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Water Quality in the Las Vegas Valley Area and the Carson and Truckee River Basir

Nevada and California, 1992–96

A COORDINATED EFFORT

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Front cover photograph: Seining fish in the Carson River downstream from Carson City, Nevada, September 1992. Photograph by Kenneth J. Covay.

Back cover photographs: Top left, collecting crayfish in the Carson River downstream from Carson City, September 1992, photograph by Ronald P. Collins; seining fish in the East Fork Carson River upstream from Carson Valley, September 1992, photograph by Stephen J. Lawrence; and top right, electrofishing in the East Fork Carson River upstream from Carson Valley, photograph by Stephen J. Lawrence, September 1992.

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Water Quality in the Las Vegas Valley Area and the Carson and Truckee River Basins, Nevada and California, 1992–96

By Hugh E. Bevans, Michael S. Lico, *and* Stephen J. Lawrence

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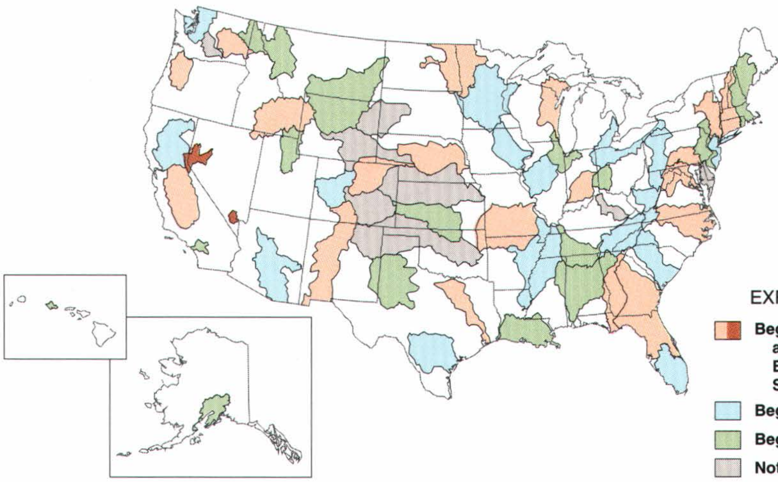


Knowledge of the quality of the Nation's streams and aquifers is important because of the implications to human and aquatic health and because of the significant costs associated with decisions involving land and water management, conservation, and regulation. In 1991, the U.S. Congress appropriated funds for the U.S. Geological Survey (USGS) to begin the National Water-Quality Assessment (NAWQA) Program to help meet the continuing need for sound, scientific information on the areal extent of the water-quality problems, how these problems are changing with time, and an understanding of the effects of human actions and natural factors on water-quality conditions.

The NAWQA Program is assessing the water-quality conditions of more than 50 of the Nation's largest river basins and aquifers, known as Study Units. Collectively, these Study Units cover about one-half of the United States and include sources of drinking water used by about 70 percent of the U.S. population. Comprehensive assessments of about one-third of the Study Units are ongoing at a given time. Each Study Unit is scheduled to be revisited every decade to evaluate changes in water-quality conditions. NAWQA assessments rely heavily on existing information collected by the USGS and many other agencies as well as the use of nationally consistent study designs and methods of sampling and analysis. Such consistency simultaneously provides information about the status and trends in water-quality conditions in a particular stream or aquifer and, more importantly, provides the basis to make comparisons among watersheds and improve our understanding of the factors that affect water-quality conditions regionally and nationally.

This report is intended to summarize major findings that emerged between 1992 and 1996 from the water-quality assessment of the Nevada Basin and Range Study Unit (NVBR) and to relate these findings to water-quality issues of regional and national concern. The information is primarily intended for those who are involved in water-resource management. Indeed, this report addresses many of the concerns raised by regulators, water-utility managers, industry representatives, and other scientists, engineers, public officials, and members of stakeholder groups who provided advice and input to the USGS during this NAWQA Study-Unit investigation. Yet, the information contained here may also interest those who simply wish to know more about the quality of water in the rivers and aquifers in the area where they live.

Robert M. Hirsch

Robert M. Hirsch, Chief Hydrologist

"NVBR NAWQA investigations determined that synthetic organic compounds were present in bottom sediments of Las Vegas Bay in Lake Mead. Subsequent cooperative investigations by the National Park Service and the NAWQA Program have provided valuable information on the sources and potential effects of these compounds on humans and aquatic wildlife in this important National Recreation Area." *Alan O'Neill, Superintendent, National Park Service, Lake Mead National Recreation Area*

"The NVBR NAWQA study detected pesticides in shallow ground water beneath urban and agricultural areas in Nevada. These results are being used by the Nevada Division of Agriculture to evaluate pesticide registrations in Nevada." *Charles Moses, Environmental Scientist, Nevada Department of Business and Industry, Division of Agriculture*

This report summarizes the major findings of the National Water-Quality Assessment (NAWQA) Program for the Las Vegas Valley area and the Carson and Truckee River Basins in Nevada and California. These areas are the Nevada Basin and Range (NVBR) NAWQA Study Unit. The statements on major findings below are expanded in the section on Major Issues and Findings of this report. Comparisons of data for this Study Unit with data from all 20 NAWQA Study Unit investigations that began in 1991 are presented in the section on Water-Quality Conditions in a National Context. Although this report is part of a national program, it also is intended as a resource for anyone interested in water-quality conditions in the NVBR Study Unit.

Geology and Climate Have Caused High Concentrations of Dissolved Solids, Arsenic, Uranium, and Radon in Some Areas

Some water-quality criteria have been exceeded in the NVBR Study Unit because of natural factors (p. 9-11).

- Median concentrations of dissolved solids (see Glossary for definitions of selected terms) for the Carson River in Carson Desert and in shallow ground-water samples from Las Vegas Valley and Carson Desert exceeded the U.S. Environmental Protection Agency (USEPA) secondary maximum contaminant level (SMCL) for drinking water. Dissolved-solids concentrations are increased by evapotranspiration in these areas.

- Median concentrations of arsenic and uranium in ground-water samples from Carson Desert exceeded the USEPA maximum contaminant level (MCL) and the proposed MCL, respectively, for drinking water. Arsenic and uranium are dissolved from coatings on sediment grains.

- Median concentrations of radon in ground-water samples from all parts of the Study Unit approached or exceeded the former proposed MCL (currently under review). Radon is a decay product of uranium-238, which is found in granitic rock.

Urban Activities Have Been Primary Sources of Nutrients, Synthetic Organic Compounds, and Trace Elements

Nutrients can enter water resources by discharge of treated sewage, leaking sewer pipes, domestic septic systems, and fertilizer applications (p. 12, 13, and 18).

- The annual total-nitrogen load of Las Vegas Wash downstream from discharge of treated sewage increased from 750 tons in 1974 to 2,400 tons in 1988 because of a rapidly increasing population in the Las Vegas urban area. Most of the load was ammonia.

- The median ammonia concentration in NAWQA samples from Las Vegas Wash was nearly 300 times the NAWQA national median and all samples exceeded the USEPA aquatic-life criterion for un-ionized ammonia. Subsequent samples collected by other agencies indicate that the criterion probably is no longer being exceeded because of improved tertiary treatment of sewage.

- Nine percent of NAWQA samples from the Truckee River downstream from discharge of tertiary-treated sewage from the Reno-Sparks urban area exceeded the aquatic-life criterion for un-ionized ammonia but nitrate concentrations were low, compared to the national NAWQA median, because of tertiary treatment of sewage effluent.

- The median nitrate concentration in NAWQA samples from shallow monitoring wells (not used for water supplies) in the Las Vegas urban area was more than twice the national NAWQA median; 12 percent equaled or exceeded the MCL. The MCL was not exceeded for any samples collected from water-supply wells.

Many pesticides were detected at low levels in water resources of urban areas (p. 13 and 18).

- Twenty-four pesticides were detected in NAWQA samples from Las Vegas Wash downstream from the Las Vegas urban area. The most commonly detected pesticides were simazine, prometon, diuron, DCPA, diazinon, and malathion. USEPA aquatic-life criteria for the insecticides diazinon and malathion were exceeded in 47 and 25 percent of the samples, respectively.
- Ten pesticides were detected at low levels in NAWQA samples from the Truckee River downstream from the Reno-Sparks urban area during May-August 1994, but only one was detected upstream. No available MCLs or aquatic-life criteria were exceeded.
- At least one pesticide was detected at a low level in 28 percent of the shallow monitoring wells sampled by NAWQA in the Las Vegas urban area and in 68 percent of those in the Reno-Sparks urban area. Two or more pesticides were detected in 39 percent of the samples from the Reno-Sparks area. No available MCLs were exceeded.
- At least one pesticide was detected at a low level in 14 percent of the water-supply wells sampled by NAWQA in the Las Vegas urban area and in 44 percent of those in the Reno-Sparks urban area. Two or more pesticides were detected in 22 percent of the samples from the Reno-Sparks area. No available MCLs were exceeded.

Volatile organic compounds (VOCs) were commonly detected at low levels in urban areas (p.13 and 18).

