from 14 sites in the study area. Chlordane (<1 to 30 μg/kg), DDT plus its metabolites (0.8 to 113.7 μg/kg), and dieldrin (<1 to 43 μg/kg) were detected at 11 or more of the sites. Other pesticides or metabolites detected included aldrin (<0.1 to 1.5 μg/kg), endosulfan (<0.1 to 0.2 μg/kg), and heptachlor epoxide (<0.1 to 0.8 μg/kg). Most of the eight compounds, when normalized for organic carbon, had the largest concentrations in drainwater and at sites below the irrigated areas in the Owyhee and Malheur Rivers. Computed, interstitial-water concentrations exceeded the "no-effect" (safe) criteria proposed for the protection of benthic fauna from chronic toxicity in 100 percent of the bottom-sediment samples analyzed for chlordane, DDT plus its metabolites, and heptachlor epoxide; 50 percent of the endosulfan samples; and 7.7 percent of the aldrin plus dieldrin samples.

Concentrations of most organic compounds generally were greater in biological samples from the Snake River and the Owyhee project area, than in the Vale project area and areas adjacent to the projects. Concentrations of DDT and its metabolites, dieldrin, and toxaphene were the only organic compounds that were elevated in some samples of birds or fish. Concentrations of DDT, DDE, DDD, dieldrin, and toxaphene in fish samples were elevated in relation to the 1980–81 national baseline from the National Pesticide Monitoring Program. However, all concentrations in the fish samples were below dietary concentrations believed to impair reproductive success of avian predators. DDE concentrations in bird eggs were below levels associated with impaired reproduction. Mallard eggshells were 9 percent thinner and black-crowned night heron eggshells were 12 percent thinner than pre-1947 eggshells of these species. Thinning in mallard eggshells did not appear to be correlated with concentrations of organochlorine insecticides in egg contents.

Monthly Microtox bioassays conducted on water samples from study-area drains indicated little toxicity associated with these drains. However, although substantial effects on aquatic invertebrates and other biota could be occurring, toxicity due to pulses of short-lived organophosphate, carbamate, or pyrethroid insecticides easily could have gone undetected because of infrequent sampling.

Chemical and biological data collected during this reconnaissance investigation have not proved conclusively that irrigation drainage from the Owyhee and Vale project areas have caused, or have the potential to cause, harmful effects on human health, fish, and wildlife. Results of the surface-water collection activities during the irrigation period indicate that increases in concentrations of TDS, major ions, nitrate plus nitrite, arsenic, boron, and selenium occurred from above to below the irrigated areas in the Owyhee and Malheur River systems. These rivers systems are major components of the Owyhee and Vale projects. Some increases in concentrations may result from the seepage of geothermal ground water to the surface-water system, but part of the increases in concentrations may result from the irrigation of the agricultural areas. Elevated pesticide concentrations were detected in surface water and bottom sediment within agricultural drains in the project areas, and below the irrigated areas in the Owyhee and Malheur River systems; these elevated concentrations may result from current and (or) historical applications of pesticides to the irrigated agricultural areas. However, results of the biological data collected during this investigation do not necessarily correlate with the findings of the water-chemistry or bottom-sediment data. Some contaminants in some biological tissues were sufficiently elevated to exceed recommended guidelines for the protection of human health, fish, and wildlife; but, these elevated concentrations were not consistently found in all sample media and at all sampling sites. Elevated concentrations may not have been found consistently because of inadequate sampling due to the absence of biota in major components of the irrigated areas, and because of a lack of suitable habitat coupled with the large spatial extent of the study area.

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SUPPLEMENTAL DATA TABLES

Table 17. Concentrations of organochlorine pesticides and polychlorinated biphenyls (PCBs) in whole-body fish collected from Snake River system, Owyhee and Vale project areas, and adjacent sites, 1990

[Concentrations in micrograms per gram on a wet weight basis; < = less than values; -- indicates not analyzed WB is whole body; o,p' = ortho,para'; p,p' = para,para'; BHC = 1,2,3,4,5,6-hexachlorocyclohexane; DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane; HCB = hexachlorobenzene; N = North; WMA = Wildlife Management Area]

					Organochlorine pesticides									
Species	Sample type	Location	Percent moisture	Percent lipid	alpha-BHC	beta-BHC	delta-BHC	gamma-BHC-(Lindane)	alpha-Chlordane	gamma-Chlordane	o,p'-DDD	p,p'-DDD	o,p'-DDE	p,p'-DDE
						Snake River								
Bullhead	WB	Weiser	83.0	0.90	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Channel catfish	WB	Above study area	74.5	7.11	<.01	<.01	<.01	<.01	.01	<.01	<.01	.03	<.01	.43
Channel catfish	WB	Mouth-Jump Creek	70.5	11.9	<.01	<.01	<.01	<.01	.04	.02	<.01	.12	<.01	1.1
Channel catfish	WB	Mouth-Owyhee River	79.5	5.76	<.01	<.01	<.01	<.01	.02	<.01	<.01	.10	<.01	.83
Channel catfish	WB	Mouth-Malheur River	77.0	3.76	<.01	<.01	<.01	<.01	.02	<.01	<.01	.14	<.01	1.0
Channel catfish	WB	Weiser	68.0	14.3	<.01	<.01	<.01	.01	.04	.01	<.01	.23	<.01	1.1
Channel catfish	WB	Brownlee Reservoir	64.5	21.7	<.01	<.01	<.01	<.01	.03	.01	<.01	.21	<.01	.80
Channel catfish	WB	Brownlee Reservoir	69.0	15.5	<.01	<.01	<.01	<.01	.04	.02	<.01	.23	<.01	1.0
						Owyhee Project								
Channel catfish	WB	Owyhee Lake	74.5	5.88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.01	<.01	.02
Channel catfish	WB	Owyhee River	74.5	7.17	<.01	<.01	<.01	<.01	.03	.01	<.01	.16	<.01	1.5
						Vale Project								
Smallmouth bass	WB	Bully Creek Dam	75.0	5.21	<.01	<.01	<.01	<.01	.03	.01	<.01	.05	<.01	1.4
Channel catfish	WB	N. Fork Malheur River	79.0	4.52	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
						Adjacent Sites								
Bullhead	WB	Payette River	81.5	1.84	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.02	<.01	.10
Bullhead	WB	Fort Boise WMA	82.5	.60	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.03	<.01	.25
Channel catfish	WB	Boise River	80.0	2.20	<.01	<.01	<.01	<.01	.03	<.01	<.01	.05	<.01	.70
Channel catfish	WB	Lake Lowell	75.5	8.48	<.01	<.01	<.01	<.01	.02	<.01	<.01	.05	<.01	.30

Table 17. Concentrations of organochlorine pesticides and polychlorinated biphenyls (PCBs) in whole-body fish collected from Snake River system, Owyhee and Vale project areas, and adjacent sites, 1990—Continued

Species	Sample type	Location	Organochlorine pesticides											Total PCBs
			o,p'-DDT	p,p'-DDT	Dieldrin	Endrin	Heptachlor epoxide	HCB	Mirex	cis-Nonachlor	trans-Nonachlor	Oxy-chlordane	Toxaphene	
							Snake River							
Bullhead	WB	Weiser	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05
Channel catfish	WB	Above study area	<.01	.06	.01	<.01	.01	<.01	<.01	<.01	.01	.01	<.05	<.05
Channel catfish	WB	Mouth-Jump Creek	.12	.36	.03	<.01	.04	<.01	<.01	<.01	.03	.01	1.0	<.05
Channel catfish	WB	Mouth-Owyhee River	<.01	.11	.05	<.01	.01	<.01	<.01	<.01	.02	<.01	.36	<.05
Channel catfish	WB	Mouth-Malheur River	<.01	.13	.05	<.01	.01	<.01	<.01	<.01	.02	<.01	.62	<.05
Channel catfish	WB	Weiser	<.01	.09	.02	<.01	.02	.01	<.01	.01	.03	.01	.60	<.05
Channel catfish	WB	Brownlee Reservoir	<.01	.07	.10	<.01	.02	.01	<.01	<.01	.01	.01	.57	<.05
Channel catfish	WB	Brownlee Reservoir	<.01	.07	.05	<.01	.02	.01	<.01	<.01	.03	.01	.61	<.05
							Owyhee Project							
Channel catfish	WB	Owyhee Lake	<.01	<.01	<.01	<.01	.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05
Channel catfish	WB	Owyhee River	.15	.44	.37	<.01	.03	.02	<.01	<.01	.03	.01	1.9	<.05
							Vale Project							
Smallmouth bass	WB	Bully Creek Dam	.06	.18	.03	<.01	.01	<.01	<.01	<.01	.01	.01	<.05	<.05
Channel catfish	WB	N. Fork Malheur River	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05
							Adjacent Sites							
Bullhead	WB	Payette River	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05
Bullhead	WB	Fort Boise WMA	<.01	.05	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05
Channel catfish	WB	Boise River	<.01	.08	.01	<.01	.01	<.01	<.01	<.01	.01	.01	<.05	<.05
Channel catfish	WB	Lake Lowell	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05

Table 18. Concentrations of organochlorine pesticides and polychlorinated biphenyls (PCBs) in aquatic bird carcasses and eggs collected from Snake River system and adjacent sites, 1990

[Concentrations in micrograms per gram on a wet-weight basis; < =less than values; -- = not analyzed; B C night heron is black-crowned night heron; egg concentrations were corrected for moisture loss by multiplying reported data by the whole egg weight divided by the egg volume (0.51 x L x W^2); o,p' = ortho,para'; p,p' = para,para'; BHC =1,2,3,4,5,6-hexachlorocyclohexane; DDD = dichlorodiphenyl- dichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT =dichlorodiphenyltrichloroethane; HCB = hexachlorobenzene; WMA = Wildlife Mnagement Area]

					Organochlorine pesticides										
Species	Sample type	Location	Percent moisture	Percent lipid	alpha-BHC	beta-BHC	delta-BHC	gamma-BHC (Lindane)	alpha-Chlordane	gamma-Chlordane	o,p'-DDD	p,p'-DDD	p,p'-DDD olefin	o,p'-DDE	p,p'-DDE
							Snake River								
Western grebe	Whole body	Above study area	60.5	19.2	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	4.8	5.8	<0.01	6.1
Western grebe	Whole body	Mouth-Jump Creek	56.5	22.5	<.01	<.01	<.01	<.01	.03	<.01	<.01	1.9	1.0	<.01	5.6
Western grebe	Whole body	Mouth-Owyhee River	66.5	14.3	<.01	<.01	<.01	<.01	.05	<.01	<.01	3.5	2.8	<.01	7.7
Mallard	Egg	Above study area	70.0	15.3	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--	<.01	.13
Mallard	Egg	Mouth-Jump Creek	69.0	14.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.03	--	<.01	2.4
B C night heron	Egg	Weiser	81.5	5.74	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.01	--	<.01	1.09
California gull	Egg	Weiser	75.5	17.1	<.01	.05	<.01	<.01	<.01	<.01	<.01	.01	--	<.01	.62
California gull	Egg	Weiser	75.0	9.48	<.01	.01	<.01	<.01	.01	<.01	<.01	.02	--	<.01	1.3
							Adjacent Sites								
Western grebe	Carcass	Lake Lowell	57.5	24.6	<.01	<.01	<.01	<.01	.03	<.01	<.01	4.1	3.9	<.01	7.4
Mallard	Carcass	Fort Boise WMA	77.5	2.36	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.03	<.01	<.01	.38
Mallard	Egg	Fort Boise WMA	69.0	14.7	<.01	<.01	<.01	<.01	.01	<.01	<.01	.01	--	<.01	.50
Cinnamon teal	Egg	Fort Boise WMA	65.0	9.56	<.01	<.01	<.01	<.01	.02	<.01	<.01	.05	--	<.01	2.8
American coot	Egg	Fort Boise WMA	73.0	10.7	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--	<.01	.28
American avocet	Egg	Fort Boise WMA	73.0	13.4	<.01	.02	<.01	<.01	.01	<.01	<.01	<.01	--	<.01	2.07

Table 18. Concentrations of organochlorine pesticides and polychlorinated biphenyls (PCBs) in aquatic bird carcasses and eggs collected from Snake River system and adjacent sites, 1990—Continued

			Organochlorine pesticides											
Species	Sample type	Location	o,p'-DDT	p,p' DDT	Dieldrin	Endrin	Heptachlor epoxide	HCB	Mirex	cis-Non-achlor	trans-Nonachlor	Oxy-chlordane	Toxaphene	Total PCBs
							Snake River							
Western grebe	Carcass	Above study area	<0.01	0.06	0.07	<0.01	<0.01	0.02	<0.01	0.15	0.21	0.05	0.63	2.6
Western grebe	Carcass	Mouth-Jump Creek	<.01	.13	.30	<.01	.03	.03	<.01	.23	.34	.08	1.9	7.8
Western grebe	Carcass	Mouth-Owyhee River	<.01	.14	.60	<.01	.08	.05	<.01	.22	.25	.07	2.7	3.0
Mallard	Egg	Above study area	<.01	.02	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05
Mallard	Egg	Mouth-Jump Creek	<.01	.10	.01	<.01	<.01	.01	<.01	<.01	<.01	<.01	<.05	<.05
B C night heron	Egg	Weiser	<.01	.02	.01	<.01	.01	.01	<.01	<.01	.04	.03	<.05	.20
California gull	Egg	Weiser	<.01	.02	.04	<.01	.01	.01	<.01	<.01	.01	.01	<.05	<.05
California gull	Egg	Weiser	.01	.03	.03	<.01	.01	.01	<.01	<.01	.01	.01	<.05	.31
							Adjacent Sites							
Western grebe	Carcass	Lake Lowell	<.01	.07	.08	<.01	<.01	.04	<.01	.29	.44	.10	.96	6.9
Mallard	Carcass	Fort Boise WMA	<.01	.02	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05
Mallard	Egg	Fort Boise WMA	<.01	.03	.02	<.01	<.01	.01	<.01	<.01	.01	.01	<.05	<.05
Cinnamon teal	Egg	Fort Boise WMA	.05	.62	.06	<.01	.02	<.01	<.01	<.01	.04	.02	<.05	.34
American coot	Egg	Fort Boise WMA	<.01	<.01	.01	<.01	.01	<.01	<.01	<.01	<.01	.01	<.05	<.05
American avocet	Egg	Fort Boise WMA	<.01	.02	.04	<.01	<.01	.01	<.01	<.01	<.01	.01	<.05	<.05

Table 19. Water-chemistry field measurements and concentrations of dissolved major ions and nutrients, Owyhee and Vale project areas, and Snake River system, April-October 1990

[deg C = degrees Celsius; mm = millimeter; Hg = mercury; µS/cm = microsiemens per centimeter; mg/L = milligrams per liter; ID = Idaho; nr = near; Cr = Creek; R = River; Res = Reservoir; blw = below; OR = Oregon; N = North; Fk = Fork; "--" not analyzed; < = less than]

Figure 2 and 3 identifications	Station name	Station number	Date	Time	Temperature water (deg C)	Barometric pressure (mm of Hg)	Discharge (cubic feet per second)	Specific conductance (µS/cm)	Oxygen, dissolved (mg/L)	Oxygen (percent saturation)
N	Snake River at Marsing, ID	13172850	07-31-90	1000	22.5	700	5,100	493	9.1	115
			10-16-90	0900	13.0	700	7,520	521	8.8	92
D	Jump Cr nr Homedale, ID	13172890	07-31-90	1645	24.5	699	50	1,210	8.0	106
			10-16-90	1100	12.0	702	80	1,210	9.4	95
E	Succor Cr nr Homedale, ID	13173500	04-17-90	1500	21.0	692	76	928	9.2	115
			08-01-90	0845	17.5	700	33	1,150	8.6	98
			10-16-90	1345	12.5	702	67	1,220	11.1	114
A	Owyhee R blw Owyhee Lake, OR	13183000	04-20-90	1330	6.0	698	196	257	9.6	84
			08-03-90	0900	6.0	701	187	255	10.4	91
B	Overstreet Drain, OR	434705117065200	04-20-90	1045	13.0	705	4.0	489	8.2	85
			08-03-90	1130	19.0	705	4.0	519	7.8	91
			10-16-90	1600	12.5	705	3.4	816	8.4	85
C	Owyhee River at Owyhee, OR	13184000	04-17-90	1100	14.0	694	71	616	9.6	102
			08-01-90	1700	25.0	700	77	641	8.8	117
			10-18-90	1000	9.5	699	77	714	10.0	96
O	Boise River nr Parma, ID	13213000	04-18-90	1000	17.0	699	99	577	7.2	82
			08-01-90	1230	22.5	700	488	511	9.3	117
			10-17-90	1530	11.5	705	818	501	12.9	128
F	Malheur R blw Warmsprings,OR	13215000	04-21-90	1100	8.0	673	412	219	10.8	103
			08-21-90	1400	18.5	676	27	1,430	9.1	111
G	N Fk Malheur R at Beulah, OR	13217500	04-21-90	1245	9.5	700	344	143	11.0	104
			08-21-90	1000	14.5	678	60	214	8.5	94
H	Bully Cr blw Bully Cr Res, OR	440104117230400	04-20-90	1515	11.0	694	57	418	9.2	92
			08-22-90	0830	19.5	699	4.6	464	6.5	77
I	Bully Creek near Vale, OR	435802117161600	04-19-90	1700	20.0	695	12	646	10.7	130
			08-22-90	1045	16.0	704	17	864	7.9	87
			10-19-90	1000	9.0	704	2.2	938	6.4	60
J	Malheur R near Vale, OR	435844117141100	04-19-90	1800	21.5	697	81	585	9.5	119
			08-22-90	1330	20.5	705	82	901	8.4	101
			10-18-90	1600	8.0	698	39	1,070	12.8	119
K	Willow Creek at Vale, OR	435917117134500	04-19-90	1615	21.5	698	12	1,130	10.7	133
			08-22-90	1600	21.0	703	20	1,360	9.8	120
			10-19-90	0830	7.0	705	17	1,310	9.4	85
L	D Drain, OR	435945117065300	04-20-90	1700	21.0	701	18	995	8.2	101
			08-23-90	0815	15.0	702	30	1,240	8.4	91
			10-18-90	1400	10.5	699	15	1,320	8.1	80
M	Malheur River nr Ontario, OR	440312116585100	04-16-90	1700	19.0	692	134	963	9.3	111
			08-03-90	1515	23.5	706	84	1,240	12.2	156
			1/ 08-03-90	1520	23.5	706	84	1,240	12.2	156
			08-23-90	1200	19.0	702	249	1,140	7.3	86
			10-15-90	1700	12.5	700	251	1,080	10.8	111
P	Payette R nr Payette, ID	13251000	04-18-90	1630	17.0	700	1,450	151	9.0	101
			08-02-90	1430	24.0	703	388	335	7.8	101
			10-17-90	1315	9.5	708	1,170	174	12.0	113
Q	Snake River at Weiser, ID	13269000	04-19-90	1130	17.0	705	10,300	374	9.3	104
			08-02-90	0930	23.5	705	7,020	504	10.0	128
			10-17-90	0930	11.0	712	12,400	493	10.4	102
R	Sand Hollow Cr inflow, ID	434759116582800	04-18-90	1145	15.5	700	78	563	8.2	90
			07-06-90	1130	18.0	702	110	525	7.9	90
			10-17-90	1645	11.5	705	92	582	9.8	97
S	Sand Hollow Cr outflow, ID	434919117003200	04-18-90	1330	17.5	700	7.2	635	7.0	80
			07-06-90	1545	22.0	700	4.4	521	10.0	126
			10-18-90	0815	9.0	700	3.5	620	9.8	92

1/ Quality-assurance split sample.