- Low levels of trihalomethanes (THMs) and of methyl *tert*-butyl ether (MTBE), a gasoline oxygenate, were detected in NAWQA samples collected from Las Vegas Wash downstream from the Las Vegas urban area. No available MCLs were exceeded.
- More than 50 percent of the shallow monitoring wells sampled by NAWQA had detections of VOCs; chloroform, a THM that is a product of chlorination, was detected in 68 percent of the samples from the Las Vegas urban area and in 21 percent of the samples from the Reno-Sparks urban area. VOC concentrations exceeded MCLs for tetrachloroethylene (three samples) and trichloroethylene (one sample) and the drinking water advisory for MTBE (two samples).
- VOCs were detected in 45 percent of the water-supply wells sampled by NAWQA in the Las Vegas and Reno-Sparks urban areas; chloroform was the most common. Combined concentrations of THMs did not exceed the MCL. Tetrachloroethylene exceeded the MCL in one water-supply well sample in the Las Vegas urban area.

Trace elements and semivolatile organic compounds (SVOCs) were enriched in bottom sediment downstream from urban areas (p. 14-17 and 27).

- An urban trace-element index computed from concentrations of cadmium, chromium, copper, lead, and zinc indicated that these elements were enriched at NAWQA sites downstream from the Las Vegas and Reno-Sparks urban areas.
- Organochlorine compounds were not detected in 11 of 13 NAWQA sites sampled in the Study Unit.
- Semivolatile organic compounds (PAHs, phenols, and phthalate esters) were commonly detected at NAWQA sites downstream from the Las Vegas and Reno-Sparks urban areas. The concentrations exceeded the national NAWQA 75th percentile.
- A study by the NAWQA Program in cooperation with the National Park Service and U.S. Fish and Wildlife Service found evidence of disruption of carp endocrine systems in Las Vegas Wash and Las Vegas Bay of Lake Mead. Partly in response to this study, the Nevada Division of Environmental Protection instituted the Lake Mead Water Quality Forum.

Agricultural Activities Have Contributed Dissolved Solids, Trace Elements, Nutrients, and Pesticides

Agricultural areas have contributed irrigation drainage and nutrients to water resources (p. 19-21).

- Aquatic-life criteria for dissolved solids, arsenic, boron, and molybdenum in Carson Desert wetlands were commonly exceeded. These constituents are leached from desert soils by irrigation in Carson Desert.

- Concentrations of orthophosphate in shallow ground water beneath agricultural areas were greater than those beneath urban areas but concentrations of nitrate were about the same for samples collected in both areas during October 1969-April 1990.

Pesticides were present at low levels, less than the MCLs, in agricultural areas (p. 22).

- Pesticides were detected in 17 of 19 NAWQA samples collected from irrigation drains in the Carson Desert agricultural area in 1995. Atrazine, simazine, and prometon were most commonly detected.

- Pesticides were detected in 27 percent of shallow monitoring wells sampled in the Carson Valley and Carson Desert agricultural areas. Atrazine and simazine were the most commonly detected pesticides.

Urban and Agricultural Activities Have Affected Water Resources Differently

Urban and agricultural activities contribute different nutrients, pesticides, and trace elements to water resources, but VOCs and semivolatile organic compounds are signatures of urban activities (p. 12-22).

- Ammonia concentrations in NAWQA samples were higher in streams draining urban areas than in streams draining agricultural areas. Orthophosphate concentrations were higher in shallow ground-water and surface-water samples from agricultural areas than from urban areas.

- The most commonly detected pesticides in Las Vegas Wash downstream from the Las Vegas urban area were simazine, prometon, diuron, DCPA, diazinon, and malathion. Atrazine, prometon, and simazine were the most commonly detected pesticides in samples from shallow monitoring wells in the Las Vegas and Reno-Sparks urban areas. Atrazine, simazine, and prometon were the most commonly detected pesticides in samples collected from irrigation drains in Carson Desert. Atrazine and simazine were the most commonly detected pesticides in samples from shallow monitoring wells in the Carson Valley and Carson Desert agricultural areas.

- Concentrations of cadmium, chromium, copper, lead, and zinc generally were enriched at NAWQA sites downstream from the Las Vegas and Reno-Sparks urban areas; whereas, arsenic, boron, and molybdenum were leached from desert soils by irrigation in Carson Desert, and commonly exceeded aquatic-life criteria.

- NAWQA samples from Las Vegas Wash had detections of VOCs (THMs and MTBE). More than 50 percent of the shallow monitoring wells and 45 percent of the water-supply wells sampled in the Las Vegas and Reno-Sparks urban areas had detections of VOCs; chloroform was the most common. SVOCs (PAHs, phenols, and phthalate esters) in bottom sediment exceeded the national NAWQA 75th percentile downstream from the Las Vegas and Reno-Sparks urban areas.

Historical Mining Activities Have Released Trace Elements to the Carson River

Trace elements were enriched in Carson River bottom sediment downstream from historical mining activities of the Leviathan Mine and the Comstock Lode (p. 23-24).

- Aluminum, arsenic, chromium, copper, lead, mercury, and nickel concentrations were enriched in bottom sediment of the East Fork Carson River downstream from the confluence of Bryant Creek, compared to those at an upstream background site. The source of these trace elements probably is acidic drainage and eroded mine tailings from Leviathan Mine and other mines.

- Silver and mercury concentrations in Carson River bottom sediment downstream from the Comstock Lode mining area ranged from nearly 3 to 25 times higher than those at an upstream background site. Historical ore processing during the Comstock mining boom (1860-80) is the principal source of enriched silver and mercury in Carson River bottom sediment.

The NVBR Study Unit (fig. 1)**, which includes the Las Vegas Valley area in southeastern Nevada and the Carson and Truckee River Basins in northwestern Nevada and northeastern California, is typical of Basin and Range physiography** (see Glossary).

High mountains, exceeding 10,000 ft in some areas, surround valleys underlain by thick, unconsolidated deposits [1]. Consolidated rocks in high mountains are primarily carbonate rocks in the Las Vegas Valley area and granitic and volcanic rocks in the Carson and Truckee River Basins (fig. 2). Unconsolidated deposits beneath valleys (fig. 2), which range from clay to boulders, are present in thicknesses as great as 5,000 ft [4].

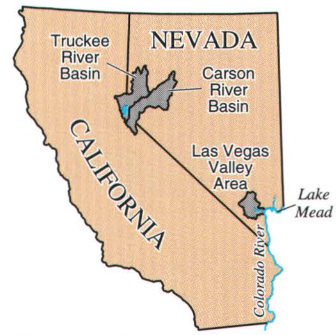


Figure 1. The Nevada Basin and Range Study Unit includes the Las Vegas Valley area and the Carson and Truckee River Basins in Nevada and California.

High mountains are headwater areas that can receive more than 20 inches of annual precipitation (fig. 3)**. Basin areas are low mountains and valleys that can receive less than 4 inches of annual precipitation** (fig. 3). Most of the precipitation falls during the winter (fig. 3). Precipitation in headwater areas provides runoff to recharge principal aquifers [4] and to sustain streamflow. Principal aquifers (fig. 3) are present in unconsolidated deposits beneath some valleys.

Streamflow in Las Vegas Wash, which drains Las Vegas Valley, is sustained by urban drainage and discharge of treated sewage from the Las Vegas urban area. Although mean seasonal streamflow is higher in winter and spring, seasonal differences are overshadowed by the nearly fourfold increase in streamflow during October 1964 through September 1995 (water years 1965-95). This increase in streamflow (fig.4a) was caused by increasing rates of urban drainage and discharge of treated sewage [4].