Table 19. Water-chemistry field measurements and concentrations of dissolved major ions and nutrients, Owyhee and Vale project areas, and Snake River system, April-October 1990—Continued

Figure 2 and 3 identi-fica-tions	Station name	Date	pH (units)	Alka-linity (mg/L as CaCO3)	Solids residue at 180 deg C (mg/L)	Sedi-ment sus-pended (mg/L)	Calcium (mg/L as Ca)	Magne-sium (mg/L as Mg)	Hard-ness (mg/L as CaCO3)	Sodium (mg/L as Na)	Sodium adsorp-tion ratio
N	Snake River at Marsing, ID	07-31-90	8.4	169	326	24	44	20	190	35	1.1
		10-16-90	8.6	188	328	62	50	21	210	35	1.0
D	Jump Cr nr Homedale, ID	07-31-90	8.2	223	886	260	130	30	450	110	2.3
		10-16-90	8.1	236	892	170	120	29	420	110	2.3
E	Succor Cr nr Homedale, ID	04-17-90	8.7	166	653	166	66	17	230	100	2.8
		08-01-90	8.1	192	844	110	94	18	310	130	3.2
		10-16-90	8.5	215	884	114	100	21	340	140	3.3
A	Owyhee R blw Owyhee Lake, OR	04-20-90	9.0	--	--	--	--	--	--	--	--
		08-03-90	8.0	92	152	7	16	4.9	60	27	1.5
B	Overstreet Drain, OR	04-20-90	8.1	131	--	1,490	--	--	--	--	--
		08-03-90	8.0	146	340	1,090	35	9.7	130	60	2.3
		10-16-90	8.2	232	629	750	63	18	230	120	3.4
C	Owyhee River at Owyhee, OR	04-17-90	8.2	174	421	107	42	11	150	68	2.4
		08-01-90	8.2	188	429	110	47	12	170	77	2.6
		10-18-90	8.3	208	477	64	53	13	190	84	2.7
O	Boise River nr Parma, ID	04-18-90	8.2	207	363	46	46	12	160	63	2.1
		08-01-90	8.2	187	327	52	43	11	150	56	2.0
		10-17-90	8.5	187	334	91	42	11	150	53	1.9
F	Malheur R blw Warmsprings, OR	04-21-90	8.2	--	--	--	--	--	--	--	--
		08-21-90	8.2	210	1010	73	92	39	390	160	3.5
G	N Fk Malheur R at Beulah, OR	04-21-90	8.0	--	--	--	--	--	--	--	--
		08-21-90	7.8	101	163	332	15	7.2	67	17	0.9
H	Bully Cr blw Bully Cr Res, OR	04-20-90	8.2	--	--	--	--	--	--	--	--
		08-22-90	8.0	185	290	12	37	12	140	48	1.8
I	Bully Creek near Vale, OR	04-19-90	8.8	--	--	--	--	--	--	--	--
		08-22-90	8.0	307	592	100	59	18	220	110	3.2
		10-19-90	7.8	312	639	119	66	20	250	110	3.0
J	Malheur R near Vale, OR	04-19-90	8.6	--	--	--	--	--	--	--	--
		08-22-90	8.1	311	619	57	56	17	210	130	3.9
		10-18-90	8.5	363	728	87	62	20	240	160	4.5
K	Willow Creek at Vale, OR	04-19-90	8.6	--	--	--	--	--	--	--	--
		08-22-90	8.3	419	944	146	66	23	260	210	5.7
		10-19-90	8.3	394	876	175	68	24	270	200	5.3
L	D Drain, OR	04-20-90	8.3	316	--	253	--	--	--	--	--
		08-23-90	8.0	399	840	25	60	22	240	190	5.3
		10-18-90	8.2	420	918	257	60	22	240	220	6.2
M	Malheur River nr Ontario, OR	04-16-90	8.5	300	643	28	43	18	180	140	4.5
		08-03-90	8.3	405	836	88	57	23	240	200	5.6
	1/	08-03-90	8.3	405	846	--	58	24	240	210	5.8
		08-23-90	8.2	356	768	183	55	21	220	170	4.9
		10-15-90	8.4	328	746	178	61	22	240	160	4.5
P	Payette R nr Payette, ID	04-18-90	8.2	66	91	95	13	2.8	44	13	.8
		08-02-90	8.4	151	219	64	28	7.5	100	36	1.6
		10-17-90	8.2	80	119	39	17	3.5	57	17	1.0
Q	Snake River at Weiser, ID	04-19-90	8.9	123	228	61	27	13	120	31	1.2
		08-02-90	8.6	171	317	76	38	18	170	44	1.5
		10-17-90	8.7	181	327	56	46	18	190	41	1.3
R	Sand Hollow Cr inflow, ID	04-18-90	8.1	--	--	--	--	--	--	--	--
		07-06-90	8.1	186	335	72	44	12	160	55	1.9
		10-17-90	8.3	205	380	99	48	14	180	64	2.1
S	Sand Hollow Cr outflow, ID	04-18-90	8.1	--	--	--	--	--	--	--	--
		07-06-90	9.0	186	318	176	31	13	130	61	2.3
		10-18-90	8.5	232	402	36	39	16	160	82	2.8

1/ Quality-assurance split sample.

Table 19. Water-chemistry field measurements and concentrations of dissolved major ions and nutrients, Owyhee and Vale project areas, and Snake River system, April-October 1990—Continued

Figure 2 and 3 identi-fica-tions	Station name	Date	Potas-sium (mg/L as K)	Chlo-ride (mg/L as Cl)	Sulfate (mg/L as SO4)	Fluo-ride (mg/L as F)	Silica (mg/L as SiO2)	Nitrogen ammonia (mg/L as N)	Nitrogen NO2+NO3 (mg/L as N)	Phos-phorus ortho (mg/L as P)
N	Snake River at Marsing, ID	07-31-90	5.1	28	51	--	--	--	0.60	0.03
		10-16-90	4.7	28	50	0.6	--	.02	1.2	.02
D	Jump Cr nr Homedale, ID	07-31-90	12	39	370	--	--	--	2.3	--
		10-16-90	9.9	42	350	.9	--	.04	2.8	.06
E	Succor Cr nr Homedale, ID	04-17-90	9.4	26	250	--	--	--	1.2	--
		08-01-90	12	29	370	--	--	--	1.5	--
		10-16-90	13	30	420	1.1	--	.02	1.8	.05
A	Owyhee R blw Owyhee Lake, OR	04-20-90	--	--	--	--	--	--	--	--
		08-03-90	3.5	9.6	24	--	--	--	.40	--
B	Overstreet Drain, OR	04-20-90	--	--	--	--	--	--	1.1	.11
		08-03-90	6.9	26	80	--	--	--	1.0	.09
		10-16-90	9.0	55	160	.9	--	.04	2.7	.08
C	Owyhee River at Owyhee, OR	04-17-90	7.4	20	92	;9	31	--	1.2	.07
		08-01-90	8.0	20	110	.9	34	--	1.7	.07
		10-18-90	7.5	23	120	1.1	35	.03	1.9	.05
O	Boise River nr Parma, ID	04-18-90	5.2	22	58	--	--	--	1.7	--
		08-01-90	4.9	18	47	--	--	--	1.7	--
		10-17-90	4.1	17	42	.3	--	.02	2.7	.30
F	Malheur R blw Warmsprings, OR	04-21-90	--	--	--	--	--	--	--	--
		08-21-90	8.8	140	320	--	--	--	1.5	--
G	N Fk Malheur R at Beulah, OR	04-21-90	--	--	--	--	--	--	--	--
		08-21-90	4.2	3.7	11	--	--	--	< .10	--
H	Bully Cr blw Bully Cr Res, OR	04-20-90	--	--	--	--	--	--	--	--
		08-22-90	6.8	18	47	--	--	--	< .10	--
I	Bully Creek near Vale, OR	04-19-90	--	--	--	--	--	--	--	--
		08-22-90	11	20	130	--	--	--	2.8	--
		10-19-90	10	21	120	.3	--	.06	6.1	.33
J	Malheur R near Vale, OR	04-19-90	--	--	--	--	--	--	--	--
		08-22-90	11	22	140	--	--	--	2.6	--
		10-18-90	9.4	28	160	.5	--	.03	3.1	.24
K	Willow Creek at Vale, OR	04-19-90	--	--	--	--	--	--	--	--
		08-22-90	14	27	250	--	--	--	3.5	--
		10-19-90	13	33	250	.6	--	.09	3.3	.36
L	D Drain, OR	04-20-90	--	--	--	--	--	--	5.0	.38
		08-23-90	13	32	200	--	--	--	7.8	.39
		10-18-90	12	37	220	.6	--	.09	7.0	.37
M	Malheur River nr Ontario,OR	04-16-90	10	32	150	.6	37	--	2.8	.26
		08-03-90	12	41	220	.7	48	--	4.2	.37
	1/	08-03-90	12	41	220	--	--	--	4.4	--
		08-23-90	13	30	200	--	--	--	4.4	.36
		10-15-90	11	34	220	.7	42	.06	3.1	.27
P	Payette R nr Payette, ID	04-18-90	1.6	3.5	7.0	--	--	--	.40	--
		08-02-90	2.9	7.8	19	--	--	--	1.1	--
		10-17-90	1.5	3.6	8.3	.5	--	.03	.40	.03
Q	Snake River at Weiser, ID	04-19-90	4.3	17	39	--	--	--	.30	--
		08-02-90	5.6	24	62	--	--	--	.50	< .01
		10-17-90	4.7	23	53	.5	--	.02	1.2	.03
R	Sand Hollow Cr inflow, ID	04-18-90	--	--	--	--	--	--	--	--
		07-06-90	4.7	10	44	--	--	--	2.1	--
		10-17-90	4.8	18	56	.4	--	.04	2.6	.22
S	Sand Hollow Cr outflow, ID	04-18-90	--	--	--	--	--	--	--	--
		07-06-90	4.7	9.6	36	--	--	--	.10	--
		10-18-90	5.9	25	72	.4	--	.05	.10	.13

1/ Quality-assurance split sample.

Table 20. Concentrations of dissolved elements, Owyhee and Vale project areas, and Snake River system, April-October 1990

[Concentrations in micrograms per liter; ID = Idaho; OR = Oregon; Cr = Creek; R = River; blw = below; Res = reservoir; "--" = not analyzed; < = less than]

Figure 2 and 3 identifications	Station name	Station number	Date	Time	Elements			
					Arsenic	Barium	Boron	Cadmium
N	Snake River at Marsing, ID	13172850	07-31-90	1000	4	--	90	<1
			10-16-90	0900	6	--	90	<1
D	Jump Cr near Homedale, ID	13172890	07-31-90	1645	31	--	180	<1
			10-16-90	1100	39	--	180	<1
E	Succor Cr near Homedale, ID	13173500	04-17-90	1500	22	--	140	<1
			08-01-90	0845	37	--	180	<1
			10-16-90	1345	31	--	200	1
A	Owyhee R blw Owyhee Lake, OR	13183000	04-20-90	1330	--	--	--	--
			08-03-90	0900	5	--	100	<1
B	Overstreet Drain, OR	434705117065200	04-20-90	1045	--	--	--	--
			08-03-90	1130	18	--	170	<1
			10-16-90	1600	47	--	310	1
C	Owyhee River at Owyhee, OR	13184000	04-17-90	1100	26	34	200	<1
			08-01-90	1700	25	38	190	<1
			10-18-90	1000	31	34	220	<1
O	Boise River near Parma, ID	13213000	04-18-90	1000	11	--	110	<1
			08-01-90	1230	9	--	100	<1
			10-17-90	1530	8	--	100	<1
F	Malheur R blw Warmsprings, OR	13215000	04-21-90	1100	--	--	--	--
			08-21-90	1400	4	--	2200	<1
G	N Fk Malheur R at Beulah, OR	13217500	04-21-90	1245	--	--	--	--
			08-21-90	1000	1	--	120	<1
H	Bully Cr blw Bully Cr Res, OR	440104117230400	04-20-90	1515	--	--	--	--
			08-22-90	0830	7	--	250	<1
I	Bully Creek near Vale, OR	435802117161600	04-19-90	1700	--	--	--	--
			08-22-90	1045	22	--	420	<1
			10-19-90	1000	25	--	410	<1
J	Malheur R near Vale, OR	435844117141100	04-19-90	1800	--	--	--	--
			08-22-90	1330	34	--	530	<1
			10-18-90	1600	56	--	640	<1
K	Willow Cr at Vale, OR	435917117134500	04-19-90	1615	--	--	--	--
			08-22-90	1600	62	--	530	<1
			10-19-90	0830	54	--	480	<1
L	D Drain, OR	435945117065300	04-20-90	1700	--	--	--	--
			08-23-90	0815	43	--	720	<1
			10-18-90	1400	55	--	810	<1
M	Malheur River near Ontario, OR	440312116585100	04-16-90	1700	33	39	460	<1
			08-03-90	1515	43	49	590	1
			1/ 08-03-90	1520	45	--	570	<1
			08-23-90	1200	37	--	530	<1
			10-15-90	1700	42	43	520	<1
P	Payette River near Payette, ID	13251000	04-18-90	1630	3	--	20	1
			08-02-90	1430	7	--	50	<1
			10-17-90	1315	4	--	30	<1
Q	Snake River at Weiser, ID	13269000	04-19-90	1130	5	--	80	1
			08-02-90	0930	7	--	100	<1
			10-17-90	0930	7	--	100	<1
R	Sand Hollow Cr inflow, ID	434759116582800	04-18-90	1145	--	--	--	--
			07-06-90	1130	9	--	100	<1
			10-17-90	1645	13	--	110	1
S	Sand Hollow Cr outflow, ID	434919117003200	04-18-90	1330	--	--	--	--
			07-06-90	1545	15	--	90	<1
			10-18-90	0815	14	--	130	<1

1/ Quality-assurance split sample.

Table 20. Concentrations of dissolved elements, Owyhee and Vale project areas, and Snake River system, April-October 1990 —Continued

Figure 2 and 3 identi-fica-tions	Station name	Date	Elements: Chromium	Copper	Iron	Lead	Manga-nese	Molyb-denum	Stron-tium
N	Snake River at Marsing, ID	07-31-90	1	8	--	10	--	2	--
		10-16-90	<1	3	--	2	--	2	--
D	Jump Cr near Homedale, ID	07-31-90	2	3	--	1	--	15	--
		10-16-90	<1	3	--	<1	--	13	--
E	Succor Cr near Homedale, ID	04-17-90	2	2	--	<1	--	11	--
		08-01-90	1	4	--	<1	--	16	--
		10-16-90	1	4	--	1	--	16	--
A	Owyhee R blw Owyhee Lake, OR	04-20-90	--	--	--	--	--	--	--
		08-03-90	1	21	--	16	--	3	--
B	Overstreet Drain, OR	04-20-90	--	--	--	--	--	--	--
		08-03-90	1	3	--	<1	--	6	--
		10-16-90	1	2	--	<1	--	13	--
C	Owyhee River at Owyhee, OR	04-17-90	<1	3	35	<1	70	8	180
		08-01-90	<1	5	28	2	35	9	190
		10-18-90	<1	2	17	1	22	9	220
O	Boise River near Parma, ID	04-18-90	<1	3	--	<1	--	4	--
		08-01-90	<1	13	--	3	--	3	--
		10-17-90	<1	4	--	<1	--	<1	--
F	Malheur R blw Warmsprings, OR	04-21-90	--	--	--	--	--	--	--
		08-21-90	<1	3	--	1	--	5	--
G	N Fk Malheur R at Beulah, OR	04-21-90	--	--	--	--	--	--	--
		08-21-90	<1	1	--	<1	--	2	--
H	Bully Cr blw Bully Cr Res, OR	04-20-90	--	--	--	--	--	--	--
		08-22-90	<1	2	--	<1	--	7	--
I	Bully Creek near Vale, OR	04-19-90	--	--	--	--	--	--	--
		08-22-90	<1	2	--	<1	--	12	--
		10-19-90	<1	2	--	<1	--	9	--
J	Malheur R near Vale, OR	04-19-90	--	--	--	--	--	--	--
		08-22-90	<1	2	--	<1	--	15	--
		10-18-90	<1	2	--	<1	--	11	--
K	Willow Cr at Vale, OR	04-19-90	--	--	--	--	--	--	--
		08-22-90	<1	2	--	<1	--	20	--
		10-19-90	<1	2	--	<1	--	15	--
L	D Drain, OR	04-20-90	--	--	--	--	--	--	--
		08-23-90	<1	4	--	<1	--	16	--
		10-18-90	1	2	--	<1	--	17	--
M	Malheur River near Ontario, OR	04-16-90	<1	6	49	<1	100	10	260
		08-03-90	2	12	18	5	75	14	340
		1/ 08-03-90	2	7	--	1	--	13	--
		08-23-90	<1	9	--	1	--	16	--
		10-15-90	<1	7	9	1	25	9	340
P	Payette River near Payette, ID	04-18-90	1	3	--	1	--	2	--
		08-02-90	1	4	--	3	--	3	--
		10-17-90	<1	2	--	1	--	1	--
Q	Snake River at Weiser, ID	04-19-90	<1	3	--	1	--	3	--
		08-02-90	<1	2	--	3	--	3	--
		10-17-90	1	2	--	1	--	<1	--
R	Sand Hollow Cr inflow, ID	04-18-90	--	--	--	--	--	--	--
		07-06-90	1	7	--	2	--	2	--
		10-17-90	<1	3	--	<1	--	3	--
S	Sand Hollow Cr outflow, ID	04-18-90	--	--	--	--	--	--	--
		07-06-90	2	6	--	6	--	1	--
		10-18-90	<1	4	--	1	--	2	--

1/ Quality-assurance split sample.

Table 20. Concentrations of dissolved elements, Owyhee and Vale project areas, and Snake River system, April-October 1990 —Continued

Figure 2 and 3 identi-fica-tions	Station name		Date	Elements					
				Vanadium	Zinc	Alumium	Lithium	Selenium	Mercury
N	Snake River at Marsing, ID		07-31-90	11	9	--	--	<1	<0.1
			10-16-90	11	5	--	--	1	<.1
D	Jump Cr near Homedale, ID		07-31-90	23	7	--	--	3	<.1
			10-16-90	22	5	--	--	3	<.1
E	Succor Cr near Homedale, ID		04-17-90	18	<3	--	--	2	<.1
			08-01-90	18	4	--	--	2	<.1
			10-16-90	20	<3	--	--	3	<.1
A	Owyhee R blw Owyhee Lake, OR		04-20-90	--	--	--	--	--	--
			08-03-90	7	8	--	--	<1	<.1
B	Overstreet Drain, OR		04-20-90	--	--	--	--	--	--
			08-03-90	15	4	--	--	1	<.1
			10-16-90	28	<3	--	--	3	<.1
C	Owyhee River at Owyhee, OR		04-17-90	15	34	20	44	2	<.1
			08-01-90	18	11	30	58	2	<.1
			10-18-90	17	<3	40	62	3	<.1
O	Boise River near Parma, ID		04-18-90	14	27	--	--	<1	<.1
			08-01-90	14	5	--	--	<1	<.1
			10-17-90	14	8	--	--	<1	<.1
F	Malheur R blw Warmsprings, OR		04-21-90	--	--	--	--	--	--
			08-21-90	16	9	--	--	<1	<.1
G	N Fk Malheur R at Beulah, OR		04-21-90	--	--	--	--	--	--
			08-21-90	7	20	--	--	<1	<.1
H	Bully Cr blw Bully Cr Res, OR		04-20-90	--	--	--	--	--	--
			08-22-90	10	<3	--	--	<1	<.1
I	Bully Creek near Vale, OR		04-19-90	--	--	--	--	--	--
			08-22-90	49	4	--	--	<1	<.1
			10-19-90	42	4	--	--	1	<.1
J	Malheur R near Vale, OR		04-19-90	--	--	--	--	--	--
			08-22-90	54	5	--	--	<1	<.1
			10-18-90	36	4	--	--	<1	<.1
K	Willow Cr at Vale, OR		04-19-90	--	--	--	--	--	--
			08-22-90	74	4	--	--	4	<.1
			10-19-90	11	<3	--	--	5	<.1
L	D Drain, OR		04-20-90	--	--	--	--	--	--
			08-23-90	69	12	--	--	2	<.1
			10-18-90	68	<3	--	--	2	<.1
M	Malheur River near Ontario, OR		04-16-90	50	<3	50	30	2	<.1
			08-03-90	69	6	30	46	2	<.1
		1/	08-03-90	70	4	--	--	3	<.1
			08-23-90	64	9	--	--	2	<.1
			10-15-90	51	6	10	66	2	<.1
P	Payette River near Payette, ID		04-18-90	6	12	--	--	<1	<.1
			08-02-90	17	4	--	--	<1	<.1
			10-17-90	7	8	--	--	<1	<.1
Q	Snake River at Weiser, ID		04-19-90	10	4	--	--	<1	<.1
			08-02-90	14	<3	--	--	<1	<.1
			10-17-90	12	<3	--	--	<1	<.1
R	Sand Hollow Cr inflow, ID		04-18-90	--	--	--	--	--	--
			07-06-90	15	8	--	--	<1	<.1
			10-17-90	16	5	--	--	<1	<.1
S	Sand Hollow Cr outflow, ID		04-18-90	--	--	--	--	--	--
			07-06-90	9	5	--	--	<1	<.1
			10-18-90	12	4	--	--	<1	<.1

1/ Quality-assurance split sample.

Table 21. Concentrations of elements in bottom sediment (less than 63-micrometer-size fraction), Owyhee and Vale project areas, and Snake River system, July and August 1990

[R = River; ID = Idaho; nr = near; blw = below; OR = Oregon; Res = Reservoir; Al = Aluminum; Ca = Calcium; Fe = Iron; K = Potassium; Mg = Magnesium; Na = Sodium; P = Phosphorus; Ti =Titanium; Mn = Manganese; Ag = Silver; As = Arsenic; Au = Gold; B = Boron; Ba = Barium; Be = Beryllium; Bi = Bismuth; Cd = Cadmium; Ce = Cerium; Co = Cobalt; Cr = Chromium; Cu = Copper; Eu = Europium; Ga = Gallium; Hg = Mercury; Ho = Holmium; La = Lanthanum; Li = Lithium; Mo = Molybdenum; Nb = Niobium; Nd = Neodymium; Ni = Nickel; Pb = Lead; Sc = Scandium; Se = Selenium; Sn = Tin; Sr = Strontium; Ta = Tantalum; Th = Thorium; U = Uranium; V = Vanadium; Y = Yttrium; Yb = Ytterbium; Zn = Zinc; %-Wt = percent by weight; μg/g = micrograms per gram; -- = not analyzed; * = insufficient sample; < = less than]

Figure 2 and 3 identifications	Station name	Date	Al	Ca	Fe	K	Mg	Na	P	Ti	Mn	Ag	As	Au	B	Ba	Be	Bi	Cd	Ce	Co	Cr
			(%-Wt)								(μg/g)											
N	Snake R at Marsing, ID	07-31-90	4.60	9.85	2.03	1.43	1.31	0.94	0.11	0.28	378	<2	2.6	<8	1	606	1	<10	<2	52	8	61
E	Succor Creek nr Homedale, ID	08-01-90	6.41	3.64	3.47	1.70	1.47	1.29	.10	.45	577	<2	7.4	<8	.7	650	2	<10	<2	60	15	87
A	Owyhee R blw Owyhee Lake, OR	08-03-90	7.08	3.00	4.45	1.41	1.60	1.47	.14	.64	655	<2	4.2	<8	2	749	2	<10	<2	51	19	114
B	Overstreet Drain, OR	08-03-90	6.14	3.62	3.41	1.72	1.47	1.29	.06	.44	690	<2	4.3	<8	.9	659	2	<10	<2	71	15	107
C	Owyhee R at Owyhee, OR	08-01-90	6.78	3.51	3.37	1.73	1.26	1.12	.10	.40	608	<2	8.6	<8	2	673	2	<10	<2	56	13	65
O	Boise R nr Parma, ID	08-01-90	6.93	2.16	2.39	1.98	.81	1.82	.09	.32	1,150	<2	4.5	<8	.7	924	2	<10	<2	64	10	60
F	Malheur R blw Warmsprings,OR	08-21-90	8.15	2.58	4.09	1.10	1.09	1.48	.08	.57	958	<2	79.	<8	2	803	2	<10	<2	56	19	84
G	N Fk Malheur R at Beulah, OR	08-21-90	7.97	2.69	4.29	.97	1.01	1.60	.10	.55	857	<2	10.	<8	2	626	1	<10	<2	42	22	90
H	Bully Creek blw Bully Creek Res, OR	08-22-90	7.18	1.92	3.74	1.62	.85	1.48	.08	.44	677	<2	5.0	<8	2	632	2	<10	<2	48	15	47
I	Bully Creek nr Vale, OR	08-22-90	7.90	2.26	4.24	1.45	.91	1.50	.08	.59	1,630	<2	10.	<8	1	685	2	<10	<2	57	16	61
J	Malheur R nr Vale, OR	08-22-90	7.31	2.71	4.04	1.60	1.09	1.20	.10	.45	748	<2	11.	<8	2	672	2	<10	<2	54	16	54
K	Willow Creek at Vale, OR	08-22-90	7.35	3.77	3.90	1.50	1.18	1.57	.10	.53	898	<2	10.	<8	3	661	2	<10	<2	49	19	69
L	D Drain, OR	08-23-90	7.57	2.62	3.97	1.60	1.08	1.75	.09	.52	640	<2	6.4	<8	3	658	2	<10	<2	49	19	66
M	Malheur R nr Ontario, OR	08-03-90	7.12	3.29	3.53	1.64	1.15	1.44	.10	.48	641	<2	6.1	<8	2	687	2	<10	<2	48	16	74
	1/	08-03-90	7.14	3.34	3.51	1.64	1.15	1.46	.10	.47	632	<2	6.1	<8	3	694	2	<10	<2	49	15	73
P	Payette R nr Payette, ID	08-02-90	7.11	2.30	2.96	1.78	.89	1.76	.10	.48	480	<2	3.0	<8	.5	811	2	<10	<2	70	12	62
Q	Snake R at Weiser, ID	08-02-90	5.48	9.81	2.41	1.44	1.14	1.16	.09	.34	441	<2	2.9	<8	.9	692	1	<10	<2	54	10	64
R	Sand Hollow Creek inflow, ID	07-06-90	7.24	2.58	2.45	2.10	.79	2.33	.09	.38	3,080	<5	*	<20	*	1,110	<3	<30	<5	150	15	84
S	Sand Hollow Creek outflow, ID	07-06-90	7.28	3.29	2.95	2.13	.95	1.96	.12	.36	3,280	<2	11.	<8	*	1,110	2	<10	<2	85	12	86

1/ Quality-assurance split sample.

Table 21. Concentrations of elements in bottom sediment (less than 63-micrometer-size fraction), Owyhee and Vale project areas, and Snake River system, July and August 1990—Continued

Figure 2 and 3 identifications	Station name	Date	Cu	Eu	Ga	Hg	Ho	La	Li	Mo	Nb	Nd	Ni	Pb	Sc	Se	Sn	Sr	Ta	Th	U	V	Y	Yb	Zn
			Elements (μg/g)																						
N	Snake R at Marsing, ID	07-31-90	16	<2	10	0.02	<4	32	22	<2	<4	26	14	10	6	0.6	<10	334	<40	9.6	2.82	52	16	2	53
E	Succor Creek nr Homedale, ID	08-01-90	25	<2	15	.02	<4	36	28	<2	6	31	29	11	11	.4	<10	262	<40	7.3	2.86	88	23	3	73
A	Owyhee R blw Owyhee Lake, OR	08-03-90	34	<2	17	.12	<4	32	28	<2	8	28	38	16	15	.4	<10	319	<40	8.8	3.32	131	24	3	82
B	Overstreet Drain, OR	08-03-90	18	<2	14	.02	<4	41	26	<2	<4	35	26	12	10	.2	<10	250	<40	10.9	3.55	97	23	3	68
C	Owyhee R at Owyhee, OR	08-01-90	25	<2	15	.04	<4	34	35	<2	8	30	27	12	11	.5	<10	238	<40	9.6	2.75	75	25	3	82
O	Boise R nr Parma, ID	08-01-90	16	<2	16	.04	<4	39	26	<2	11	29	16	19	7	.4	<10	330	<40	13.4	4.77	56	18	2	80
F	Malheur R blw Warmsprings, OR	08-21-90	36	<2	18	.06	<4	29	23	<2	14	28	32	59	15	.2	<10	338	<40	5.0	1.81	113	29	3	79
G	N Fk Malheur R at Beulah, OR	08-21-90	39	<2	17	.02	<4	23	20	<2	9	24	41	15	16	.5	<10	320	<40	4.7	1.72	123	28	3	110
H	Bully Creek blw Bully Creek Res, OR	08-22-90	33	<2	16	.02	<4	27	26	<2	10	26	22	13	13	.2	<10	256	<40	6.0	2.17	89	28	3	88
I	Bully Creek nr Vale, OR	08-22-90	29	<2	19	<.02	<4	32	31	<2	13	30	22	16	14	.2	<10	304	<40	5.1	2.33	111	29	3	88
J	Malheur R nr Vale, OR	08-22-90	32	<2	17	.02	<4	29	32	<2	12	28	27	14	14	.4	<10	266	<40	7.0	1.95	98	30	3	90
K	Willow Creek at Vale, OR	08-22-90	32	<2	17	.02	<4	28	32	<2	10	26	32	14	14	.6	<10	364	<40	6.4	2.10	115	26	3	96
L	D Drain, OR	08-23-90	36	<2	17	<.02	<4	27	27	<2	9	27	29	12	14	.4	<10	314	<40	6.5	1.99	109	28	3	87
M	Malheur R nr Ontario, OR	08-03-90	28	<2	16	.04	<4	30	29	<2	9	29	30	12	12	.4	<10	287	<40	7.6	2.29	93	25	3	84
	1/	08-03-90	27	<2	16	.02	<4	31	30	<2	7	28	28	14	12	.4	<10	291	<40	8.0	2.06	92	24	3	85
P	Payette R nr Payette, ID	08-02-90	20	<2	16	.02	<4	43	25	<2	13	33	19	16	9	.2	<10	327	<40	13.2	3.87	79	20	2	74
Q	Snake R at Weiser, ID	08-02-90	16	<2	12	.02	<4	33	24	<2	5	28	18	13	8	.5	<10	377	<40	9.1	3.05	63	18	2	60
R	Sand Hollow Creek inflow, ID	07-06-90	24	<5	20	.76	<10	88	20	<5	30	60	26	470	7	*	680	398	<100	--	--	61	22	<3	65
S	Sand Hollow Creek outflow, ID	07-06-90	16	<2	20	.08	<4	48	36	<2	24	36	25	27	8	.5	<10	402	<40	--	--	54	23	2	112

1/ Quality-assurance split sample.