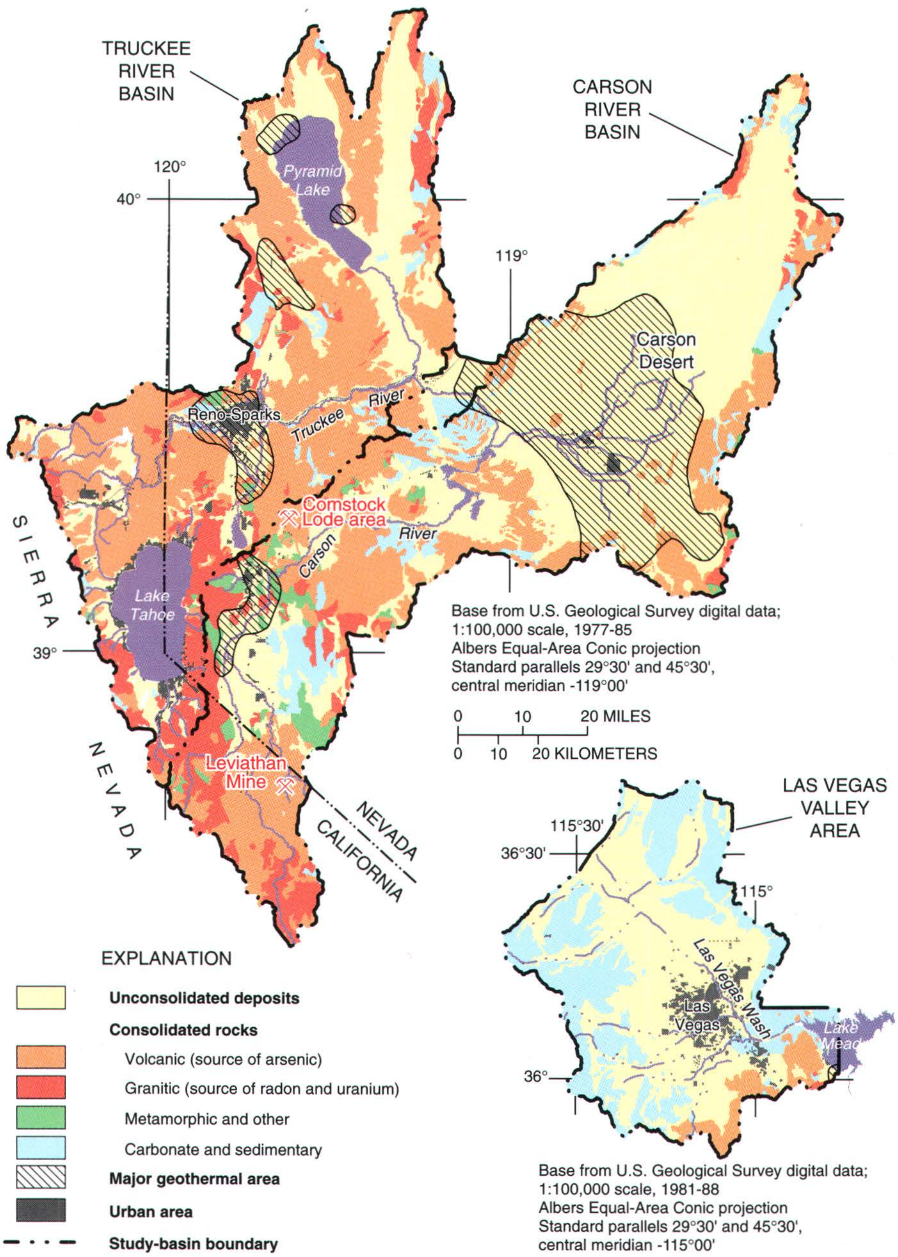


Figure 2. Natural factors (rock types and geothermal activity) and human activities (mining) affect water resources. Geology modified from [2,3].

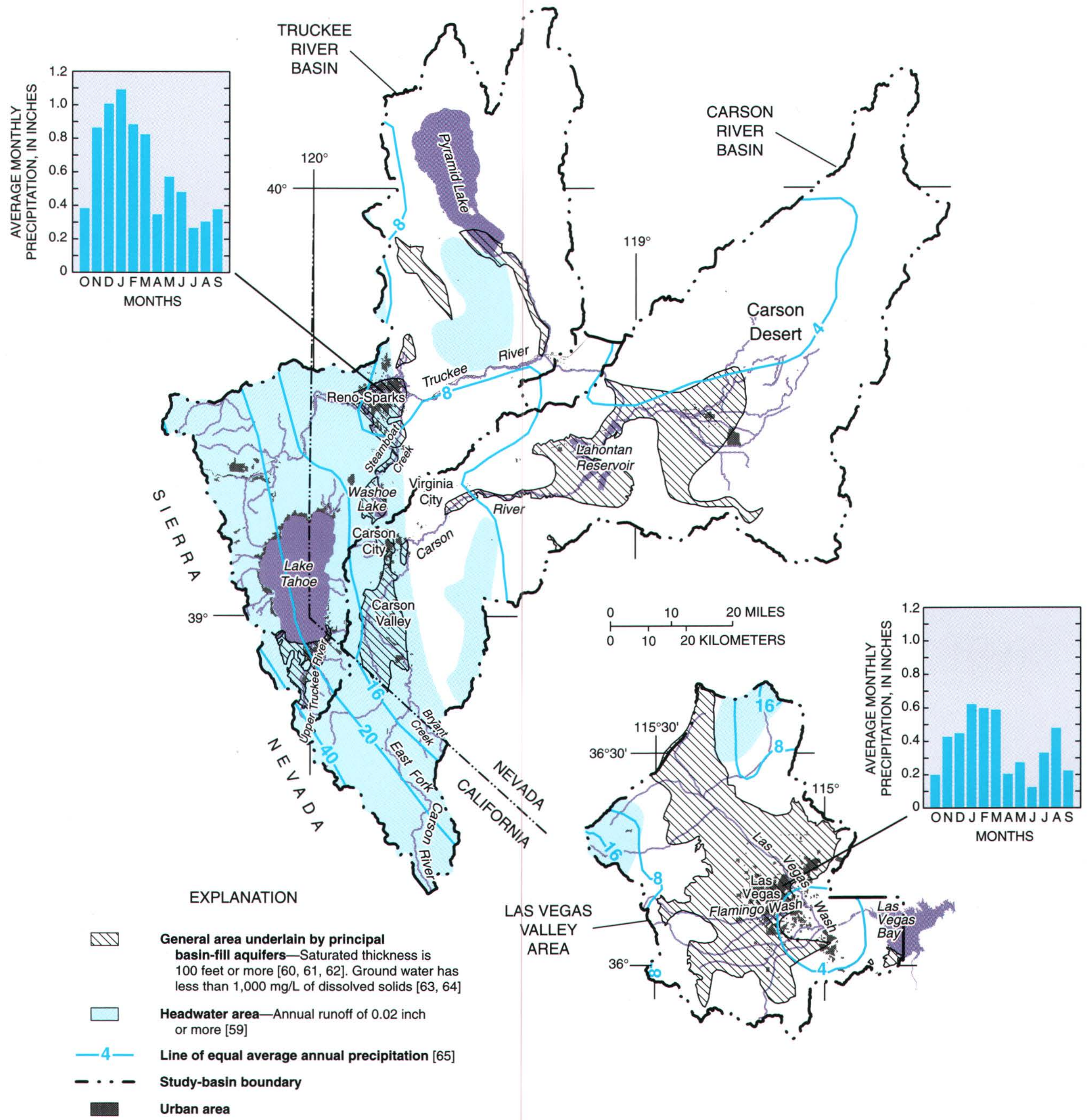


Figure 3. Winter precipitation in mountainous headwater areas provides water for streamflow and aquifer recharge.

Streamflow in the Carson and Truckee Rivers, which drain the Carson and Truckee River Basins, is primarily due to snowmelt runoff in mountainous headwater areas. Streamflow in the Carson and Truckee Rivers commonly is highest in the spring and lowest in the autumn. Periods of above- and below-average streamflow are shown in the barcharts below the streamflow hydrographs in figure 4. During the 3-year intensive sampling period for this cycle of the NVBR NAWQA investigation (1993-95), near-average, below-average, and above-average streamflow conditions were measured. Streamflow in the rivers decreases as it flows from headwater areas in the Sierra Nevada to terminal areas. Treated sewage effluent can be a substantial part of flow in the Truckee River downstream from the Reno-Sparks urban area during low-flow conditions.

Although range and forest land uses dominate in the Study Unit, urban and agricultural land uses are important in some areas. Land use in Las Vegas Valley (fig. 5) included about 79 percent range, 14 percent forest, and 5 percent urban [4]. Urban land use in Las Vegas Valley is concentrated in the Las Vegas area, which includes Las Vegas and adjacent developed areas. Land use in the Carson River Basin (fig. 5) included about 62 percent range, 18 percent forest, 14 percent open water and wetlands, and 5 percent irrigated agriculture [1]. Agricultural land use in the Carson River Basin was primarily in Carson Valley and Carson Desert (fig. 5). Land use in the Truckee River Basin (fig. 5) included about 53 percent range, 27 percent forest, 12 percent open water and wetlands, 3 percent urban, and 2 percent irrigated agriculture [1]. The primary urban area in the Truckee River Basin is Reno-Sparks. The principal irrigated crops grown in the Study Unit are pasture and alfalfa.

Historical mining activities in the Carson River Basin have affected the quality of streams. The Leviathan Mine (fig. 2) was operated intermittently from the early 1860s until 1962. About 22 million tons of overburden containing sulfide minerals were discarded in the mine area [5]. Bryant Creek, a tributary to the East Fork Carson River (fig. 3), and several of its tributaries receive acidic drainage and trace metals from the mine. The Comstock Lode, a silver- and gold-rich ore body, (fig. 2) was intensively mined during 1860-80. During this period, mercury amalgamation was used to recover silver and gold from bulk ore. An estimated 7,500 tons of elemental mercury were lost from ore processing, mostly in the Carson River Basin downstream from Carson City (fig. 3) [6]. The reach of the Carson River downstream from Carson City currently (1998) is being investigated by other researchers as a U.S. Environmental Protection Agency (USEPA) Superfund Site.

In 1990, Nevada was the State with the greatest population growth rate, in percent, and had the fourth greatest percentage of total population residing in urban areas. More than 90 percent of Nevada's population lived in the NVBR Study Unit; about 710,000 were in Las Vegas Valley, about 89,000 in the Carson River Basin, and about 290,000 in the Truckee River Basin [1]. Most of the population resided in the Las Vegas and Reno-Sparks urban areas (fig. 5). These rapidly growing urban areas require increasing amounts of public-water supplies, and urban activities have the potential to affect the quality of water resources.