Table 22. Concentrations of elements in bottom sediment (less than 2-millimeter-size fraction), Owyhee and Vale project areas, and Snake River system, July and August 1990

[R = River; ID = Idaho; nr = near; blw = below; OR = Oregon; Res = Reservoir; Al = Aluminum; Ca = Calcium; Fe = Iron; K = Potassium; Mg = Magnesium; Na = Sodium; P = Phosphorus; Ti = Titanium; Mn = Manganese; Ag = Silver; As = Arsenic; Au = Gold; B = Boron; Ba = Barium; Be = Beryllium; Bi = Bismuth; Cd = Cadmium; Ce = Cerium; Co = Cobalt; Cr = Chromium; Cu = copper; Eu = europium; Ga = Gallium; Hg = Mercury; Ho = Holmium; La = Lanthanum; Li = Lithium; Mo = Molybdenum; Nb = Niobium; Nd = Neodymium; Ni = Nickel; Pb = Lead; Sc = Scandium; Se = Selenium; Sn = Tin; Sr = Strontium; Ta = Tantalum; Th = Thorium; U = Uranium; V = Vanadium; Y= Yttrium; Yb = Ytterbium; Zn = Zinc; %-Wt = percent by weight; μg/g = micrograms per gram; < = less than]

Figure 2 and 3 identifications	Station name	Date	Al (%-Wt)	Ca (%-Wt)	Fe (%-Wt)	K (%-Wt)	Mg (%-Wt)	Na (%-Wt)	P (%-Wt)	Ti (%-Wt)	Mn (μg/g)	Ag (μg/g)	As (μg/g)	Au (μg/g)	B (μg/g)	Ba (μg/g)	Be (μg/g)	Bi (μg/g)	Cd (μg/g)	Ce (μg/g)	Co (μg/g)	Cr (μg/g)
N	Snake R at Marsing, ID	07-31-90	4.81	5.87	1.91	1.65	1.01	1.21	0.10	0.26	376	<2	2.9	<8	0.7	719	1	<10	<2	56	11	61
E	Succor Creek nr Homedale, ID	08-01-90	6.54	3.17	2.95	2.04	1.14	1.54	.08	.35	532	<2	6.9	<8	.5	958	2	<10	<2	55	14	63
	1/	08-01-90	6.52	3.16	2.95	1.99	1.16	1.52	.08	.34	508	<2	6.8	<8	.7	935	2	<10	<2	55	14	65
A	Owyhee R blw Owyhee Lake, OR	08-03-90	7.49	3.48	4.15	1.87	1.56	1.98	.15	.59	653	<2	3.9	<8	.8	999	2	<10	<2	48	19	99
B	Overstreet Drain, OR	08-03-90	6.40	2.78	2.35	2.34	.88	1.57	.07	.29	645	<2	5.9	<8	.8	1,130	2	<10	<2	76	13	55
C	Owyhee R at Owyhee, OR	08-01-90	7.19	3.48	3.28	1.95	1.19	1.45	.10	.43	597	<2	7.5	<8	1	856	2	<10	<2	58	15	70
O	Boise R nr Parma, ID	08-01-90	6.39	.86	.48	2.59	.13	2.37	.02	.06	257	<2	1.0	<8	.2	1,410	1	<10	<2	36	3	8
F	Malheur R blw Warmsprings, OR	08-21-90	8.26	3.19	3.91	1.24	1.16	1.70	.08	.58	928	<2	23	<8	2	947	2	<10	<2	50	20	91
G	N Fk Malheur R at Beulah, OR	08-21-90	8.65	3.28	4.39	1.15	1.15	1.90	.10	.55	955	<2	4.4	<8	1	701	1	<10	<2	41	24	99
H	Bully Creek blw Bully Creek Res, OR	08-22-90	7.21	1.92	3.73	1.65	.84	1.47	.08	.43	700	33	6.5	<8	2	647	2	<10	<2	50	15	45
I	Bully Creek nr Vale, OR	08-22-90	7.88	2.32	3.81	1.74	.81	1.83	.08	.50	1840	<2	10	<8	1	773	2	<10	<2	58	18	47
J	Malheur R nr Vale, OR	08-22-90	7.20	2.88	3.96	1.58	1.09	1.31	.10	.46	727	<2	10	<8	3	702	2	<10	<2	51	17	57
	1/	08-22-90	7.21	2.86	3.95	1.58	1.09	1.30	.10	.46	718	<2	9.2	<8	2	703	2	<10	<2	50	17	58
K	Willow Creek at Vale, OR	08-22-90	7.57	3.93	3.79	1.49	1.50	1.96	.09	.48	879	<2	11	<8	2	754	1	<10	<2	43	20	129
L	D Drain, OR	08-23-90	7.77	2.95	3.76	1.75	1.08	1.95	.09	.49	626	<2	6.4	<8	4	781	2	<10	<2	50	18	62
M	Malheur R nr Ontario, OR	08-03-90	7.38	3.18	3.64	1.85	1.04	1.93	.10	.47	594	<2	5.2	<8	2	988	2	<10	<2	49	16	67
	1/	08-03-90	7.38	3.15	3.67	1.89	1.03	1.98	.09	.46	585	<2	6.3	<8	1	1,020	2	<10	<2	50	16	66
P	Payette R nr Payette, ID	08-02-90	7.64	2.29	2.48	1.95	.63	2.24	.08	.41	480	<2	2.3	<8	.5	1,000	2	<10	<2	67	11	37
Q	Snake R at Weiser, ID	08-02-90	6.42	4.30	2.01	2.06	.73	1.92	.07	.30	411	<2	2.6	<8	.4	1,100	2	<10	<2	49	10	48
R	Sand Hollow Creek inflow, ID	07-06-90	5.70	.76	.24	2.57	.05	2.02	.01	.03	420	<2	1.2	<8	<.2	1,570	1	<10	<2	18	3	2
S	Sand Hollow Creek outflow, ID	07-06-90	6.33	1.11	1.06	2.52	.36	2.38	.03	.17	412	<2	1.5	<8	.2	1,240	2	<10	<2	58	5	23

1/ Quality-assurance split sample.

Table 22. Concentrations of elements in bottom sediment (less than 2-millimeter-size fraction), Owyhee and Vale project areas, and Snake River system, July and August 1990—Continued

Figure 2 and 3 identifications	Station name	Date	Cu	Eu	Ga	Hg	Ho	La	Li	Mo	Nb	Nd	Ni	Pb	Sc	Se	Sn	Sr	Ta	Th	U	V	Y	Yb	Zn
			Elements (μg/g)																						
N	Snake R at Marsing, ID	07-31-90	11	<2	11	0.02	<4	34	18	<2	6	27	13	11	6	0.4	<10	286	<40	7.2	2.43	50	17	2	47
E	Succor Creek nr Homedale, ID	08-01-90	16	2	15	.02	<4	34	23	<2	5	29	23	12	9	.2	<10	297	<40	6.8	2.19	76	24	3	61
		1/ 08-01-90	17	2	15	.02	<4	34	24	<2	<4	28	24	13	9	.3	<10	294	<40	5.4	2.30	76	23	3	61
A	Owyhee R blw Owyhee Lake, OR	08-03-90	26	2	16	.02	<4	32	22	<2	11	29	38	12	17	.2	<10	354	<40	5.3	2.34	129	25	3	68
B	Overstreet Drain, OR	08-03-90	13	2	15	<.02	<4	45	23	<2	<4	36	17	14	7	.1	<10	274	<40	11.7	2.62	64	28	3	53
C	Owyhee R at Owyhee, OR	08-01-90	21	2	16	.02	<4	36	32	<2	9	32	29	14	11	.4	<10	286	<40	9.1	2.61	81	27	3	77
O	Boise R nr Parma, ID	08-01-90	3	<2	12	<.02	<4	22	11	<2	5	14	2	14	<2	<.1	<10	391	<40	6.3	1.39	9	6	<1	19
F	Malheur R blw Warmsprings, OR	08-21-90	26	<2	17	.02	<4	29	21	<2	12	28	29	21	16	.5	<10	364	<40	3.1	1.68	116	29	3	72
G	N Fk Malheur R at Beulah, OR	08-21-90	34	<2	18	.02	<4	23	20	<2	7	24	36	22	17	.4	<10	359	<40	3.7	1.69	133	27	3	110
H	Bully Creek blw Bully Creek Res, OR	08-22-90	33	<2	16	.04	<4	28	26	<2	9	27	20	11	13	.2	<10	252	<40	5.7	2.30	86	30	3	88
I	Bully Creek nr Vale, OR	08-22-90	23	2	19	<.02	<4	33	26	<2	12	32	19	16	13	.2	<10	310	<40	6.7	2.19	99	37	4	86
J	Malheur R nr Vale, OR	08-22-90	29	<2	16	.04	<4	29	28	<2	11	28	22	14	15	.3	<10	273	<40	5.3	2.15	105	31	4	86
		1/ 08-22-90	30	<2	16	.02	<4	29	28	<2	11	28	25	13	15	.3	<10	273	<40	7.0	2.02	104	31	4	86
K	Willow Creek at Vale, OR	08-22-90	26	<2	17	.04	<4	24	23	<2	6	24	54	10	14	.5	<10	407	<40	5.9	1.76	132	26	3	92
L	D Drain, OR	08-23-90	32	<2	17	.02	<4	28	24	<2	11	28	25	13	14	.3	<10	344	<40	6.5	1.89	109	33	4	83
M	Malheur R nr Ontario, OR	08-03-90	22	2	18	.04	<4	33	21	<2	8	31	23	12	14	.2	<10	319	<40	5.7	2.05	102	33	4	82
		1/ 08-03-90	21	2	17	.02	<4	32	20	<2	7	31	23	11	13	.2	<10	322	<40	6.4	2.08	102	33	4	82
P	Payette R nr Payette, ID	08-02-90	15	<2	17	<.02	<4	40	21	<2	16	31	14	17	8	.1	<10	428	<40	10.9	3.09	66	17	2	63
Q	Snake R at Weiser, ID	08-02-90	11	<2	14	<.02	<4	31	17	<2	8	23	14	12	7	.2	<10	384	<40	7.0	2.18	55	17	2	47
R	Sand Hollow Creek inflow, ID	07-06-90	2	<2	10	<.02	<4	12	8	<2	4	8	5	13	<2	<.1	<10	394	<40	3.6	.67	5	4	<1	8
S	Sand Hollow Creek outflow, ID	07-06-90	3	<2	13	<.02	<4	36	12	<2	16	22	9	13	3	<.1	<10	363	<40	6.7	1.97	23	11	1	24

1/ Quality-assurance split sample.

Table 23. Concentrations of trace elements in aquatic plants collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990

[Concentrations in micrograms per gram, dry weight; wet weight = dry weight x (1 - percent moisture content expressed as a decimal); where all values all values are less than (<), no mean is reported; for individual less-than values, one-half of the value was used to calculate the mean; -- = not determined; * = not analyzed; Ag. = agriculture; Fk = Fork; Ft = Fort, WMA = Wildlife Management Area]

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements							
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium
Algae	Snake River above study area	70.4	3,050	*	6.2	165	0.20	69.0	0.17	7.60
Algae	Snake River at Weiser	84.1	7,710	<10.0	12.3	132	.25	52.5	.17	7.78
Geometric Mean			**4,850**	--	**8.73**	**148**	**.23**	**60.2**	**.17**	**7.69**
Sago Pondweed	Snake River above study area	83.7	1,100	*	2.60	92.1	.11	377	.34	3.20
Sago Pondweed	Snake River at Weiser	87.0	4,830	<10.0	3.06	84.9	<.10	185	.32	5.80
Geometric Mean			**2,300**	--	**2.82**	**88.4**	--	**264**	**.33**	**4.31**
Algae	Jump Creek	83.5	4,240	<10.0	29.3	116	.14	127	.21	6.39
Algae	Owyhee River below Owyhee Lake	89.0	5,420	<10.0	18.2	64.3	.19	133	.23	8.89
Algae	Owyhee River in Ag. Land	87.2	9,540	<10.0	18.6	100	.35	102	.38	8.85
Algae	Owyhee River in Ag. Land	87.6	12,000	*	12.3	137	.59	24	.41	12.0
Geometric Mean			**7,160**	--	**18.7**	**100**	**.27**	**80.2**	**.29**	**8.81**
Sago Pondweed	Jump Creek	87.8	3,450	<10.0	19.2	62.4	<.10	249	.57	5.13
Sago Pondweed	Owyhee River below Owyhee Lake	91.3	1,380	<10.0	3.02	30.1	<.10	22.4	<.15	2.93
Sago Pondweed	Owyhee River in Ag. Land	85.3	8,920	<10.0	21	133	.40	26.7	.49	10.3
Sago Pondweed	Owyhee River in Ag. Land	88.0	8,270	*	7.30	107	.43	200	.42	7.90
Geometric Mean			**4,330**	--	**9.71**	**71.9**	**.14**	**73.9**	**.31**	**5.91**
Algae	Middle Fk Malheur River below Warm Springs Reservoir	86.1	2,780	<10.0	9.30	74.7	<.10	249	.53	6.44
Algae	North Fk Malheur River below Beulah Reservoir	87.7	25,200	<10.0	7.71	350	.58	50.4	.94	24.2
Algae	Bully Creek below Bully Creek Dam	89.5	6,650	*	9.60	109	.35	92.0	.39	5.9
Algae	Malheur River in Ag. Land	81.4	15,200	<10.0	19.8	1,330	.74	45.5	.45	20.4
Algae	Malheur River in Ag. Land	83.5	8,180	*	16.6	138	.40	100	.41	10.0
Geometric Mean			**8,960**	--	**11.8**	**221**	**.31**	**87.9**	**.51**	**11.3**

Table 23. Concentrations of trace elements in aquatic plants collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements: Alu-minum	Anti-mony	Arsenic	Barium	Beryl-lium	Boron	Cad-mium	Chro-mium
Sago Pondweed	Middle Fk Malheur River below Warm Springs Reservoir	87.4	2,480	<10.0	3.75	301	<0.10	184	1.06	4.42
Sago Pondweed	Malheur River in Ag. Land	88.5	3,310	<10.0	4.82	65.4	<.10	402	1.12	4.35
Sago Pondweed	Malheur River in Ag. Land	87.7	6,440	*	5.60	81.4	.30	288	.53	8.80
Geometric Mean			**3,750**	--	**4.66**	**117**	--	**277**	**.86**	**5.53**
Horned Pondweed	North Fk Malheur River below Beulah Reservoir	91.9	888	<10.0	2.77	104	<.10	13.4	3.03	3.96
Horned Pondweed	Bully Creek below Bully Creek Dam	89.7	4,250	*	6.10	302	.24	16.0	.40	5.60
Horned Pondweed	Middle Fk Malher River below Warm Springs Reservoir	90.8	1,220	<10.0	1.87	251	<.10	126	1.98	4.56
Geometric Mean			**1,660**	--	**3.16**	**199**	--	**30.0**	**1.34**	**4.66**
Algae	Payette River	92.4	6,250	*	7.20	123	.32	26.0	.30	6.70
Sago Pondweed	Payette River	92.5	738	*	1.50	84.4	.04	150	.26	.49
Algae	Boise River	94.1	10,000	*	4.80	137	.51	13.0	.36	10.0
Sago Pondweed	Boise River	90.5	1,300	*	1.90	60.1	.09	219	.37	2.60
Algae	Ft. Boise WMA	83.1	4,930	*	6.60	136	.28	180	.31	5.00
Sago Pondweed	Ft. Boise WMA	87.8	540	*	5.90	93.5	.07	295	.15	1.90
Algae	Lake Lowell	82.2	4,430	*	13.8	106	.22	163	.29	7.68
Sago Pondweed	Lake Lowell	83.5	1,670	*	4.04	104	.11	121	.12	2.15

Table 23. Concentrations of trace elements in aquatic plants collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements: Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel
Algae	Snake River above study area	70.4	*	6.58	3,660	3.80	6,820	365	0.01	<1.00	6.70
Algae	Snake River at Weiser	84.1	4.97	7.55	5,120	6.82	5,140	1,410	<.10	<.80	4.77
Geometric Mean			--	**7.05**	**4,330**	**5.09**	**5,920**	**717**	--	--	**5.65**
Sago Pondweed	Snake River above study area	83.7	*	7.22	2,060	<1.00	5,280	248	.02	1.00	20.0
Sago Pondweed	Snake River at Weiser	87.0	3.07	7.71	3,190	6.08	3,980	239	<.10	.97	3.30
Geometric Mean			--	**7.46**	**2,560**	--	**4,580**	**243**	--	**.99**	**8.12**
Algae	Jump Creek	83.5	3.48	6.98	3,220	4.76	3,630	559	<.10	<.80	4.20
Algae	Owyhee River below Owyhee Lake	89.0	3.63	5.62	4,490	4.04	2,800	162	<.10	1.86	5.39
Algae	Owyhee River in Ag. Land	87.2	6.48	7.22	7,420	6.55	5,740	390	<.10	1.29	7.17
Algae	Owyhee River in Ag. Land	87.6	*	16.7	11,800	8.30	9,480	774	.03	<1.00	12.0
Geometric Mean			**4.34**	**8.29**	**5,960**	**5.69**	**4,850**	**407**	--	**.83**	**6.64**
Sago Pondweed	Jump Creek	87.8	12.1	14.0	2,460	3.91	4,970	962	<.10	3.31	5.06
Sago Pondweed	Owyhee River below Owyhee Lake	91.3	1.15	8.53	1,310	<3.00	1,280	169	<.10	1.19	3.91
Sago Pondweed	Owyhee River in Ag. Land	85.3	7.33	9.09	8,850	10.1	3,480	1,550	<.10	4.08	7.08
Sago Pondweed	Owyhee River in Ag. Land	88.0	*	15.6	8,700	6.20	6,490	898	.02	<1.00	11.0
Geometric Mean			**4.67**	**11.4**	**3,970**	**4.38**	**3,460**	**690**	--	**1.68**	**6.27**
Algae	Middle Fk Malheur River below Warm Springs Reservoir	86.1	5.02	12.8	2,220	3.19	3,590	1,970	<.10	1.81	5.50
Algae	North Fk Malheur River below Beulah Reservoir	87.7	23.5	20.2	18,000	13.0	4,320	3,110	<.10	3.90	18.4
Algae	Bully Creek below Bully Creek Dam	89.5	*	13.0	7,860	5.40	3,070	15,100	.07	1.00	8.60
Algae	Malheur River in Ag. Land	81.4	14.1	17.2	12,400	14.6	3,760	970	<.10	<.80	13.9
Algae	Malheur River in Ag. Land	83.5	*	13.7	8,230	5.20	6,350	1,480	.02	<1.00	9.60
Geometric Mean			**11.8**	**15.1**	**7,960**	**7.02**	**4,080**	**2,660**	**.04**	**1.07**	**10.3**

Table 23. Concentrations of trace elements in aquatic plants collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements								
			Cobalt	Copper	Iron	Lead	Magne-sium	Manga-nese	Mercury	Molyb-denum	Nickel
Sago Pondweed	Middle Fk Malheur River below Warm Springs Reservoir	87.4	17.6	13.7	1,830	3.48	2,870	7,500	<0.10	<0.80	13.4
Sago Pondweed	Malheur River in Ag. Land	88.5	11.9	12.9	2,080	<3.00	4,360	624	<.10	1.06	7.29
Sago Pondweed	Malheur River in Ag. Land	87.7	*	16.2	6,080	4.20	5,860	1,070	.01	2.00	11.0
Geometric Mean			**14.5**	**14.2**	**2,850**	**2.80**	**4,190**	**1,710**	--	**.95**	**10.2**
Horned Pondweed	North Fk Malheur River below Beulah Reservoir	91.9	14.3	9.68	2,020	<3.00	883	2,900	<.10	.88	4.24
Horned Pondweed	Bully Creek below Bully Creek Dam	89.7	*	20.2	6,220	3.00	2,620	6,040	.04	1.00	6.60
Horned Pondweed	Middle Fk Malheur River below Warm Springs Reservoir	90.8	16.4	21.9	1,740	3.23	2,100	7,470	<.10	<.80	10.8
Geometric Mean			**15.3**	**16.2**	**2,800**	**2.44**	**1,690**	**5,080**	--	**.71**	**6.71**
Algae	Payette River	92.4	*	17.7	6,360	5.10	3,720	1,790	.02	1.00	5.60
Sago Pondweed	Payette River	92.5	*	10.8	1,070	1.60	4,140	893	.02	2.00	2.20
Algae	Boise River	94.1	*	16.40	9,880	8.30	5,170	1,870	.05	<1.00	8.70
Sago Pondweed	Boise River	90.5	*	10.90	1,280	1.70	4,420	909	.02	<1.00	3.90
Algae	Ft. Boise WMA	83.1	*	9.03	4,600	5.70	6,760	1,720	.04	<1.00	6.20
Sago Pondweed	Ft. Boise WMA	87.8	*	4.90	854	1.00	4,430	2,060	.03	1.00	2.70
Algae	Lake Lowell	82.2	*	9.09	4,460	5.94	3,780	375	<.25	<.50	7.17
Sago Pondweed	Lake Lowell	83.5	*	4.06	1,650	3.22	2,600	259	<.25	<.50	1.80

Table 23. Concentrations of trace elements in aquatic plants collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements						
			Sele-nium	Silver	Stron-tium	Thal-lium	Tin	Vana-dium	Zinc
Algae	Snake River above study area	70.4	0.95	<2.0	397	<0.50	*	12.0	15.5
Algae	Snake River at Weiser	84.1	1.42	<3.0	196	*	<6.0	16.5	23.8
Geometric Mean			**1.16**	--	**279**	--	--	**14.1**	**19.2**
Sago Pondweed	Snake River above study area	83.7	1.20	<2.0	266	2.20	*	7.4	17.2
Sago Pondweed	Snake River at Weiser	87.0	<.60	<3.0	95.2	*	6.3	13.7	21.6
Geometric Mean			--	--	**159**	--	--	**10.1**	**19.3**
Algae	Jump Creek	83.5	1.32	<3.0	177	*	<6.0	16.1	12.5
Algae	Owyhee River below Owyhee Lake	89.0	2.21	<3.0	40.8	*	<6.0 <6.0	11.8	15.6
Algae	Owyhee River in Ag. Land	87.2	1.30	<3.0	98.2	*	<6.0	19.8	23.2
Algae	Owyhee River in Ag. Land	87.6	.81	<2.0	183	<.60	*	24.0	38.6
Geometric Mean			**1.32**	--	**107**	--	--	**17.3**	**20.4**
Sago Pondweed	Jump Creek	87.8	.98	<3.0	82.3	*	<6.0	15.8	23.0
Sago Pondweed	Owyhee River below Owyhee Lake	91.3	1.19	<3.0	31.1	*	<6.0	5.7	17.9
Sago Pondweed	Owyhee River in Ag. Land	85.3	1.10	<3.0	75.0	*	<6.0	27.8	35.4
Sago Pondweed	Owyhee River in Ag. Land	88.0	.77	<2.0	132.0	<.60	*	17.0	34.7
Geometric Mean			**1.00**	--	**70.9**	--	--	**14.4**	**26.7**
Algae	Middle Fk Malheur River below Warm Springs Reservoir	86.1	.66	<3.0	71.2	*	<6.0	11.3	13.1
Algae	North Fk Malheur River below Beulah Reservoir	87.7	.84	<3.0	118	*	<6.0	51.2	51.2
Algae	Bully Creek below Bully Creek Dam	89.5	1.20	<2.0	93.7	1.00	*	30.0	29.2
Algae	Malheur River in Ag. Land	81.4	1.29	<3.0	219	*	<6.0	49.7	55.2
Algae	Malheur River in Ag. Land	83.5	1.40	<2.0	313	<.60	*	33.0	31.4
Geometric Mean			**1.04**	--	**140**	--	--	**31.0**	**32.1**

Table 23. Concentrations of trace elements in aquatic plants collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements						
			Selenium	Silver	Strontium	Thallium	Tin	Vanadium	Zinc
Sago Pondweed	Middle Fk Malheur River below Warm Springs Reservoir	87.4	<0.60	<3.0	70.9	*	<6.0	15.6	16.1
Sago Pondweed	Malheur River in Ag. Land	88.5	.72	<3.0	92.5	*	<6.0	18.8	22.5
Sago Pondweed	Malheur River in Ag. Land	87.7	.69	<2.0	103	<0.6	*	26.0	24.1
Geometric Mean			**.53**	**--**	**87.7**	**--**	**--**	**19.7**	**20.6**
Horned Pondweed	North Fk Malheur River below Beulah Reservoir	91.9	<.60	<3.0	35.6	*	<6.0	11.7	32.7
Horned Pondweed	Bully Creek below Bully Creek Dam	89.7	.49	<2.0	84.4	<.6	*	26.0	25.8
Horned Pondweed	Middle Fk Malheur River below Warm Springs Reservoir	90.8	.70	<3.0	90.2	*	<6.0	15.1	21.6
Geometric Mean			**.47**	**--**	**64.7**	**--**	**--**	**16.6**	**26.3**
Algae	Payette River	92.4	.71	<2.0	130	<.5	*	13.0	25.3
Sago Pondweed	Payette River	92.5	.30	<2.0	93.8	<.4	*	6.8	23.4
Algae	Boise River	94.1	.47	<2.0	97.2	<.6	*	16.0	46.2
Sago Pondweed	Boise River	90.5	.43	<2.0	82.3	<.4	*	9.4	36.8
Algae	Ft. Boise WMA	83.1	.98	<2.0	241	<.6	*	14.0	20.4
Sago Pondweed	Ft. Boise WMA	87.8	.57	<2.0	174	<.5	*	7.5	17.7
Algae	Lake Lowell	82.2	<.70	*	234	*	*	13.1	40.0
Sago Pondweed	Lake Lowell	83.5	<.70	*	235	*	*	5.6	12.7

Table 24. Concentrations of trace elements in aquatic invertebrates collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990

[Concentrations in micrograms per gram, dry weight; wet weight = dry weight x (1 - percent moisture content expressed as a decimal); where all values are less than (<), no mean is reported; for individual less-than values, one-half of the value was used to calculate the mean; -- = not determined; * = not analyzed; Ag. = agriculture; Fk = Fork; Ft = Fort; WMA = Wildlife Management Area]

Taxon	Location (figures 2 and 3)	Percent moisture content	Trace elements: Alu-minum	Anti-mony	Arsenic	Barium	Beryl-lium	Boron	Cad-mium	Chro-mium	Cobalt
Corixidae	Snake River above study area	77.6	188	*	0.30	23.1	<0.01	<2.00	0.94	1.70	*
Corixidae	Snake River at Weiser	85.7	2,000	<10.0	.98	45.9	<.10	5.55	1.16	7.48	2.34
Geometric Mean			**613**	--	**.54**	**32.6**	--	--	**1.04**	**3.56**	--
Ephemeroptera	Snake River above study area	80.5	1920	*	.94	28.4	.07	6.00	.62	3.00	*
Odonata	Snake River above study area	82.1	790	*	.59	10.2	<.09	3.00	.30	1.00	*
Hemiptera	Snake River at Weiser	74.1	466	<10.0	1.20	8.0	<.10	2.93	1.26	2.41	<.80
Corixidae	Owyhee River in Ag. Land	77.1	771	<10.0	1.58	110	<.10	2.15	1.36	2.9	3.31
Corixidae	Owyhee River below Owyhee Lake	82.6	5,160	<10.0	4.17	273	<.10	8.30	<.15	10.1	4.97
Geometric Mean			**2,000**	--	**2.57**	**173**	--	**4.22**	**.32**	**5.42**	**4.06**
Ephemeroptera	Owyhee River below Owyhee Lake	85.8	7,960	<10.0	3.11	103	<.10	4.20	.68	10.9	7.76

Table 24. Concentrations of trace elements in aquatic invertebrates collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990—Continued

Taxon	Location (figures 2 and 3)	Percent moisture content	Trace elements: Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt
Odonata	Owyhee River in Ag. Land	86.2	4,320	<10.0	4.18	56.2	0.10	8.64	.36	5.26	2.86
Odonata	Jump Creek	85.1	5,420	<10.0	7.55	64.5	.14	10.5	.48	7.10	4.98
Geometric Mean			**4,840**	--	**5.62**	**60.2**	**.12**	**9.52**	**.42**	**6.11**	**3.77**
Corixidae	North Fk Malheur River below Beulah Reservoir	78.4	470	<10.0	<.60	13.4	<.10	1.95	2.29	3.07	1.38
Corixidae	Bully Creek below Bully Creek Dam	80.0	4,900	*	1.60	74.8	.23	6.40	.98	7.60	*
Corixidae	Malheur River in Ag. Land	84.1	2,530	<10.0	1.56	42.5	<.10	6.13	.42	8.05	2.21
Corixidae	Malheur River in Ag. Land	85.9	4,080	*	5.70	86.8	.19	14.0	.89	6.70	*
Geometric Mean			**2,210**	--	**1.44**	**43.9**	**.10**	**5.72**	**.96**	**5.96**	**1.75**
Odonata	Middle Fk Malheur River below Warm Springs Reservoir	84.9	1,830	<10.0	1.27	31.4	<.10	19.0	1.66	3.40	4.21
Odonata	Middle Fk Malheur River below Warm Springs Reservoir	83.8	5,830	<10.0	.77	51.2	<.10	11.2	2.13	12.4	9.64
Odonata	Bully Creek below Bully Creek Dam	84.4	972	*	.88	39.1	<.02	6.00	.77	1.30	*
Geometric Mean			**2,180**	--	**.95**	**39.8**	--	**10.8**	**1.40**	**3.80**	**6.37**
Hemiptera	Middle Fk Malheur River below Warm Springs Reservoir	78.2	312	<10.0	<.60	21.7	<.10	6.77	1.13	4.66	<.80
Corixidae	Payette River	82.2	824	*	.61	57.5	.03	2.00	.45	2.30	*
Corixidae	Boise River	91.3	498	*	.91	159	.01	3.00	.11	12.90	*
Corixidae	Ft. Boise WMA	86.2	566	*	.75	124	.02	3.00	.35	2.20	*
Odonata	Ft. Boise WMA	85.3	332	*	1.60	9.0	<.01	7.70	.24	.61	*
Corixidae	Lake Lowell	66.7	213	<10.0	.48	4.1	<.1	<1.00	<.15	2.02	<.8
Odonata	Lake Lowell	77.0	980	<10.0	1.41	8.8	<.1	4.83	<.15	2.62	<.8

Table 24. Concentrations of trace elements in aquatic invertebrates collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990—Continued

Taxon	Location (figures 2 and 3)	Percent moisture content	Trace elements								
			Copper	Iron	Lead	Magne-sium	Manga-nese	Mercury	Molyb-denum	Nickel	Sele-nium
Corixidae	Snake River above study area	77.6	14.3	286	1.60	1,180	27.6	0.05	<1.00	1.00	2.90
Corixidae	Snake River at Weiser	85.7	19.1	1,430	10.7	1,440	82.9	<.10	1.22	3.71	2.00
Geometric Mean			**16.5**	**639**	**4.13**	**1,300**	**47.8**	--	--	**1.93**	**2.41**
Ephemeroptera	Snake River above study area	80.5	11.9	1,710	2.00	1,900	54.8	.03	<1.00	1.50	4.40
Odonata	Snake River above study area	82.1	11.0	706	<4.00	1,140	29.0	.06	<.90	<2.00	2.70
Hemiptera	Snake River at Weiser	74.1	16.3	437	3.42	1,200	53.7	<.10	<.80	1.09	2.71
Corixidae	Owyhee River in Ag. Land	77.1	19.3	566	<3.00	1,180	68.4	<.10	<.80	1.56	1.66
Corixidae	Owyhee River below Owyhee Lake	82.6	18.7	5,170	<3.00	1,670	183.0	<.10	1.19	6.69	2.98
Geometric Mean			**19.0**	**1,710**	--	**1,400**	**112**	--	**.69**	**3.23**	**2.22**
Ephemeroptera	Owyhee River below Owyhee Lake	85.8	26.3	4,960	3.69	2,300	114	<.10	1.31	5.28	9.65
Odonata	Owyhee River in Ag. Land	86.2	21.4	2,880	<3.00	2,090	67.3	<.10	.85	2.92	3.47
Odonata	Jump Creek	85.1	16.1	3,390	4.99	1,940	354	<.10	<.80	3.23	3.23
Geometric Mean			**18.6**	**3,120**	--	**2,010**	**154**	--	--	**3.07**	**3.35**

Table 24. Concentrations of trace elements in aquatic invertebrates collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990—Continued

Taxon	Location (figures 2 and 3)	Percent moisture content	Trace elements: Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Selenium
Corixidae	North Fk Malheur River below Beulah Reservoir	78.4	20.3	441	<3.00	870	79.9	0.12	1.25	<0.80	1.22
Corixidae	Bully Creek below Bully Creek Dam	80.0	19.1	7,620	3.50	2,180	637	.36	<1.00	6.70	0.88
Corixidae	Malheur River in Ag. Land	84.1	30.9	1,770	4.77	1,620	83.9	<.10	1.04	4.17	1.84
Corixidae	Malheur River in Ag. Land	85.9	24.9	6,240	4.40	2,380	220	.05	<1.00	6.20	1.60
Geometric Mean			**23.4**	**2,470**	**3.24**	**1,640**	**175**	**.10**	**0.76**	**2.89**	**1.33**
Odonata	Middle Fk Malheur River below Warm Springs Reservoir	84.9	19.4	1,250	<3.00	1,450	654	.12	<.80	1.87	1.45
Odonata	Middle Fk Malheur River below Warm Springs Reservoir	83.8	21.3	3,360	<3.00	2,100	721	<.10	<.80	3.49	1.57
Odonata	Bully Creek below Bully Creek Dam	84.4	16.2	1,120	<0.70	1,210	745	.41	<1.00	1.10	1.40
Geometric Mean			**18.8**	**1,680**	**--**	**1,540**	**706**	**.14**	**--**	**1.93**	**1.47**
Hemiptera	Middle Fk Malheur River below Warm Springs Reservoir	78.2	39.2	290	<3.00	835	107	.34	1.23	.81	1.65
Corixidae	Payette River	82.2	26.4	926	3.90	1,080	108	.08	2.00	1.30	1.30
Corixidae	Boise River	91.3	14.3	752	5.60	1,180	118	.11	1.00	8.30	.86
Corixidae	Ft. Boise WMA	86.2	18.9	687	3.90	1,220	113	.14	<1.00	1.60	.95
Odonata	Ft. Boise WMA	85.3	14.5	327	.80	1,710	38.2	.16	<1.00	.30	1.30
Corixidae	Lake Lowell	66.7	21.3	177	<3.0	697	9.7	<.10	<.80	<.80	.84
Odonata	Lake Lowell	77.0	15.7	522	<3.0	993	21.9	<.10	<.80	<.80	1.02

Table 24. Concentrations of trace elements in aquatic invertebrates collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990—Continued

Taxon	Location (figures 2 and 3)	Percent moisture content	Trace elements				
			Silver	Strontium	Tin	Vanadium	Zinc
Corixidae	Snake River above study area	77.6	<2.0	15.3	*	0.70	140
Corixidae	Snake River at Weiser	85.7	<3.0	19.2	7.48	4.35	199
Geometric Mean			--	**17.1**	--	**1.74**	**167**
Ephemeroptera	Snake River above study area	80.5	<2.0	44.5	*	4.00	48.9
Odonata	Snake River above study area	82.1	<2.0	15.8	*	1.80	61.0
Hemiptera	Snake River at Weiser	74.1	<3.0	7.06	<6.0	1.43	175
Corixidae	Owyhee River in Ag. Land	77.1	<3.0	10.1	<6.0	1.68	140
Corixidae	Owyhee River below Owyhee Lake	82.6	<3.0	240	<6.0	12.70	83.4
Geometric Mean			--	**49.2**	--	**4.62**	**108**
Ephemeroptera	Owyhee River below Owyhee Lake	85.8	<3.0	46.3	<6.0	14.2	67.5
Odonata	Owyhee River in Ag. Land	86.2	<3.0	29.2	<6.0	7.59	84.5
Odonata	Jump Creek	85.1	<3.0	28.8	<6.0	11.9	90.3
Geometric Mean			--	**29.0**	--	**9.50**	**87.4**

Table 24. Concentrations of trace elements in aquatic invertebrates collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990—Continued