Surface water is the principal source of water supplies, providing more than 80 percent of the 990 million gallons per day (Mgal/d) withdrawn in the Study Unit during 1990. In Las Vegas Valley, more than 90 percent of the 280 Mgal/d withdrawn (Marilee Horn, U.S. Geological Survey, written commun., 1997) was used for public supplies (fig. 6*A*). Water use in the Carson and Truckee River Basins is combined herein (fig. 6*B*) because of large interbasin transfers of Truckee River water for irrigation in Carson Desert. In these basins, more than 80 percent of the 710 Mgal/d withdrawn was used mostly for irrigated agriculture, with a small part used for livestock.

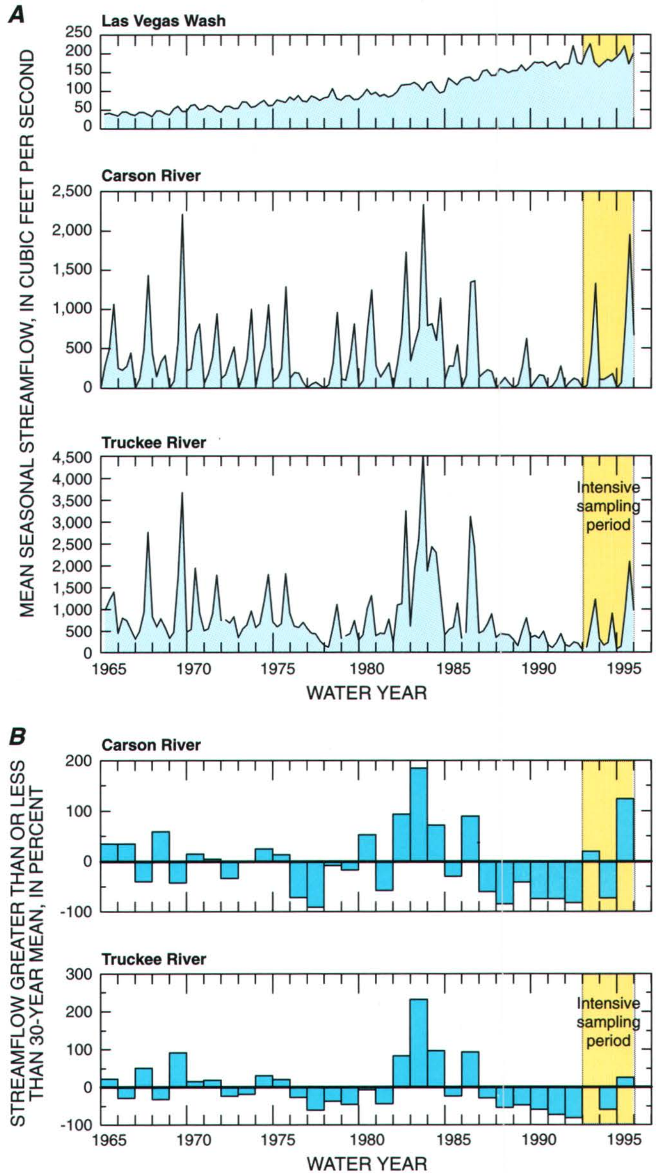


Figure 4. Streamflow during October 1964-September 1995 (water years 1965-95) in Las Vegas Wash increased because of urban drainage and discharge of treated sewage *(A)*. Streamflow in the Carson and Truckee Rivers was characterized by periods of above- and below-average streamflow *(B)*.

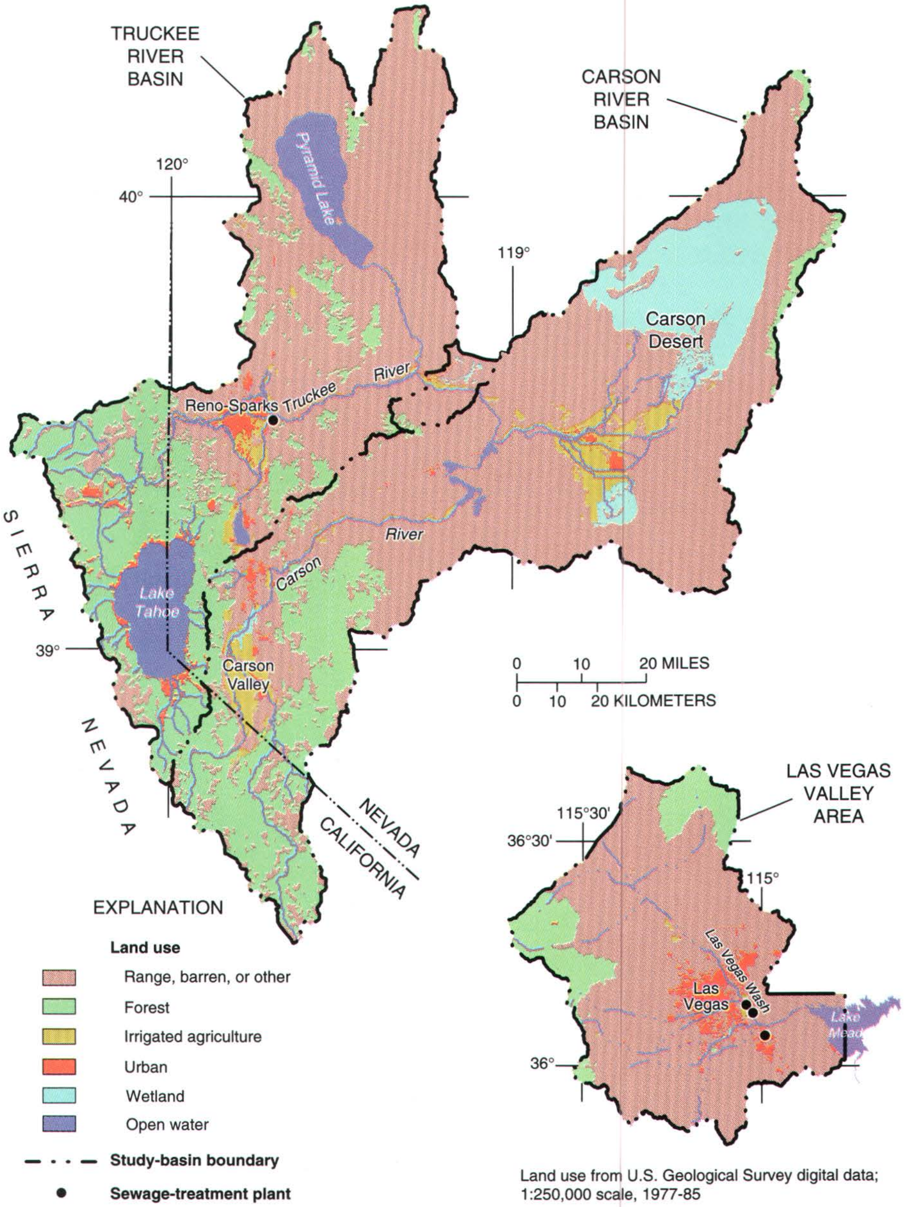


Figure 5. Although most land use in the Nevada Basin and Range Study Unit represents more natural conditions (forest and range), the Las Vegas and Reno-Sparks urban areas and irrigated agriculture in Carson Valley and Carson Desert are important land uses.

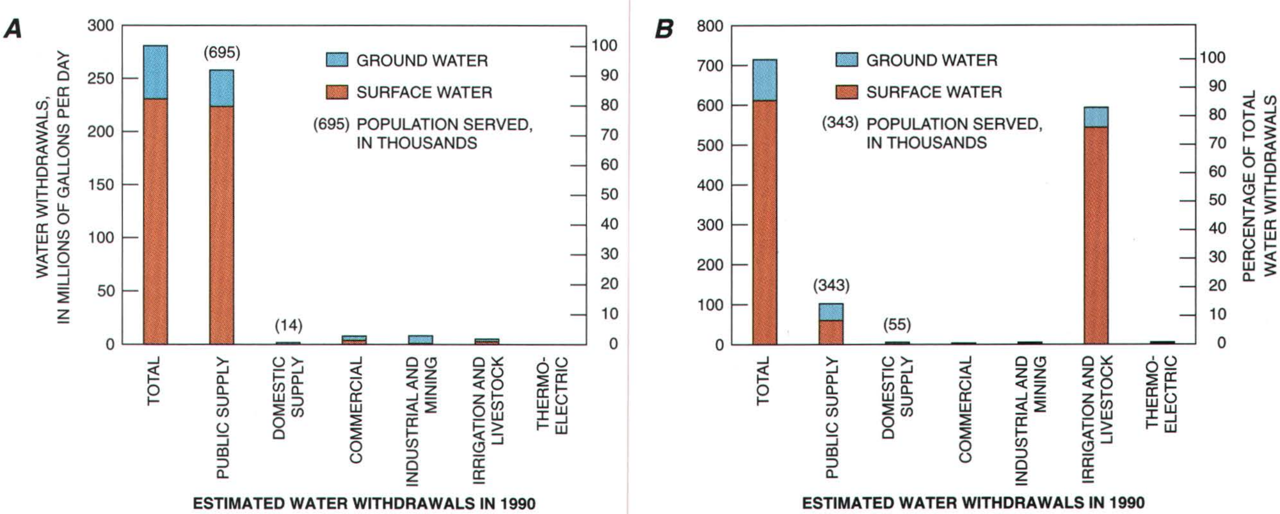


Figure 6. Surface water provided more than 80 percent of the 990 million gallons per day withdrawn in the Nevada Basin and Range Study Unit. The water was used mostly for public supplies in the Las Vegas Valley *(A)* and for irrigation in the Carson and Truckee River Basins, combined *(B)*.