Taxon	Location (figures 2 and 3)	Percent moisture content	Trace elements: Silver	Strontium	Tin	Vanadium	Zinc
Corixidae	North Fk Malheur River below Beulah Reservoir	78.4	<3.0	6.22	<6.0	1.23	156
Corixidae	Bully Creek below Bully Creek Dam	80.0	<2.0	59.0	*	20.0	86.7
Corixidae	Malheur River in Ag. Land	84.1	<3.0	22.3	<6.0	4.98	173
Corixidae	Malheur River in Ag. Land	85.9	<2.0	37.4	*	16.0	156
Geometric Mean			--	**23.5**	--	**6.65**	**138**
Odonata	Middle Fk Malheur River below Warm Springs Reservoir	84.9	<3.0	14.7	<6.0	4.12	88.3
Odonata	Middle Fk Malheur River below Warm Springs Reservoir	83.8	<3.0	26.4	<6.0	13.0	83.1
Odonata	Bully Creek below Bully Creek Dam	84.4	<2.0	11.4	*	4.20	77.4
Geometric Mean			--	**16.4**	--	**6.08**	**82.8**
Hemiptera	Middle Fk Malheur River below Warm Springs Reservoir	78.2	<3.0	9.25	<6.0	1.28	128
Corixidae	Payette River	82.2	<2.0	16.7	*	2.20	128
Corixidae	Boise River	91.3	<2.0	18.5	*	2.20	129
Corixidae	Ft. Boise WMA	86.2	<2.0	17.8	*	1.40	162
Odonata	Ft. Boise WMA	85.3	<2.0	30.5	*	1.10	80.1
Corixidae	Lake Lowell	66.7	<3.0	5.43	<6.0	<.80	52.5
Odonata	Lake Lowell	77.0	<3.0	8.57	<6.0	2.39	67.9

Table 25. Concentrations of trace elements in composite samples of fish collected from the Owyhee and Vale project areas, and Snake River system, July-September 1990

[Concentrations in micrograms per gram, dry weight; wet weight = dry weight x (1 - percent moisture content expressed as a decimal; where all values are less than (<), no mean is reported; for individual less-than values, one-half of the value was used to calculate the mean; -- = not determined; * = not analyzed; Ag. = agriculture; Fk = Fork; Ft = Fort; WMA = Wildlife Management Area]

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements								
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt
Carp	Snake River above study area	59.9	34.8	*	1.20	1.60	<0.01	<2.00	0.35	0.86	*
Carp	Snake River-mouth of Jump Creek	72.8	11.0	*	1.10	3.30	.01	<2.00	.70	2.70	*
Carp	Snake River-mouth of Owyhee River	70.3	454	*	.50	8.10	.03	<2.00	.89	4.50	*
Carp	Snake River-mouth of Malheur River	75.3	930	*	1.00	17.7	.05	<2.00	.64	4.10	*
Carp	Snake River at Weiser	72.0	244	<5.0	.51	7.80	<.10	.54	<.10	1.80	<0.50
Carp	Snake River below study area (Brownlee Reservoir)	68.0	9.6	*	.62	2.00	<.01	<2.00	.29	1.20	*
Geometric Mean			**85.1**		**.77**	**4.77**	**.02**	**--**	**.36**	**2.13**	**--**
Channel Catfish	Snake River above study area	73.9	185	*	<.20	5.20	.02	<2.00	.08	2.90	*
Channel Catfish	Snake River-mouth of Jump Creek	75.0	128	*	.20	3.20	.01	<2.00	.07	1.70	*
Channel Catfish	Snake River-mouth of Owyhee River	77.7	178	*	<.20	4.00	<.01	<2.00	.29	9.60	*
Channel Catfish	Snake River-mouth of Malheur River	76.7	161	*	<.20	2.90	.01	<2.00	.17	9.70	*
Channel Catfish	Snake River at Weiser	69.9	24.6	<5.0	<.30	2.01	<.10	<.50	<.10	1.69	<.50
Channel Catfish	Snake River below study area (Brownlee Reservoir)	72.9	124	*	<.20	2.20	.01	<2.00	.32	2.00	*
Geometric Mean			**113**	**--**	**--**	**3.08**	**.01**	**--**	**.13**	**3.40**	**--**
Smallmouth Bass	Snake River above study area	79.3	28.0	*	.50	1.10	<.01	<2.00	.12	.57	*
Smallmouth Bass	Snake River-mouth of Jump Creek	76.3	12.0	*	.50	1.50	.01	<2.00	.04	3.90	*
Smallmouth Bass	Snake River-mouth of Owyhee River	79.0	133	*	.50	5.20	.01	<2.00	.23	1.30	*
Smallmouth Bass	Snake River-mouth of Malheur River	77.0	34.2	*	.30	.60	<.01	<2.00	<.04	5.70	*
Smallmouth Bass	Snake River at Weiser	70.7	<2.0	<5.0	<.30	2.91	<.10	<.50	<.10	1.42	<.50
Geometric Mean			**17.3**	**--**	**.35**	**1.72**	**.01**	**--**	**.06**	**1.88**	**--**
Crappie	Snake River below study area (Brownlee Reservoir)	69.0	12.0	*	.69	3.10	<.01	<2.00	.27	1.80	*
Mountain Whitefish	Snake River-mouth of Jump Creek	62.6	8.3	*	.40	.37	<.01	<2.00	<.04	.32	*
Carp	Owyhee Reservoir	70.0	32.5	<5.0	1.04	8.80	.82	1.56	6.19	2.61	1.25
Carp	Owyhee River in Ag. Land	80.7	739	*	.50	11.9	.04	<2.00	.99	4.80	*
Geometric Mean			**155**	**--**	**.72**	**10.2**	**.18**	**--**	**2.48**	**3.54**	**--**
Channel Catfish	Owyhee Reservoir	70.8	59.8	<5.0	.44	5.72	<.10	<.50	<.10	1.81	<.50
Channel Catfish	Owyhee River in Ag. Land	75.0	1,320	*	.72	18.2	.06	3.00	.92	5.60	*
Geometric Mean			**281**	**--**	**.56**	**10.2**	**--**	**--**	**--**	**3.18**	**--**

Table 25. Concentrations of trace elements in composite samples of fish collected from the Owyhee and Vale project areas, and Snake River system, July-September 1990—Continued

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements								
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadminm	Chromium	Cobalt
Smallmouth Bass	Owyhee River in Ag. Land	75.6	144	*	<0.20	4.00	0.01	<2.00	0.12	4.90	*
Largemouth Bass	Owyhee Reservoir	69.2	<2.0	<5.0	<.30	1.63	<.10	<.50	<.10	1.38	<0.50
Redear Sunfish	Owyhee River in Ag. Land	73.8	561	*	.40	11.0	.03	<2.00	.08	3.30	*
Channel Catfish	North Fk Malheur River below Beulah Reservoir	75.7	276	<5.0	<.30	8.68	<.10	<.50	<.10	1.85	<.50
Bullhead	Middle Fk Malheur River below Warm Springs Reservoir	77.2	60.8	<5.0	<.30	7.33	<.10	1.17	<.10	1.39	<.50
Bullhead	Malheur River in Ag. Land	75.1	384	<5.0	.60	8.88	<.10	1.52	<.10	2.18	<.50
Geometric Mean			**153**	--	--	**8.07**	--	**1.33**	--	**1.74**	--
Smallmouth Bass	Bully Creek below Bully Creek Dam	73.5	75.5	*	<.20	<2.00	<.01	1.90	.16	2.30	*
Crappie	Middle Fk Malheur River below Warm Springs Reservoir	73.5	46.0	<5.0	<.30	8.23	<.10	1.61	<.10	1.52	<.50
Crappie	Bully Creek below Bully Creek Dam	73.7	103	*	.30	3.90	.01	<2.00	.17	4.00	*
Geometric Mean			**68.8**	--	--	**5.67**	--	--	--	**2.47**	--
Northern Squawfish	North Fk Malheur River below Beulah Reservoir	73.1	<2.0	<5.0	<.30	7.55	<.10	<.50	<.10	1.43	<.50
Carp	Payette River	75.6	322	*	.80	9.10	.02	<2.00	.45	4.50	*
Bullhead	Payette River	76.9	377	*	.20	15.1	.02	<2.00	.16	5.50	*
Smallmouth Bass	Payette River	74.8	106	*	.60	3.00	<.01	<2.00	.06	5.10	*
Channel Catfish	Boise River	70.9	168	<5.0	.49	5.24	<.10	3.48	<.10	2.92	<.50
Bullhead	Boise River	77.7	1,180	*	.72	22.2	.06	2.00	.83	3.60	*
Smallmouth Bass	Boise River	75.6	68.2	*	<.20	5.80	<.01	<2.00	<.04	2.70	*
Carp	Ft. Boise WMA	71.5	<2.0	<5.0	.46	5.29	<.10	.52	<.10	1.66	<.50
Bullhead	Ft. Boise WMA	78.2	398	<5.0	.66	17.7	<.10	1.49	<.10	2.48	<.50
Sunfish	Ft. Boise WMA	71.1	7.5	<5.0	<.30	4.85	<.10	<.50	<.10	1.75	<.50
Carp	Lake Lowell	76.3	42.0	<5.0	<.30	17.1	<.10	1.38	.43	2.14	<.50
Channel Catfish	Lake Lowell	72.6	<2.0	<5.0	<.30	1.66	<.10	<.50	<.10	1.31	<.50
Sunfish	Lake Lowell	68.4	11.1	<5.0	<.30	5.08	<.10	.52	<.10	2.02	<.50

Table 25. Concentrations of trace elements in composite samples of fish collected from the Owyhee and Vale project areas, and Snake River system, July-September 1990—Continued

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements								
			Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Selenium
Carp	Snake River above study area	59.9	2.30	78.6	<0.40	701	4.42	0.80	<1.0	0.80	0.92
Carp	Snake River-mouth of Jump Creek	72.8	4.34	121	<.60	1,070	8.69	.55	<1.0	3.90	1.90
Carp	Snake River-mouth of Owyhee River	70.3	4.20	485	<.80	1,050	16.1	.63	2.0	11.0	1.90
Carp	Snake River-mouth of Malheur River	75.3	5.75	1,040	<.50	1,310	21.5	.69	<1.0	3.50	2.60
Carp	Snake River at Weiser	72.0	4.91	500	<1.50	1,190	13.4	.45	<.5	<.50	1.94
Carp	Snake River-below study area (Brownlee Reervoir)	68.0	2.70	118	<.40	814	4.66	1.40	<1.0	.89	1.30
Geometric Mean			**3.84**	**256**	**--**	**1,000**	**9.70**	**.70**	**--**	**1.73**	**1.67**
Channel Catfish	Snake River above study area	73.9	1.80	423	<.40	962	10.6	.33	<1.0	1.60	2.40
Channel Catfish	Snake River-mouth of Jump Creek	75.0	1.60	187	<.40	995	9.05	.37	<1.0	1.10	2.90
Channel Catfish	Snake River-mouth of Owyhee River	77.7	3.10	309	<1.00	1,160	14.1	1.10	3.2	22.6	1.70
Channel Catfish	Snake River-mouth of Malheur River	76.7	2.10	255	<.40	1,100	8.70	.50	<1.0	5.00	2.10
Channel Catfish	Snake River at Weiser	69.9	1.14	81.4	<1.50	1,010	7.03	.69	<.5	<.50	1.88
Channel Catfish	Snake River below study area (Brownlee Reservoir)	72.9	1.20	219	<.90	869	6.37	.58	2.0	1.20	1.40
Geometric Mean			**1.72**	**219**	**--**	**1,012**	**8.99**	**.55**	**--**	**1.98**	**2.01**
Smallmouth Bass	Snake River above study area	79.3	2.50	108	<.40	1,280	2.90	.47	<1.0	.72	4.70
Smallmouth Bass	Snake River-mouth of Jump Creek	76.3	2.20	76.5	<.40	1,270	2.40	.53	<1.0	2.10	3.50
Smallmouth Bass	Snake River-mouth of Owyhee River	79.0	2.80	203	<.50	1,390	7.37	.47	<1.0	2.40	3.80
Smallmouth Bass	Snake River-mouth of Malheur River	77.0	2.40	92.3	<.40	810	3.48	.42	<1.0	3.20	2.20
Smallmouth Bass	Snake River at Weiser	70.7	1.20	53.5	<1.50	1,320	4.83	.78	<.5	<.50	2.44
Geometric Mean			**2.13**	**96.3**	**--**	**1,190**	**3.87**	**.52**	**--**	**1.24**	**3.20**
Crappie	Snake River below study area (Brownlee Reservoir)	69.0	1.20	57.6	<.90	1,100	9.07	.76	2.0	9.70	.95
Mountain Whitefish	Snake River-mouth of Jump Creek	62.6	2.00	38.0	<.40	724	2.48	.05	<1.0	.30	4.50
Carp	Owyhee Reservoir	70.0	4.97	169	4.24	1,390	15.5	2.52	.8	4.37	2.19
Carp	Owyhee River in Ag. land	80.7	10.8	830	1.00	1,280	27.8	.22	<1.0	3.10	2.20
Geometric Mean			**7.33**	**374**	**2.06**	**1,330**	**20.8**	**.74**	**--**	**3.68**	**2.19**
Channel Catfish	Owyhee Reservoir	70.8	1.75	122	<1.50	1,190	7.95	1.98	<.5	<.50	1.11
Channel Catfish	Owyhee River in Ag. Land	75.0	58.7	1,310	<.70	1,200	122	.75	1.0	7.80	1.90
Geometric Mean			**10.1**	**400**	**--**	**1,200**	**31.1**	**1.22**	**--**	**--**	**1.45**

Table 25. Concentrations of trace elements in composite samples of fish collected from the Owyhee and Vale project areas, and Snake River system, July-September 1990—Continued

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements: Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Selenium
Smallmouth Bass	Owyhee River in Ag. Land	75.6	3.74	214	<0.40	1,560	11.5	0.69	<1.0	2.50	2.80
Largemouth Bass	Owyhee Reservoir	69.2	1.49	37	<1.50	1,310	3.31	1.05	<.5	<.50	1.67
Redear Sunfish	Owyhee River in Ag. Land	73.8	1.90	555	<.50	1,680	17.7	.34	<1.0	1.80	3.00
Channel Catfish	North Fk Malheur River below Beulah Reservoir	75.7	7.00	315	<1.50	1,170	41.6	.19	<.5	<.50	1.92
Bullhead	Middle Fk Malheur River below Warm Springs Reservoir	77.2	2.92	131	<1.50	1,280	43.1	.47	<.5	<.50	1.32
Bullhead	Malheur River in Ag. Land	75.1	2.82	454	<1.50	1,510	72.2	.26	<.5	<.50	2.50
Geometric Mean			**2.87**	**244**	--	**1,390**	**55.8**	**.35**	--	--	**1.82**
Smallmouth Bass	Bully Creek below Bully Creek Dam	73.5	2.50	136	<.60	906	17.0	.96	<1.0	4.90	1.60
Crappie	Middle Fk Malheur River below Warm Springs Reservoir	73.5	1.37	80.4	<1.50	1,430	28.1	.36	<.5	<.50	.82
Crappie	Bully Creek below Bully Creek Dam	73.7	1.80	146	<.50	896	36.8	.55	<1.0	2.60	1.00
Geometric Mean			**1.57**	**108**	--	**1,130**	**32.2**	**.45**	--	--	**.90**
Northern Squawfish	North Fk Malheur River below Beulah Reservoir	73.1	3.59	56.8	<1.50	1,390	20.4	.65	.8	<.50	1.38
Carp	Payette River	75.6	5.40	490	<.50	1,060	30.5	.35	<1.0	2.60	1.10
Bullhead	Payette River	76.9	3.85	501	.60	1,270	49.0	.23	<1.0	3.40	1.70
Smallmouth Bass	Payette River	74.8	3.10	209	.50	1,200	20.2	.23	<1.0	2.70	1.20
Channel Catfish	Boise River	70.9	1.66	247	<1.50	1,060	59.4	.55	<0.5	<0.50	1.53
Bullhead	Boise River	77.7	5.52	1,050	<.70	1,620	45.2	.34	<1.0	6.90	2.00
Smallmouth Bass	Boise River	75.6	1.90	107	<.40	1,650	28.3	.29	<1.0	1.50	1.70
Carp	Ft. Boise WMA	71.5	5.94	56.4	21.2	965	6.28	.31	<.5	<.50	.97
Bullhead	Ft. Boise WMA	78.2	3.19	488	<1.50	1,660	123	.31	<.5	<.50	1.47
Sunfish	Ft. Boise WMA	71.1	.86	44.6	<1.50	1,380	26.4	.26	<.5	<.50	1.58
Carp	Lake Lowell	76.3	3.46	158	2.25	1,870	16.4	1.22	<.5	<.50	1.22
Channel Catfish	Lake Lowell	72.6	1.02	48.4	<1.50	948	3.76	.28	<.5	<.50	.89
Sunfish	Lake Lowell	68.4	.81	58.3	<1.50	1,450	12.7	.37	<.5	<.50	1.44

Table 25. Concentrations of trace elements in composite samples of fish collected from the Owyhee and Vale project areas, and Snake River system, July-September 1990—Continued