Natural factors of geology and climate have affected the chemical composition of both surface and ground water. In the Nevada Basin and Range (NVBR) Study Unit, several chemical constituents were present in water, sometimes at levels that exceeded water-quality standards and criteria, because of geology and climate. Among these constituents were dissolved solids, arsenic, uranium, and radon.

Minerals in Rocks and Sediment Are Sources of Chemical Constituents

Certain rock types contain elements that may be harmful to humans or animals if they are released and concentrated in the water. In the NVBR Study Unit, arsenic, radon, and uranium were detected in some water samples at concentrations that exceeded drinking-water standards. The geology of the NVBR NAWQA Study Unit is quite diverse (fig. 2), including carbonate, metamorphic, sedimentary, granitic, and volcanic rocks, and unconsolidated deposits derived from the rocks [4]. Water in contact with each of these rock types can derive a chemistry specific to that particular rock type. In headwater areas, such as Carson Valley and the Reno-Sparks area, ground and surface water tend to be dilute (less than 1,000 mg/L of dissolved solids) and contain calcium and bicarbonate ions as the major dissolved constituents. In basin areas, such as Carson Desert and Las Vegas Valley, ground water tends to be dilute to briny (more than 35,000 mg/L of dissolved solids) and contain sodium, calcium, bicarbonate, and sulfate as the major dissolved constituents.

Dissolved Solids Are Contributed by Evaporite Minerals

In headwater areas (fig. 3), contact time between the water and rock, or sediment derived from the rock, is generally short, allowing minimal time for reaction with, or dissolution of, the minerals in the rock. In basin settings, Las Vegas Valley and Carson Desert, water tends to have higher concentrations of dissolved solids than in headwater areas owing to the longer time the water has to react with the rock and sediment. Sediments in the basin parts of the NVBR Study Unit also tend to be finer grained than those in headwater areas; thus, they have more surface area upon which the reactions can take place. Evaporite minerals, characteristically quite soluble, are present in parts of Las Vegas Valley and Carson Desert. If these minerals come into contact with water, they may dissolve, adding constituents including sodium, calcium, bicarbonate, and sulfate. In Las Vegas Valley and Carson Desert, the USEPA secondary maximum contaminant level (SMCL) of 500 mg/L for dissolved solids [7] is commonly exceeded.

Arsenic is Derived From Coatings on Sediment Grains

Surface-water samples from Carson Desert, mostly irrigation-return flow, and Steamboat Creek, in the Reno-Sparks area, had high arsenic concentrations. Agricultural drainwater and lake samples from Carson Desert had arsenic concentrations as great as 380 and 1,400 μg/L, respectively [8,9]. Steamboat Creek (fig. 3) had arsenic concentrations ranging from 44 to 120 μg/L during 1994 [10].

Ground water in several general areas of the Study Unit had arsenic concentrations that exceeded drinking-water standards. Arsenic concentrations in Carson Desert ground-water samples commonly were high with about 57 percent of the samples exceeding the USEPA maximum contaminant level (MCL) of 50 μg/L [7,11,12]. Previous reports have explained that the high arsenic concentrations are a result of dissolution of arsenic-bearing iron oxyhydroxide coatings on sediment grains [8,11,13] caused by a rise in the water table associated with large-scale irrigation. The ultimate source of arsenic probably is volcanic rocks and sediment derived from volcanic rocks.

Uranium is Dissolved From Granitic Rocks and Sediment

In surface waters within the NVBR Study Unit, uranium concentrations were high in Las Vegas Valley and Carson Desert. Las Vegas Wash (fig. 2), which carries urban runoff and drainage from the Las Vegas urban area, had a median uranium concentration of 24 μg/L during 1993-95 [10,14]. Shallow ground-water seepage into Las Vegas Wash is the most likely source. The proposed MCL for uranium is 20 μg/L [7]. Agricultural drains in Carson Desert had median uranium concentrations that ranged from 8 to 157 μg/L [9]. Water samples collected from five drain systems had uranium concentrations greater than 100 μg/L. Lico [8] noted uranium concentrations in drain-water samples ranging from 2.2 to 470 μg/L with a median concentration of 83 μg/L.

Ground water in Las Vegas Valley, Carson Desert, and Lake Tahoe Basin had uranium concentrations greater than the proposed MCL for drinking water. Five shallow monitoring wells in the water-table aquifer in the Las Vegas urban area had uranium concentrations that ranged from 7 to 56 μg/L [12]; the source of this uranium is not known. In the Sierra Nevada, uranium is dissolved from granitic rocks by water rich in carbon dioxide and oxygen [15]. Most of this released uranium is quickly removed from the water by attachment to fracture surfaces and fine-grained sediment and organic material. The resulting uranium-rich sediment grains and organic material have been transported to downstream valleys. Ground-water samples from deep wells on the southern side of Lake Tahoe (fig. 2) had high uranium concentrations ranging from less than 1 to 60 µg/L with a median concentration of 7.4 µg/L. Samples from shallow monitoring wells in the Lake Tahoe area, which had lower uranium concentrations than those from the deep wells, ranged from 0.5 to 16 µg/L with a median concentration of 1.4 µg/L.

Shallow (less than 50 ft) ground-water samples from irrigated areas in Carson Desert, collected during the NVBR study, had a median concentration of 40 µg/L [12], which is double the proposed MCL of 20 µg/L. Previous authors have suggested that uranium in Carson Desert ground water is due to the dissolution of uranium-rich sedimentary organic material and iron- and manganese-oxide coatings and was caused by a rise in the water table from large-scale irrigation in the area [11,15]. Ground water near the distal end of the flow system, in Carson Desert wetlands, had uranium concentrations ranging from 1.9 to 1,500 µg/L with a median value of 200 µg/L [8].

Radon is Derived From Granitic and Volcanic Rocks

The Sierra Nevada (fig. 2) **has rock types that typically have high uranium content and high radon-generating potential.** Radon is a radioactive gas derived from the decay of uranium-238 [16]. Granitic rocks have uranium concentrations that are high relative to most rocks. Radon has been reported at high concentrations in ground-water samples from western Nevada and eastern California [10,12,14,16,17,18], mostly where these rock types (fig. 2) and sediment from them are present. Ground-water samples from most of the study area, with the exception of Las Vegas Valley, had median values that exceeded the former proposed MCL [7] (currently under review for possible revision) of 300 picocuries per liter (pCi/L; see table below).

Median radon concentrations in ground-water samples from the NVBR Study Unit, 1986-95

[--, no sample collected; pCi/L, picocuries per liter]

Geographic area	Shallow monitoring wells		Water-supply wells		Data source (see references)
	Number of samples	Radon-222 (pCi/L)	Number of samples	Radon-222 (pCi/L)	
Las Vegas Valley	28	275	22	380	12,21
Carson Valley	26	1,025	37	860	10,12,14,20
	14	700	41	860	17,18,19
Carson Desert	34	655	18	455	10,12
	51	700	23	440	11,17,19
Lake Tahoe Basin	31	1,300	22	2,200	10,14,17
Reno-Sparks area	28	705	17	760	10,12,14
	--	--	12	750	17

Geothermal Water Has High Concentrations of Arsenic, Boron, and Mercury

Geothermal systems in Carson Desert and Reno-Sparks area add arsenic and boron to ground- and surface-water systems. Active geothermal areas are present in the NVBR Study Unit (fig. 2). A representative water sample from a geothermal aquifer in Carson Desert was reported [22] as having high concentrations of arsenic (130 µg/L) and boron (18,000 µg/L) compared to other ground water in the area. In this area, deeper geothermal water moving upward may affect the quality of shallow ground water [23].

Geothermal systems in the Reno-Sparks area have an effect on the surrounding water quality—arsenic, boron, and mercury concentrations in ground-water samples commonly are high in comparison to other ground water in the area. Arsenic concentrations in water samples from wells have been reported as high as 640 µg/L and from springs as high as 4,000 µg/L [24]. The reported median arsenic concentration for all wells and springs was 970 µg/L [24]. Boron concentrations in water samples from wells and springs, ranged up to 127,000 µg/L with a median concentration of 22,000 µg/L.

Mercury is actively being deposited [24,25] as cinnabar (mercury sulfide), which is a possible source of mercury that could contaminate ground- or surface-water resources. Water samples collected at two sites on Steamboat Creek had a median mercury concentration of 3.2 µg/L [26] during 1977. The same report gives values of 1.7 and 2.0 µg/L of mercury in water samples collected from geothermal springs. Mercury concentrations in water and bottom-sediment samples were reported for three sites along Steamboat Creek [27]. Mercury was detected in 4 of 12 water samples, with a median concentration of 0.2 µg/L. The 17 bottom-sediment samples had a median concentration of 0.31 microgram per kilogram (µg/kg). Two bottom-sediment samples had mercury concentrations of 1.8 µg/kg, much higher than most of the values. Another possible source of mercury in Steamboat Creek was silver and gold ore processing in Washoe Valley during the late 1800s.

Evapotranspiration Concentrates Dissolved Chemical Constituents

Nevada is the driest State in the Nation. Hot summer weather in parts of the Study Unit, namely Las Vegas Valley and Carson Desert, cause high rates of evaporation on open water bodies (lakes and streams) and transpiration by plants, especially when these high temperatures are accompanied by wind. Surface and ground water are affected by these processes directly and indirectly. Evapotranspiration (combined evaporation and transpiration) in the Carson and Truckee River Basins causes dissolved-solids concentrations to increase in a downstream direction. Headwater reaches of the Carson and Truckee Rivers, in the Sierra Nevada and adjacent areas, had median dissolved-solids concentrations of 123 and 86 mg/L, respectively.

Truckee River downstream from Lake Tahoe September 1992. Photograph by Ronald P. Collins, U.S. Geological Survey.

Downstream reaches of the rivers, in Carson Desert and near Pyramid Lake, had median concentrations of 604 and 454 mg/L, respectively—nearly a fivefold increase in dissolved solids. The median concentration in the Carson River in Carson Desert exceeds the 500-mg/L SMCL. Certainly, other factors contribute to this increase, but evapotranspiration is a major factor. Dissolved solids in ground water, especially near the water table, can be concentrated by high rates of evapotranspiration. In Carson Desert, large tracts of phreatophytes (plants that obtain much of their water from ground water) use large amounts of water and leave the dissolved solids behind. Median concentrations of dissolved solids in shallow ground water in Las Vegas Valley and Carson Desert (3,240 and 790 mg/L, respectively) exceeded the SMCL. Evapotranspiration increases the dissolved solids of water in some areas to concentrations greater than that of seawater.

Truckee River upstream from Pyramid Lake, September 1994. Photograph by Stephen J. Lawrence, U.S. Geological Survey.

Surface-Water Quality

Urban activities may create conditions that result in higher-than-normal concentrations of the nutrients, ammonia, nitrite plus nitrate (hereafter referred to as nitrate), and phosphate, trace elements, and synthetic organic compounds including polycyclic aromatic hydrocarbons (PAHs), phthalate esters, phenols, organochlorine pesticides, and polychlorinated biphenyls (PCBs) in water bodies downstream from urban areas. The degree to which downstream water bodies are affected by urban activities depends on many factors such as the size of the urban area, the types of residential, commercial, and industrial activities, and the hydrologic setting.

Nutrients Increased Downstream From Discharges of Sewage

Between 1974 and 1988, the annual total nitrogen load in Las Vegas Wash downstream from sewage discharge increased more than threefold from 750 to 2,400 tons and closely paralleled the population growth during that time. This nitrogen load consisted almost entirely of ammonia. Except for infrequent rainstorms, streamflow upstream from the sewage discharges (fig. 5) was almost entirely urban drainage (site 1, fig. 7). Downstream from sewage discharges (site 2, fig. 7), streamflow in Las Vegas Wash was mostly sewage effluent (86 percent of streamflow in 1990) [28].

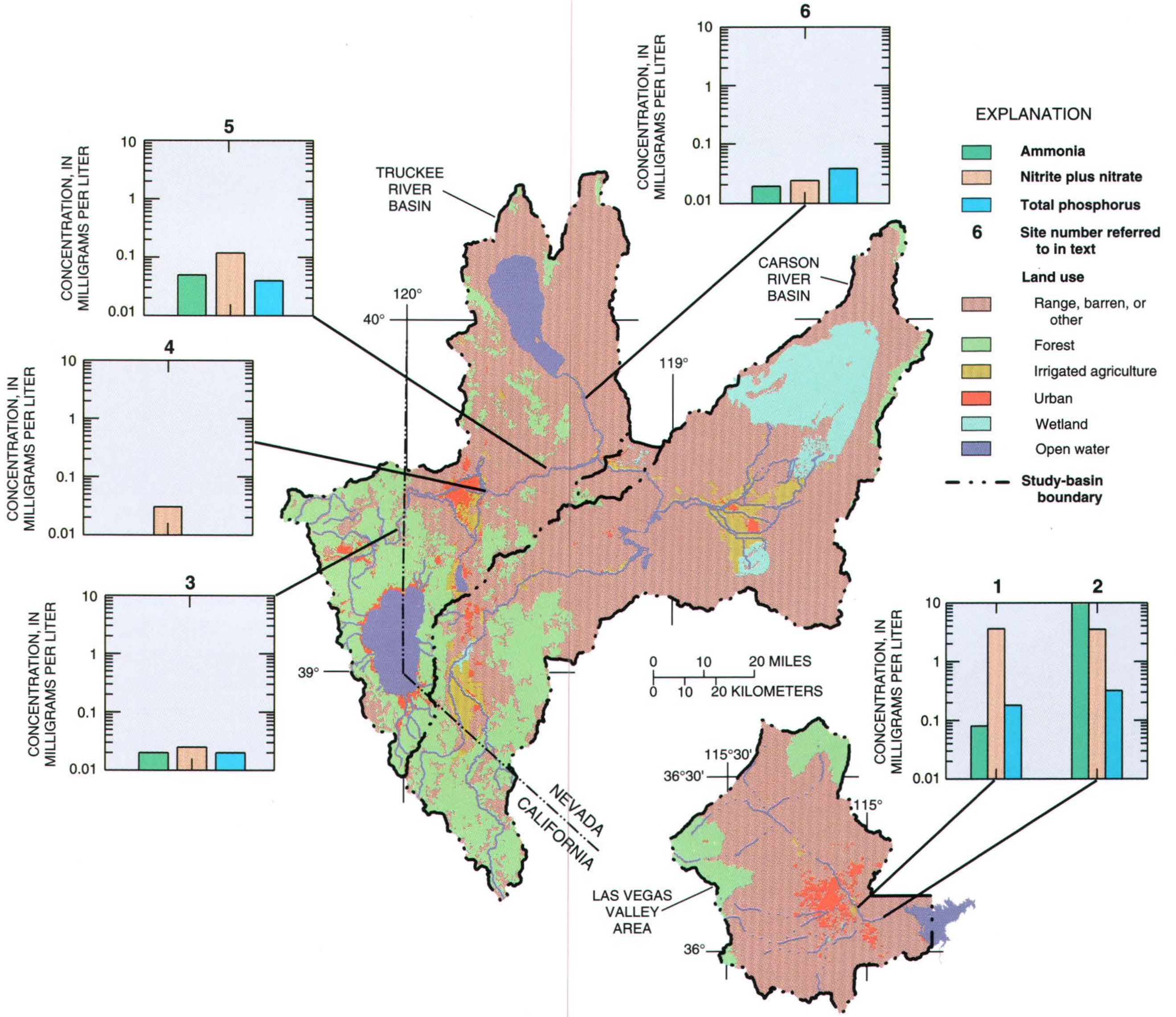


Figure 7. Median concentrations of nutrients during 1993-95 were highest downstream from the discharge of tertiary-treated sewage.

The median ammonia concentration was 2 times higher than the NAWQA national median downstream from Las Vegas urban area, but nearly 300 times higher downstream from the discharge of tertiary-treated sewage. Surface-water samples collected from Las Vegas Wash between April 1993 and April 1995 contained high nutrient concentrations (fig. 7). Ammonia was still a large proportion of the total nitrogen load downstream from the points of sewage discharge (fig. 5). All NAWQA samples collected in Las Vegas Wash downstream from the sewage discharges between April 1993 and April 1995 exceeded the aquatic-life criterion for un-ionized ammonia (0.07 to 2.1 mg/L as N, depending on water temperature and pH [29]). Based on data provided by Steven W. Miller (City of Las Vegas, written commun., 1998), concentrations of ammonia had decreased fivefold in samples collected from Las Vegas Wash during 1996 and 1997, following full implementation of tertiary treatment. These greatly reduced concentrations of ammonia indicate that the aquatic-life criterion for un-ionized ammonia probably is no longer being exceeded.

Nitrate and total-phosphorus concentrations were much higher at the sites on Las Vegas Wash (fig. 7), as compared to sites in the Carson and Truckee River Basins (fig. 7). The median concentration of nitrate for Las Vegas Wash did not exceed the MCL of 10 mg/L as N [7].

Truckee River nutrient concentrations were much lower than those in Las Vegas Wash but were greater downstream from the Reno-Sparks urban area and the discharge of tertiary-treated sewage. Between April 1993 and April 1995, ammonia, nitrate, and total phosphorus were much greater (3 to 10 times) in the river at site 5 (fig. 7) downstream from the discharge of tertiary-treated sewage (fig. 5), as compared to sites 3 and 4. However, Steamboat Creek and other tributaries enter the Truckee River between Reno-Sparks (site 4) and site 5. Just upstream from Pyramid Lake (site 6, fig. 7), ammonia and nitrate had decreased to concentrations close to those measured in the forested headwater area (site 3), but total phosphorus remained elevated (fig. 7). A similar pattern of nitrate and dissolved-phosphorus concentrations was documented in the Truckee River from October 1969 to April 1990 [28]. Nine percent of the NAWQA samples at site 5 (fig. 7) exceeded the aquatic-life criterion for un-ionized ammonia. Nitrate concentrations in NAWQA samples from the Truckee River were low compared to other NAWQA Study Units and did not exceed the MCL. Sewage from Reno-Sparks undergoes tertiary treatment prior to discharge. Although concentrations of nutrients in NAWQA samples were low, the State of Nevada has identified elevated levels of total phosphorus, ammonia, and nitrate as special concerns [30].