Species	Location (fugures 2 and 3)	Percent moisture content	Trace elements				
			Silver	Stron-tium	Tin	Vana-dium	Zinc
Carp	Snake River above study area	59.9	<2.0	27.3	*	<.30	168
Carp	Snake River-mouth of Jump Creek	72.8	<2.0	62.4	*	.60	184
Carp	Snake River-mouth of Owyhee River	70.3	<2.0	35.7	*	1.20	180
Carp	Snake River-mouth of Malheur River	75.3	<2.0	54.4	*	2.80	318
Carp	Snake River at Weiser	72.0	<1.5	43.6	<4.00	.84	233
Carp	Snake river below study area (Brownlee Reservoir)	68.0	<2.0	34.6	*	.60	151
Geometric Mean			--	**41.3**	--	**.73**	**199**
Channel Catfish	Snake River above study area	73.9	<2.0	21.9	*	1.30	55.4
Channel Catfish	Snake River-mouth of Jump Creek	75.0	<2.0	22.8	*	.60	52.4
Channel Catfish	Snake River-mouth of Owyhee River	77.7	<2.0	31.3	*	1.30	67.4
Channel Catfish	Snake River-mouth of Malheur River	76.7	<2.0	25.0	*	1.10	69.5
Channel Catfish	Snake River at Weiser	69.9	<1.5	41.3	<4.00	<.50	60.9
Channel Catfish	Snake River-below study area (Brownlee Reservoir)	72.9	<2.0	14.3	*	.92	47.0
Geometric Mean			--	**24.8**	--	**.80**	**58.2**
Smallmouth Bass	Snake River above study area	79.3	<2.0	23.6	*	<.30	65.3
Smallmouth Bass	Snake River-mouth of Jump Creek	76.3	<2.0	30.1	*	<.30	52.3
Smallmouth Bass	Snake River-mouth of Owyhee River	79.0	<2.0	32.2	*	.50	63.8
Smallmouth Bass	Snake River-mouth of Malheur River	77.0	<2.0	12.0	*	<.30	50.3
Smallmouth Bass	Snake River at Weiser	70.7	<1.5	52.0	<4.00	<.50	57.5
Geometric Mean			--	**27.0**	--	--	**57.5**
Crappie	Snake River below study area (Brownlee Reservoir)	69.0	<2.0	83.6	*	.30	48.3
Mountain Whitefish	Snake River-mouth of Jump Creek	62.6	<2.0	7.4	*	.30	28.7
Carp	Owyhee Reservoir	70.0	<1.5	74.6	4.13	3.78	412
Carp	Owyhee River in Ag. land	80.7	<2.0	25.6	*	1.90	164
Geometric Mean			--	**43.7**	--	**2.68**	**260**
Channel Catfish	Owyhee Reservoir	70.8	<1.5	54.6	<4.00	1.02	72.0
Channel Catfish	Owyhee River in Ag. Land	75.0	<2.0	22.0	*	3.10	53.2
Geometric Mean			--	**34.7**	--	**1.78**	**61.9**

Table 25. Concentrations of trace elements in composite samples of fish collected from the Owyhee and Vale project areas, and Snake River system, July-September 1990—Continued

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements				
			Silver	Strontium	Tin	Vanadium	Zinc
Smallmouth Bass	Owyhee River in Ag. Land	75.6	<2.0	47.0	*	0.30	69.0
Largemouth Bass	Owyhee Reservoir	69.2	<1.5	45.5	<4.00	<.50	52.4
Redear Sunfish	Owyhee River in Ag. Land	73.8	<2.0	52.4	*	1.90	71.8
Channel Catfish	North Fk Malheur River below Beulah Reservoir	75.7	<1.5	54.6	<4.00	1.21	84.9
Bullhead	Middle Fk Malheur River below Warm Springs Reservoir	77.2	<1.5	94.2	<4.00	1.32	62.1
Bullhead	Malheur River in Ag. Land	75.1	<1.5	80.7	<4.00	5.19	76.6
Geometric Mean			--	**87.2**	--	**2.62**	**69.0**
Smallmouth Bass	Bully Creek below Bully Creek Dam	73.5	<2.0	9.3	*	.40	39.4
Crappie	Middle Fk Malheur River below Warm Springs Reservoir	73.5	<1.5	116	<4.00	.93	63.9
Crappie	Bully Creek below Bully Creek Dam	73.7	<2.0	45.6	*	.80	65.6
Geometric Mean			--	**72.7**	--	**1.26**	**64.7**
Northern Squawfish	North Fk Malheur River below Beulah Reservoir	73.1	<1.5	69.7	<4.00	<.50	87.6
Carp	Payette River	75.6	<2.0	31.6	*	1.10	217
Bullhead	Payette River	76.9	<2.0	77.6	*	2.30	78
Smallmouth Bass	Payette River	74.8	<2.0	29.6	*	.40	51.5
Channel Catfish	Boise River	70.9	<1.5	45.5	<4.00	.55	56.7
Bullhead	Boise River	77.7	<2.0	81.9	*	3.40	64.6
Smallmouth Bass	Boise River	75.6	<2.0	73.4	*	.50	73.6
Carp	Ft. Boise WMA	71.5	<1.5	41.0	<4.00	<.50	247
Bullhead	Ft. Boise WMA	78.2	<1.5	133	<4.00	2.14	96.1
Sunfish	Ft. Boise WMA	71.1	<1.5	92.5	<4.00	<.50	83.2
Carp	Lake Lowell	76.3	<1.5	161	<4.00	1.83	302
Channel Catfish	Lake Lowell	72.6	<1.5	45.3	<4.00	<.50	52.9
Sunfish	Lake Lowell	68.4	<1.5	105	<4.00	.73	55.9

Table 26. Concentrations of trace elements in waterbird eggs collected from the Owyhee and Vale project areas, and Snake River system, April-May 1990

[Concentrations in micrograms per gram, dry weight; wet weight = dry weight x (1 - percent moisture content expressed as a decimal); where all values are less than (<), no mean is reported; for individual less-than values, one-half of the value was used to calculate the mean; -- = not determined; * = not analyzed; Ft = Fort; WMA = Wildlife Management Area]

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements							
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium
Mallard	Snake River above study area	67.5	<2.0	<5.0	<0.3	4.73	<0.1	<0.50	<0.1	0.90
Mallard	Snake River above study area	66.8	<2.0	<5.0	<.3	7.21	<.1	<.50	<.1	.72
Mallard	Snake River above study area	68.9	<2.0	<5.0	<.3	7.97	<.1	.53	<.1	.86
Mallard	Snake River-mouth of Jump Creek	71.7	<2.0	<5.0	<.3	1.95	<.1	1.15	<.1	.58
Mallard	Snake River-mouth of Jump Creek	68.4	<2.0	<5.0	<.3	9.14	<.1	<.50	<.1	.71
Mallard	Snake River-mouth of Jump Creek	67.8	<2.0	<5.0	<.3	3.23	<.1	.50	<.1	.84
Geometric Meen			--	--	--	**5.00**	--	**.41**	--	**.76**
Black-crowned Night heron	Snake River at Weiser	80.9	<2.0	<5.0	<.3	2.23	<.1	<.50	<.1	.84
Black-crowned Night heron	Snake River at Weiser	79.5	<2.0	<5.0	<.3	.88	<.1	1.46	<.1	.79
Geometric Mean			--	--	--	**1.40**	--	**.60**	--	**.82**
California Gull	Snake River at Weiser	75.2	<2.0	<5.0	<.3	7.90	<.1	<.50	<.1	.96
California Gull	Snake River at Weiser	76.6	<2.0	<5.0	<.3	6.54	<.1	<.50	<.1	.97
Geometric Mean			--	--	--	**7.19**	--	--	--	**.97**
American Avocet	Ft. Boise WMA	72.6	<2.0	<5.0	.39	2.08	<.1	.58	<.1	1.18
American Avocet	Ft. Boise WMA	71.6	<2.0	<5.0	.37	3.88	<.1	.51	<.1	1.21
American Avocet	Ft. Boise WMA	73.0	<2.0	<5.0	<.30	2.75	<.1	.78	<.1	1.14
Geometric Mean			--	--	**.28**	**2.81**	--	**.61**	--	**1.18**
American Coot	Ft. Boise WMA	75.6	<2.0	<5.0	<.30	5.32	<.1	.73	<.1	.96
American Coot	Ft. Boise WMA	74.7	<2.0	<5.0	<.30	6.31	<.1	.82	<.1	1.02
American Coot	Ft. Boise WMA	73.3	<2.0	<5.0	.31	6.92	<.1	.92	<.1	1.18
Geometric Mean			--	--	--	**6.15**	--	**.82**	--	**1.05**
Black-necked Stilt	Ft. Boise WMA	73.3	<2.0	5.5	<.30	2.90	<.1	.72	<.1	.83
Cinnamon Teal	Ft. Boise WMA	67.8	<2.0	<5.0	<.30	12.0	<.1	<.50	<.1	.83
Mallard	Ft. Boise WMA	68.0	<2.0	<5.0	<.30	7.53	<.1	<.50	<.1	.88

Table 26. Concentrations of trace elements in waterbird eggs collected from the Owyhee and Vale project areas, and Snake River system, April-May 1990

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements								
			Copper	Iron	Lead	Magne-sium	Manga-nese	Mercury	Molyb-denum	Nickel	Sele-nium
Mallard	Snake River above study area	67.5	2.88	83.1	<1.5	289	1.53	<0.05	<0.5	<0.5	1.65
Mallard	Snake River above study area	66.8	3.19	115	<1.5	382	2.80	<.05	<.5	<.5	4.54
Mallard	Snake River above study area	68.9	3.77	123	<1.5	333	1.25	<.05	<.5	<.5	2.78
Mallard	Snake River-mouth of Jump Creek	71.7	3.09	24.2	<1.5	348	.73	<.05	<.5	<.5	.96
Mallard	Snake River-mouth of Jump Creek	68.4	2.51	49.2	<1.5	373	2.86	<.05	<.5	<.5	2.71
Mallard	Snake River-mouth of Jump Creek	67.8	3.19	107	<1.5	336	1.39	<.05	<.5	<.5	2.40
Geometric Mean			**3.08**	**72.9**	--	**342**	**1.58**	--	--	--	**2.25**
Black-crowned Night Heron	Snake River at Weiser	80.9	5.06	32	<1.5	520	4.55	.74	.93	<.5	2.98
Black-crowned Night Heron	Snake River at Weiser	79.5	4.98	16.9	<1.5	424	3.00	5.90	.52	<.5	3.60
Geometric Mean			**5.02**	**23.3**	--	**470**	**3.69**	**2.08**	**.70**	--	**3.28**
California Gull	Snake River at Weiser	75.2	2.81	108	<1.5	475	2.34	.19	<.50	<.50	3.33
California Gull	Snake River at Weiser	76.6	2.59	76.3	<1.5	467	1.67	.10	<.50	<.50	2.28
Geometric Mean			**2.70**	**90.8**	--	**471**	**1.98**	**.14**	--	--	**2.76**
American Avocet	Ft. Boise WMA	72.6	2.92	125	<1.5	387	2.78	.49	.84	<.50	3.15
American Avocet	Ft. Boise WMA	71.6	3.52	108	<1.5	423	4.10	.18	.55	<.50	2.80
American Avocet	Ft. Boise WMA	73.0	2.42	90.6	<1.5	403	2.38	.80	.51	<.50	2.86
Geometric Mean			**2.92**	**107**	--	**404**	**3.00**	**.41**	**.62**	--	**2.93**
American Coot	Ft. Boise WMA	75.6	3.02	117	<1.5	650	2.90	.24	<.5	<.5	1.80
American Coot	Ft. Boise WMA	74.7	2.89	97.1	<1.5	574	2.83	.37	<.5	<.5	1.73
American Coot	Ft. Boise WMA	73.3	2.71	114	<1.5	754	1.49	.12	<.5	<.5	1.85
Geometric Mean			**2.87**	**109**	--	**655**	**2.30**	**.22**	--	--	**1.79**
Black-necked Stilt	Ft. Boise WMA	73.3	3.64	33.2	<1.5	371	2.27	2.15	<.5	<.5	3.95
Cinnamon Teal	Ft. Boise WMA	67.8	3.68	114	<1.5	204	4.15	.19	<.5	<.5	1.75
Mallard	Ft. Boise WMA	68.0	2.83	78.1	<1.5	282	1.17	<.05	<.5	<.5	1.50

Table 26. Concentrations of trace elements in waterbird eggs collected from the Owyhee and Vale project areas, and Snake River system, April-May 1990

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements				
			Silver	Strontium	Tin	Vanadium	Zinc
Mallard	Snake River above study area	67.5	<1.5	3.80	<3.0	<0.5	51.2
Mallard	Snake River above study area	66.8	<1.5	4.87	<3.0	<.5	58.6
Mallard	Snake River above study area	68.9	<1.5	5.38	<3.0	<.5	49.1
Mallard	Snake River-mouth of Jump Creek	71.7	<1.5	2.17	<3.0	<.5	52.4
Mallard	Snake River-mouth of Jump Creek	68.4	<1.5	5.58	<3.0	<.5	55.8
Mallard	Snake River-mouth of Jump Creek	67.8	<1.5	3.33	<3.0	<.5	47.6
Geometric Mean			--	**3.99**	--	--	**52.3**
Black-crowned Night Heron	Snake River at Weiser	80.9	<1.5	2.57	<3.0	<.5	95.3
Black-crowned Night Heron	Snake River at Weiser	79.5	<1.5	1.77	<3.0	<.5	48.3
Geometric Mean			--	**2.13**	--	--	**67.8**
California Gull	Snake River at Weiser	75.2	<1.5	6.28	<3.0	.57	59.9
California Gull	Snake River at Weiser	76.6	<1.5	5.72	<3.0	<.5	55.9
Geometric Mean			--	**5.99**	--	--	**57.9**
American Avocet	Ft. Boise WMA	72.6	<1.5	4.23	<3.0	<.5	36.4
American Avocet	Ft. Boise WMA	71.6	2.39	7.00	<3.0	<.5	48.7
American Avocet	Ft. Boise WMA	73.0	<1.5	6.22	<3.0	<.5	38.8
Geometric Mean			--	**5.69**	--	--	**41.0**
American Coot	Ft. Boise WMA	75.6	<1.5	9.59	<3.0	<.5	55.5
American Coot	Ft. Boise WMA	74.7	<1.5	6.47	<3.0	<.5	53.1
American Coot	Ft. Boise WMA	73.3	2.05	11.0	<3.0	<.5	42.2
Geometric Mean			--	**8.80**	--	--	**49.9**
Black-necked Stilt	Ft.Boise WMA	73.3	<1.5	7.59	<3.0	<.5	46.0
Cinnamon Teal	Ft. Boise WMA	67.8	<1.5	5.93	<3.0	<.5	62.7
Mallard	Ft. Boise WMA	68.0	<1.5	4.63	<3.0	<.5	47.6

Table 27. Concentrations of trace elements in waterbird livers collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990

[Concentrations in micrograms per gram, dry weight; wet weight = dry weight x (1 - percent moisture content expressed as a decimal); where all values are less than (<), no mean is reported for individual less-than values, one-half of the value was used to calculate the mean; -- = not determined; * = not analyzed; Ft = Fort; WMA = Wildlife Management Area]

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements: Alu-minum	Anti-mony	Arsenic	Barium	Beryl-lium	Boron	Cad-mium	Chro-mium
American coot	Snake River above study area	73.1	2.93	<5.0	1.32	<0.5	<0.1	0.85	1.68	0.83
Western grebe	Snake River above study area	68.2	3.24	<5.0	<0.30	<.5	<.1	<.50	.28	1.05
Western grebe	Snake River-mouth of Jump Creek	69.5	6.37	<5.0	.45	<.5	<.1	<.50	.53	1.15
Western grebe	Snake River-mouth of Owyhee River	71.8	<2.00	<5.0	<.30	<.5	<.1	<.50	1.91	.93
Geometric Mean			**2.74**	--	--	--	--	--	**.66**	**1.04**
American avocet	Ft. Boise WMA	73.8	<2.00	<5.0	<.30	<.5	<.1	<.50	<.10	.83
American coot	Ft. Boise WMA	75.1	2.71	<5.0	1.05	<.5	<.1	<.50	<.10	.85
Mallard	Ft. Boise WMA	76.0	7.65	<5.0	<.30	<.5	<.1	<.50	1.01	1.12
American avocet	Lake Lowell	72.3	<5.00	*	<.30	<.5	<.1	1.33	1.95	<.50
American coot	Lake Lowell	71.5	<5.00	*	<.30	<.5	<.1	2.89	.15	<.50
Western grebe	Lake Lowell	71.1	<5.00	*	<.30	<.5	<.1	2.02	.27	<.50

Table 27. Concentrations of trace elements in waterbird livers collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990—Continued

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements							
			Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel
American coot	Snake River above study area	73.1	15.4	1,980	<1.5	606	16.1	0.59	1.11	<0.5
Western grebe	Snake River above study area	68.2	19.3	2,510	<1.5	620	14.6	9.56	1.18	<.5
Western grebe	Snake River-mouth of Jump Creek	69.5	16.5	3,290	<1.5	681	16.0	9.54	1.59	<.5
Western grebe	Snake River-mouth of Owyhee River	71.8	17.1	2,240	<1.5	681	11.7	9.08	1.58	<.5
Geometric Mean			**17.6**	**2,640**	--	**660**	**14.0**	**9.39**	**1.44**	--
American avocet	Ft. Boise WMA	73.8	12.5	1,010	<1.5	592	11.9	1.15	2.31	<.5
American coot	Ft. Boise WMA	75.1	7.52	1,420	<1.5	486	10.3	.55	1.76	<.5
Mallard	Ft. Boise WMA	76.0	43.1	5,250	<1.5	634	13.0	.54	5.86	<.5
American avocet	Lake Lowell	72.3	27.7	1,820	<1.5	549	9.8	3.75	1.74	<.8
American coot	Lake Lowell	71.5	32.1	3,010	<1.5	520	10.6	1.74	3.63	<.8
Western grebe	Lake Lowell	71.1	11.9	2,110	<1.5	566	16.9	7.65	2.06	<.8

Table 27. Concentrations of trace elements in waterbird livers collected from the Owyhee and Vale project areas, and Snake River system, August-September 1990—Continued