Numbers of Pesticides Were Greatest Downstream From Las Vegas and Reno-Sparks

In samples from Las Vegas Wash and the tertiary-treated sewage, 27 pesticides were detected [31]. During 1993-95, twenty-four of these compounds were detected in samples from Las Vegas Wash downstream from the urban area but upstream from the discharge of sewage. The source of these compounds was urban drainage from the Las Vegas area. At least one pesticide was detected in each of the samples collected at this site. The most commonly detected pesticides were the herbicides simazine (98 percent of the samples), prometon (94 percent), diuron (76 percent), and DCPA (69 percent), and the insecticides diazinon (100 percent) and malathion (52 percent). Only one pesticide in one sample from Las Vegas Wash upstream from the discharge of sewage exceeded an MCL. Simazine, a herbicide, exceeded the MCL of 4 µg/L [7]. The aquatic-life criterion for diazinon (0.08 µg/L [32]) was exceeded in 47 percent of the samples and malathion exceeded the criterion (0.1 µg/L [33]) in 25 percent of the samples.

The sewage effluent had detections of 9 compounds and Las Vegas Wash downstream from the discharge of sewage had detections of 12 compounds, during May-August 1994. Las Vegas Wash transports these pesticides to Las Vegas Bay of Lake Mead.

Fourteen pesticides were detected in surface-water samples from the Truckee River and its tributaries downstream from Reno-Sparks urban area, during May-August 1994. Upstream from the Reno-Sparks urban area, the Truckee River had only one pesticide detected in water samples, but downstream 10 compounds were detected. All detections of pesticides had concentrations less than 0.2 µg/L. The most commonly detected pesticides, present at two or more sites on the Truckee River downstream from the Reno-Sparks area, were atrazine, DCPA, deethyl atrazine (a degradation product of atrazine), diazinon, prometon, and simazine. None of these pesticide detections exceeded available MCLs or aquatic-life criteria.

VOCs (THMs and MTBE) Were Detected Downstream From Las Vegas

VOCs were detected in all four samples collected at Las Vegas Wash downstream from the discharge of treated sewage during 1995. All samples contained trihalomethanes (THMs) and methyl *tert*-butyl ether (MTBE). Of the THMs detected, two were detected in all samples; chloroform ranged from 0.6 to 1.4 µg/L and bromodichloromethane ranged from 0.2 to 0.4 µg/L. Two other THMs detected were bromoform (one sample) and chlorodibromomethane (two samples). THMs are known to form when water is chlorinated. MTBE, a gasoline oxygenate, was detected at concentrations that ranged from 0.7 to 1.3 µg/L. The source of these VOCs may be urban drainage from Las Vegas or treated sewage discharged into Las Vegas Wash. The combined concentrations of THMs did not exceed the proposed MCL of 80 µg/L [7] and MTBE did not exceed the drinking water advisory at 20-40 µg/L [34].

Bottom Sediment Was Enriched with Trace Elements Downstream From Las Vegas and Reno-Sparks

Between 1992 and 1996, a large suite of trace elements and synthetic organic compounds were measured in bottom sediment collected from seven sites in Las Vegas Valley and six sites in the Truckee River Basin. Trace elements were analyzed for the silt- and clay-sized particles smaller than 0.063 millimeter (mm) [35]. Elevated concentrations of cadmium, chromium, copper, lead, and zinc are common in water and bottom sediment within urban areas [36,37,38]. Because these five elements may be indicative of an urban influence, they were used to compute an urban trace-element index (UTEI) for each site in Las Vegas Valley and the Truckee River Basin. This index was calculated by computing the ratio of the concentration of each element at each site to the corresponding element concentration at a background (unaffected by urban activities) site [39], then summing these ratios to get one value for each site.

The background site for Las Vegas Valley (site 3, fig. 8*A*) drains an area east of Las Vegas Wash. Although a U.S. Air Force base is upstream from this site, the trace-element concentrations were the lowest measured in Las Vegas Valley during the NAWQA study. The background site in the Truckee River Basin (site 2, fig. 9*A*) is upstream from Reno-Sparks [39]. Both sites appear to be minimally affected by urban activity.

Bottom sediment in water bodies downstream from the Las Vegas and Reno-Sparks urban areas were enriched with trace elements. The UTEIs for the lower part of Las Vegas Wash (site 6, fig. 8*A*) and Las Vegas Bay (fig. 3) near the mouth of Las Vegas Wash (site 7) were about 1.5 to 2 times higher than the background site, respectively. This indicates that drainage and sewage effluent from the Las Vegas urban area has enriched the

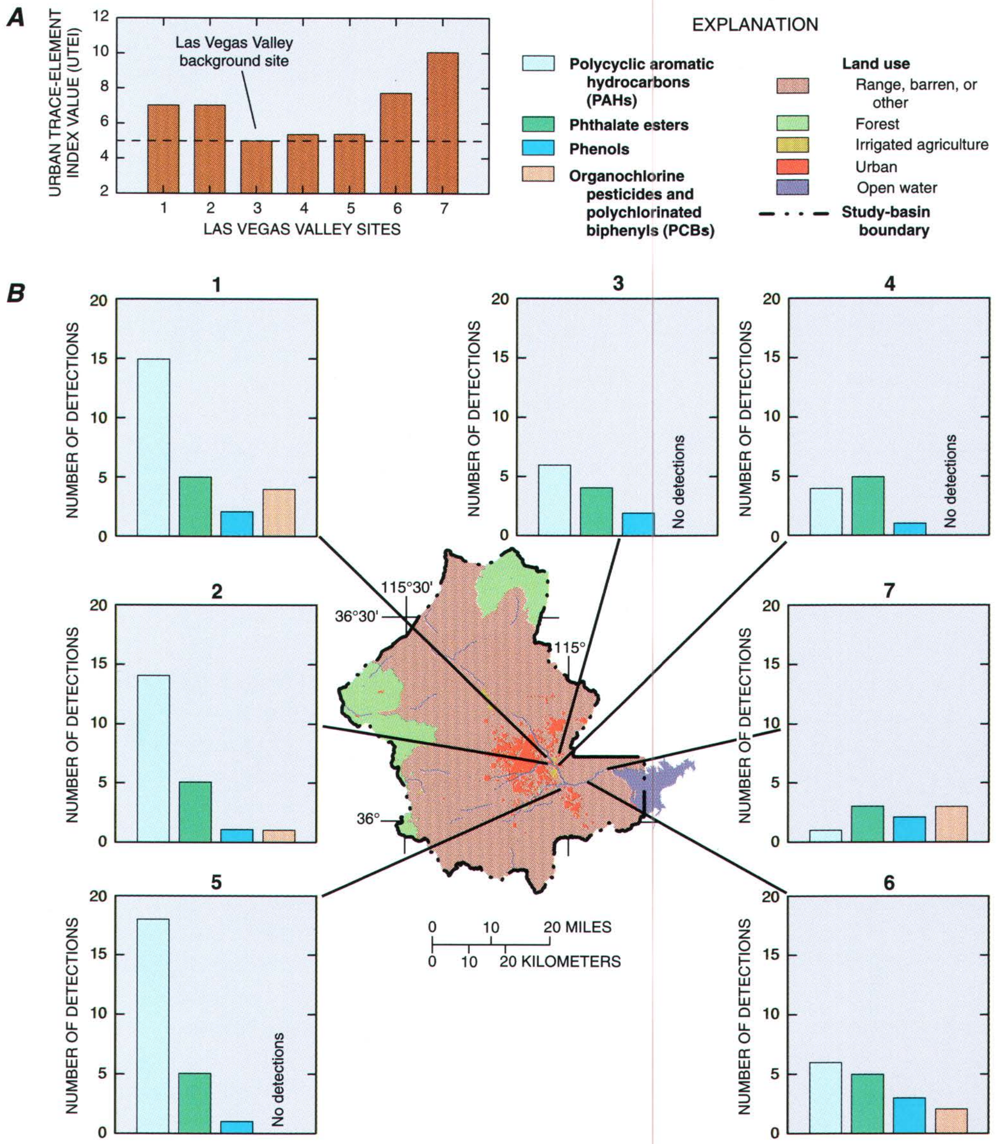


Figure 8. An index of trace elements *(A)* commonly associated with urban activities (cadmium, chromium, copper, lead, and zinc) and numbers of synthetic organic compounds *(B)* detected in bottom sediment were high downstream from the Las Vegas urban area.

bottom sediment in water bodies downstream with cadmium, chromium, copper, lead, or zinc.

In the Truckee River Basin, the highest UTEI in bottom sediment was measured at a site within Reno (site 3, fig. 9*A*). The UTEI is three times higher at the Reno site than upstream at the background site (site 2). Several miles downstream from the Reno-Sparks urban area (site 4), the UTEI drops markedly but still is about 50 percent higher than background. The UTEI remains at this level downstream at site 5.