Species	Location (figures 2 and 3)	Percent moisture content	Trace elements: Sele-nium	Silver	Stron-tium	Tin	Vana-dium	Zinc
American coot	Snake River above study area	73.1	3.83	<1.5	0.56	<4.0	<0.50	65.7
Western grebe	Snake River above study area	68.2	10.9	<1.5	<.50	<4.0	<.50	68.6
Western grebe	Snake River-mouth of Jump Creek	69.5	17.3	<1.5	<.50	<4.0	<.50	99.1
Western grebe	Snake River-mouth of Owyhee River	71.8	10.9	<1.5	<.50	<4.0	<.50	69.7
Geometric Mean			**12.7**	--	--	--	--	**78.0**
American avocet	Ft. Boise WMA	73.8	13.6	<1.5	.73	<4.0	<.50	69.2
American coot	Ft. Boise WMA	75.1	2.58	<1.5	<.50	<4.0	<.50	72.3
Mallard	Ft. Boise WMA	76.0	19.5	<1.5	.78	<4.0	.99	189
American avocet	Lake Lowell	72.3	14.3	*	<.50	*	<.50	113
American coot	Lake Lowell	71.5	3.50	*	<.50	*	<.50	231
Western grebe	Lake Lowell	71.1	10.2	*	<.50	*	<.50	68.5

Table 28. Concentrations of organic compounds in whole water, Owyhee and Vale project areas, and Snake River system, April-October 1990

[ID = Idaho; OR = Oregon; Cr = Creek; Concentrations in micrograms per liter; "--" = not analyzed; < = less than; 2,4-D = 2,4-dichlorophenoxyacetic acid; 2,4DP = 2-(2,4-dichlorophenoxy)-propionic acid; 2,4,5-T = 2,4,5-trichlorophenoxyacetic acid; PCN = polychlorinated naphthalenes; PCB = polychlorinated biphenyl; Cr = Creek; nr = near]

Station name (figures 2 and 3)	Station number	Date	Time	2,4-D	2,4-DP	2,4,5-T	Silvex	Dicamba
Snake River at Marsing, ID	13172850	07-31-90	1000	0.05	<0.01	<0.01	<0.01	<0.01
Succor Cr nr Homedale, ID	13173500	04-17-90	1500	.50	< .10	< .10	< .10	< .10
		08-01-90	0845	.28	< .01	< .01	< .01	.01
		10-16-90	1345	--	--	--	--	--
Overstreet Drain, OR	434705117065200	08-03-90	1130	.30	< .01	< .01	< .01	< .01
		10-16-90	1600	.06	< .01	< .01	< .01	.02
Owyhee River at Owyhee, OR	13184000	04-17-90	1100	.30	< .10	< .10	< .10	< .10
		08-01-90	1700	.17	< .01	< .01	< .01	.02
		10-18-90	1000	< .01	< .01	< .01	< .01	< .01
Boise River nr Parma, ID	13213000	08-01-90	1230	.67	< .01	< .01	< .01	.02
		10-17-90	1530	--	--	--	--	--
D Drain, OR	435945117065300	08-23-90	0815	.04	< .01	< .01	< .01	.01
		10-18-90	1400	.06	< .01	< .01	< .01	< .01
Malheur River nr Ontario, OR	440312116585100	04-16-90	1700	.40	< .10	< .10	< .10	< .10
		1/ 08-03-90	1515	.27	< .01	< .01	< .01	.02
		08-03-90	1520	.33	< .01	< .01	< .01	.04
		10-15-90	1700	.05	< .01	< .01	< .01	< .01
Payette River nr Payette, ID	13251000	08-02-90	1430	.12	< .01	< .01	< .01	< .01
Snake River at Weiser, ID	13269000	04-19-90	1130	.10	< .10	< .10	< .10	< .10
		08-02-90	0930	.25	< .01	< .01	< .01	< .01
		10-17-90	0930	.03	< .01	< .01	< .01	< .01
Sand Hollow Cr inflow, ID	434759116582800	07-06-90	1130	.15	< .01	< .01	< .01	.02
Sand Hollow Cr outflow, ID	434919117003200	07-06-90	1545	.21	< .01	< .01	< .01	.02

1/ Quality-assurance split sample.

Table 28. Concentrations of organic compounds in whole water, Owyhee and Vale project areas, and Snake River system, April-October 1990—Continued

Station name (figures 2 and 3)	Date	Picloram	Dacthal	Aldrin	Chlordane	Chlor-pyrifos	DDD	DDE	DDT
Snake River at Marsing, ID	07-31-90	<0.01	0.04	<0.001	<0.1	--	<0.001	<0.001	<0.001
Succor Cr nr Homedale, ID	04-17-90	< .10	3.40	< .001	< .1	--	.002	.004	.005
	08-01-90	< .01	11.8	< .001	< .1	--	.002	.004	.003
	10-16-90	--	>2.00	< .001	< .1	< .01	< .001	.002	.002
Overstreet Drain, OR	08-03-90	< .01	3.20	< .001	< .1	--	.010	.038	.036
	10-16-90	< .01	3.20	< .001	< .1	< .01	.005	.016	.009
Owyhee River at Owyhee, OR	04-17-90	< .10	.50	< .001	< .1	--	.003	.009	.006
	08-01-90	< .01	2.10	< .001	< .1	--	.006	.011	.007
	10-18-90	< .01	2.80	< .001	< .1	< .01	.001	.003	.001
Boise River nr Parma, ID	08-01-90	< .01	.73	< .001	< .1	--	.001	.002	< .001
D Drain, OR	08-23-90	< .01	19.4	< .001	< .1	< .01	.004	.002	.001
	10-18-90	< .01	15.8	< .001	< .1	< .01	.008	.014	< .010
Malheur River nr Ontario, OR	04-16-90	< .10	2.2	< .001	< .1	--	.001	.007	.004
	08-03-90	< .01	10.3	< .001	< .1	--	.003	.008	.003
1/	08-03-90	< .01	12.9	--	--	--	--	--	--
	10-15-90	< .01	7.9	< .001	< .1	.03	.002	.004	.001
Payette River nr Payette, ID	08-02-90	< .01	1.4	< .001	< .1	--	< .001	.004	.003
Snake River at Weiser, ID	08-02-90	< .01	1.40	< .001	< .1	--	.001	.002	< .001
	10-17-90	< .01	.89	< .001	< .1	< .01	< .001	< .001	< .001
Sand Hollow Cr inflow, ID	07-06-90	< .01	1.54	< .001	< .1	--	.004	.007	.010
Sand Hollow Cr outflow, ID	07-06-90	< .01	2.16	< .001	< .1	--	< .001	< .001	< .001

1/ Quality-assurance split sample.

Table 28. Concentrations of organic compounds in whole water, Owyhee and Vale project areas, and Snake River system, April-October 1990—Continued

Station name (figures 2 and 3)	Date	Diazinon	Dieldrin	Disyston	Endosulfan	Endrin	Ethion	Fonofos	PCB
Snake River at Marsing, ID	07-31-90	<0.01	<0.001	<0.01	<0.001	<0.001	<0.01	--	<0.1
Succor Cr nr Homedale, ID	04-17-90	< .01	.007	< .01	.001	.002	< .01	--	< .1
	08-01-90	< .01	.002	< .01	< .001	.002	< .01	--	< .1
	10-16-90	< .01	.002	< .01	.003	< .001	< .01	< .01	< .1
Overstreet Drain, OR	08-03-90	< .01	.053	< .01	< .001	.008	.01	--	< .1
	10-16-90	< .01	.007	< .01	< .001	< .001	< .01	< .01	< .1
Owyhee River at Owyhee, OR	04-17-90	< .01	.010	< .01	< .001	.002	.01	--	< .1
	08-01-90	< .01	.013	< .01	.002	.004	.01	--	< .1
	10-18-90	< .01	.002	< .01	< .001	< .001	< .01	< .01	< .1
Boise River nr Parma, ID	08-01-90	< .01	.002	< .01	.002	< .002	< .01	--	< .1
D Drain, OR	08-23-90	< .01	.007	< .01	< .001	.002	< .01	< .01	< .1
	10-18-90	< .01	.009	< .01	< .001	< .001	< .01	< .01	< .1
Malheur River nr Ontario, OR	04-16-90	< .01	.008	< .01	< .001	.005	.02	--	< .1
	08-03-90	< .01	.010	< .01	< .001	< .001	.01	--	< .1
1/	08-03-90	--	--	--	--	--	--	--	--
	10-15-90	< .01	.003	< .01	< .001	< .001	< .01	< .01	< .1
Payette River nr Payette, ID	08-02-90	< .01	.001	< .01	< .001	< .001	< .01	--	< .1
Snake River at Weiser, ID	04-19-90	< .01	.001	< .01	< .001	< .001	< .01	--	< .1
	08-02-90	< .01	.002	< .01	< .001	.001	< .01	--	< .1
	10-17-90	< .01	< .001	< .01	< .001	< .001	< .01	< .01	< .1
Sand Hollow Cr inflow, ID	07-06-90	< .01	.005	< .01	< .001	.002	< .01	--	< .1
Sand Hollow Cr outflow, ID	07-06-90	< .01	< .001	< .01	< .001	< .001	< .01	--	< .1

1/ Quality-assurance split sample.

Table 28. Concentrations of organic compounds in whole water, Owyhee and Vale project areas, and Snake River system, April-October 1990—Continued

Station name (figures 2 and 3)	Date	PCN	Hepta- chlor	Heptachlor epoxide	Lindane	Malathion	Methoxy- chlor	Methyl parathion
Snake River at Marsing, ID	07-31-90	<0.10	<0.001	<0.001	<0.001	<0.01	<0.01	<0.01
Succor Cr nr Homedale, ID	04-17-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	08-01-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	10-16-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
Overstreet Drain, OR	08-03-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	10-16-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
Owyhee River at Owyhee, OR	04-17-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	08-01-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	10-18-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
Boise River nr Parma, ID	08-01-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
D Drain, OR	08-23-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	10-18-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
Malheur River nr Ontario, OR	04-16-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	08-03-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
1/	08-03-90	--	--	--	--	--	--	--
	10-15-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
Payette River nr Payette, ID	08-02-90	< .10	< .001	< .001	.002	.07	< .01	< .01
Snake River at Weiser, ID	04-19-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	08-02-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
	10-17-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
Sand Hollow Cr inflow, ID	07-06-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01
Sand Hollow Cr outflow, ID	07-06-90	< .10	< .001	< .001	< .001	< .01	< .01	< .01

1/ Quality-assurance split sample.

Table 28. Concentrations of organic compounds in whole water, Owyhee and Vale project areas, and Snake River system, April-October 1990—Continued

Station name (figures 2 and 3)	Date	Methyl trithion	Mirex	Parathion	Perthane	Phorate	Toxaphene	Trithion
Snake River at Marsing, ID	07-31-90	<0.01	<0.01	<0.01	<0.1	<0.01	<1	<0.01
Succor Cr nr Homedale, ID	04-17-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
	08-01-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
	10-16-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
Overstreet Drain, OR	08-03-90	< .01	< .01	.05	< .1	< .01	<1	< .01
	10-16-90	< .01	< .01	< .01	< .1	.05	<1	< .01
Owyhee River at Owyhee, OR	04-17-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
	08-01-90	< .01	< .01	.01	< .1	< .01	<1	< .01
	10-18-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
Boise River nr Parma, ID	08-01-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
D Drain, OR	08-23-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
	10-18-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
Malheur River nr Ontario, OR	04-16-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
	08-03-90	< .01	< .01	.06	< .1	< .01	<1	< .01
1/	08-03-90	--	--	--	--	--	--	--
	10-15-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
Payette River nr Payette, ID	08-02-90	< .01	< .01	.01	< .1	< .01	<1	< .01
Snake River at Weiser, ID	04-19-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
	08-02-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
	10-17-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
Sand Hollow Cr inflow, ID	07-06-90	< .01	< .01	< .01	< .1	< .01	<1	< .01
Sand Hollow Cr outflow, ID	07-06-90	< .01	< .01	< .01	< .1	< .01	<1	< .01

1/ Quality-assurance split sample.

Table 29. Concentrations of organochlorine compounds recovered from less than 2-millimeter-size bottom sediment and percent organic carbon, Owyhee and Vale project areas, and Snake River system, July-August 1990

[DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane; PCB = polychlorinated biphenyls; PCN = polychlorinated naphthalenes; ID = Idaho; OR = Oregon; Cr = Creek; R = River organochlorine compound concentrations in micrograms per kilogram; < = less than]

Station name (figures 2 and 3)	Station number	Date	Time	Aldrin	Chlordane	DDD	DDE
Snake River at Marsing, ID	13172850	07-31-90	1000	<0.1	1.0	2.4	5.4
Succor Cr near Homedale, ID	13173500	08-01-90	0845	<.1	2.0	5.8	23
Overstreet Drain, OR	434705117065200	08-03-90	1130	<.1	3.0	6.7	21
Owyhee River at Owyhee, OR	13184000	08-01-90	1700	.3	10	20	67
Boise River near Parma, ID	13213000	08-01-90	1230	<.1	< 1.0	.4	.9
Bully Creek near Vale, OR	435802117161600	08-22-90	1045	.9	30	16	55
Malheur R near Vale, OR	435844117141100	08-22-90	1330	1.5	2.0	4.9	17
Willow Creek at Vale, OR	435917117134500	08-22-90	1600	<.1	1.0	1.3	3.1
D Drain, OR	435945117065300	08-23-90	0815	<.1	6.0	8.0	21
Malheur R near Ontario, OR	440312116585100	08-03-90	1515	.2	6.0	9.9	23
	1/	08-03-90	1520	.3	8.0	12	29
Payette R near Payette, ID	13251000	08-02-90	1430	<.1	2.0	5.0	14
Snake River at Weiser, ID	13269000	08-02-90	0930	.1	1.0	2.1	5.4
Sand Hollow Cr inflow, ID	434759116582800	07-06-90	1130	<.1	< 1.0	.2	.7
Sand Hollow Cr outflow, ID	434919117003200	07-06-90	1545	<.1	< 1.0	.1	.7

1/ Quality-assurance split sample.

Table 29. Concentrations of organochlorine compounds recovered from less than 2-millimeter-size bottom sediment and percent organic carbon, Owyhee and Vale project areas, and Snake River system, July-August 1990

Station name (figures 2 and 3)	Date	DDT	Dieldrin	Endo-sulfan	Endrin	PCB	PCN	Hepta-chlor
Snake River at Marsing, ID	07-31-90	1.2	0.2	<0.1	<0.1	<1	<1	<0.1
Succor Cr near Homedale, ID	08-01-90	18	1.2	.2	< .1	<1	<1	< .1
Overstreet Drain, OR	08-03-90	86	4.0	< .1	< .1	<1	<1	< .1
Owyhee River at Owyhee, OR	08-01-90	8.7	9.6	.2	< .1	<1	<1	< .1
Boise River near Parma, ID	08-01-90	0.1	.1	< .1	< .1	<1	<1	< .1
Bully Creek near Vale, OR	08-22-90	15	43	<1.0	<1.0	<1	<1	< .1
Malheur R near Vale, OR	08-22-90	1.6	5.9	< .1	< .1	<1	<1	< .1
Willow Creek at Vale, OR	08-22-90	4.5	1.7	< .1	< .1	<1	<1	< .1
D Drain, OR	08-23-90	4.8	3.8	<1.0	< .1	<1	<1	< .1
Malheur R near Ontario, OR	08-03-90	4.7	3.7	.1	< .1	<1	<1	< .1
1/	08-03-90	5.9	4.4	.2	< .1	<1	<1	< .1
Payette R near Payette, ID	08-02-90	4.1	.4	< .1	< .1	<1	<1	< .1
Snake River at Weiser, ID	08-02-90	1.4	.2	< .1	< .1	<1	<1	< .1
Sand Hollow Cr inflow, ID	07-06-90	1.4	.1	< .1	< .1	<1	<1	< .1
Sand Hollow Cr outflow, ID	07-06-90	< .1	< .1	< .1	< .1	<1	<1	< .1

1/ Quality-assurance split sample.

Table 29. Concentrations of organochlorine compounds recovered from less than 2-millimeter-size bottom sediment and percent organic carbon, Owyhee and Vale project areas, and Snake River system, July-August 1990

Station name (figures 2 and 3)	Date	Hepta-chlor epoxide	Lindane	Meth-oxy-chlor	Mirex	Per-thane	Toxa-phene	Percent organic carbon
Snake River at Marsing, ID	07-31-90	<0.1	<0.1	<0.1	<0.1	<1.0	<10	1.20
Succor Cr near Homedale, ID	08-01-90	< .1	< .1	< .1	< .1	<1.0	<10	.49
Overstreet Drain, OR	08-03-90	< .1	< .1	< .1	< .1	<1.0	<10	.14
Owyhee River at Owyhee, OR	08-01-90	< .1	< .1	< .1	< .1	<1.0	<10	1.02
Boise River near Parma, ID	08-01-90	< .1	< .1	< .1	< .1	<1.0	<10	.07
Bully Creek near Vale, OR	08-22-90	.8	< .1	< .1	< .1	<10.0	<10	.44
Malheur R near Vale, OR	08-22-90	< .1	< .1	< .1	< .1	<1.0	<10	1.34
Willow Creek at Vale, OR	08-22-90	< .1	< .1	< .1	< .1	<1.0	<10	.53
D Drain, OR	08-23-90	< .1	< .1	< .1	< .1	<1.0	<10	.68
Malheur R near Ontario, OR	08-03-90	< .1	< .1	< .1	< .1	<1.0	<10	.44
1/	08-03-90	< .1	< .1	< .1	< .1	<1.0	<10	.41
Payette R near Payette, ID	08-02-90	< .1	< .1	< .1	< .1	<1.0	<10	.90
Snake River at Weiser, ID	08-02-90	< .1	< .1	< .1	< .1	<1.0	<10	.59
Sand Hollow Cr inflow, ID	07-06-90	< .1	< .1	< .1	< .1	<1.0	<10	<.05
Sand Hollow Cr outflow, ID	07-06-90	< .1	< .1	< .1	< .1	<1.0	<10	<.05

1/ Quality-assurance split sample.

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