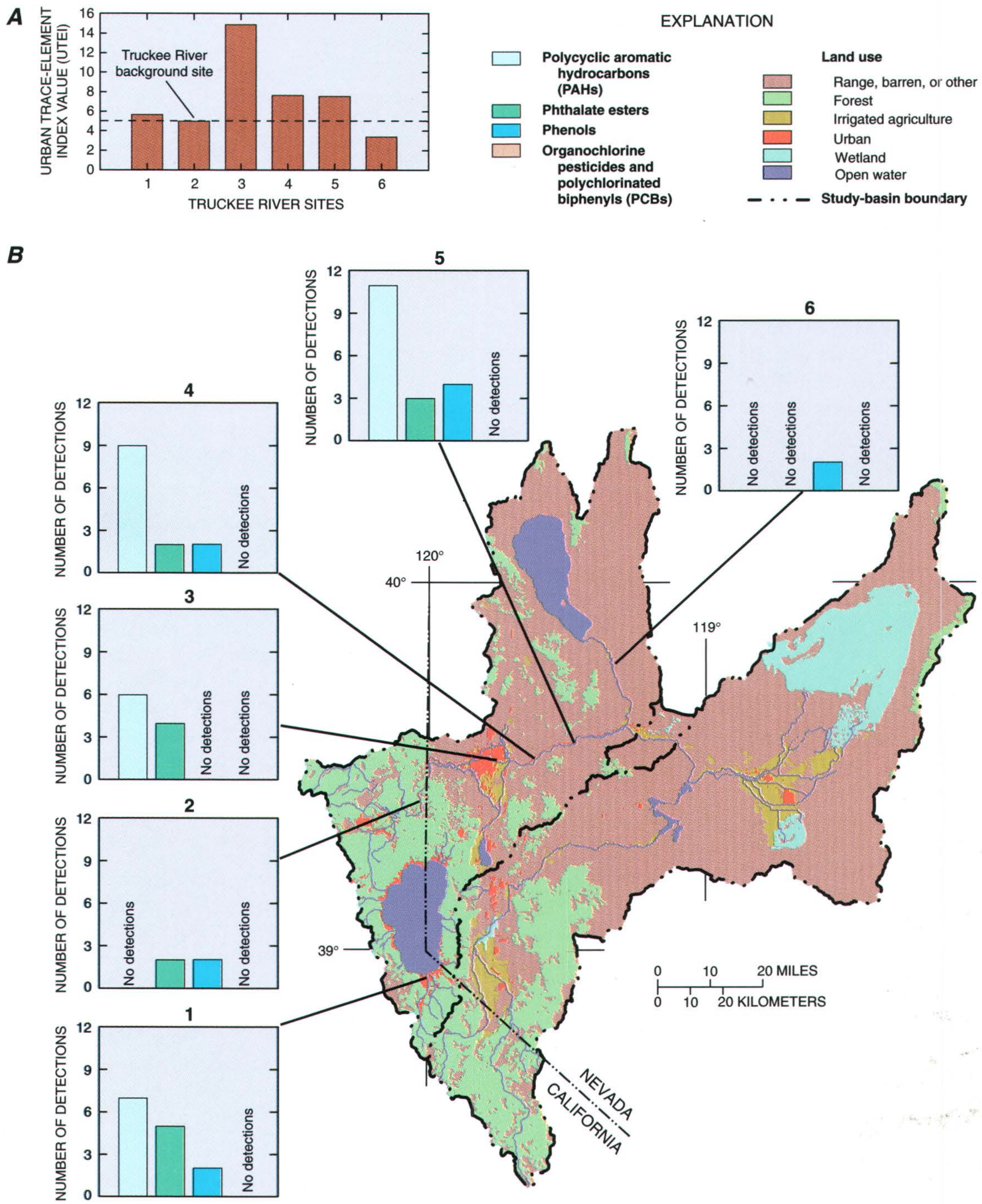
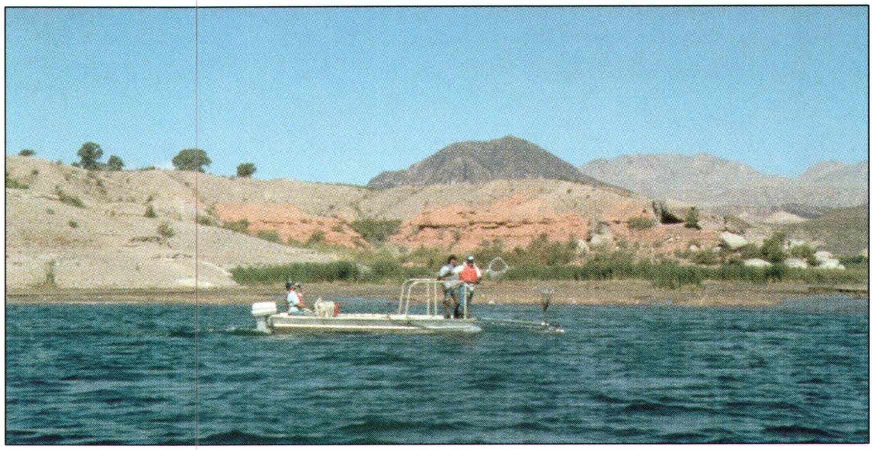


Figure 9. An index of trace elements *(A)* commonly associated with urban activities (cadmium, chromium, copper, lead, and zinc) and numbers of synthetic organic compounds *(B)* detected in bottom sediment were high downstream from the Reno-Sparks urban area.

Synthetic Organic Compounds Were Found in Bottom Sediment Downstream From Las Vegas and Reno-Sparks



Electrofishing for carp on Lake Mead, May 1995. Photograph by Kenneth J. Covay, U.S. Geological Survey.

Four classes of synthetic organic compounds were detected in bottom sediment collected from sites in Las Vegas Valley and three classes were detected in Truckee River bottom sediments. Twelve compounds—six PAHs, four phthalate esters, and two phenols—were detected in clay-, silt-, and sand-sized particles smaller than 2.0 mm [35] at the background site in the Las Vegas Valley (site 3, fig. 8*B*). PAHs can be produced by human activities and natural processes, including incineration of wastes or forest fires [40]. Phthalate esters are used as plasticizers in manufacturing processes, and phenols are used in the production of pesticides, pharmaceuticals, dyes, plastics, and explosives [40]. Only 9 organic compounds were detected in Las Vegas Bay (site 7), the lowest number detected in the Las Vegas Valley area, but 16 compounds were detected at site 6, upstream from Las Vegas Bay. Twenty-one compounds were detected in Flamingo Wash (site 2). Bottom-sediment samples from those streams that drain the most urbanized parts of Las Vegas Valley contained the greatest number of organic compounds (fig 8*B*).

The most commonly detected organochlorine compounds were chlordane and degradation products of DDT such as DDD. These compounds did not exceed sediment-quality guidelines proposed by the U.S. Environmental Protection Agency [41].

The NVBR NAWQA, National Park Service, and U.S. Fish and Wildlife Service studied the occurrence of synthetic organic compounds and their potential effects on endocrine systems of carp in Las Vegas Wash and Las Vegas and Callville Bays of Lake Mead [42]. Las Vegas Wash transports urban drainage and sewage effluent from Las Vegas Valley to Las Vegas Bay. Callville Bay, in a part of Lake Mead that is upstream from Las Vegas Bay, was used as a background site.

Synthetic organic compounds including organochlorine pesticides, PCBs, dioxins and furans, phthalate esters, and phenols were detected at higher concentrations in the water column, bottom sediments, or carp tissues from Las Vegas Wash and Bay than from Callville Bay [42]. The authors concluded that Las Vegas Wash was contributing the compounds to Lake Mead.

PCBs have been used as plasticizers, as hydraulic lubricants in heat-transfer systems, and as dielectric fluids in electrical capacitors and transformers [40]. Dioxins and furans were produced inadvertently during the

National Park Service divers retrieve semipermeable membrane devices from Lake Mead, July 1995. Photograph by Kenneth J. Covay, U.S. Geological Survey.

manufacture of pesticides and PCBs; they are commonly found in effluent from sewage-treatment plants [40].

As a result of findings by this study and other water-quality issues, the Nevada Division of Environmental Protection instituted the Lake Mead Water Quality Forum. Forum members, including representatives of Federal, State, and local agencies and Las Vegas area communities, meet to discuss and exchange information on water-quality issues.

Synthetic organic compounds were detected at all sites in the Truckee River Basin, including the background site (two phthalate esters and two phenols; site 2, fig. 9*B*). Organochlorine pesticides and PCBs were not detected in bottom-sediment samples from the Truckee River. The bottom sediment at site 5 contained the largest number of compounds (18) detected in the basin, representing PAH, phthalate ester, and phenol classes (fig. 9*B*). Bottom sediment at site 1 contained the second largest number of compounds (14), site 4 had 13 compounds, and site 3 had 10 compounds. These sites are affected by urban activities. The farthest downstream sampling site (site 6) had only two compounds, both in the phenol class.

Bottom-sediment samples are collected from Lake Mead, July 1995. Photograph by Kenneth J. Covay, U.S. Geological Survey.

Ground-Water Quality

Shallow monitoring wells near the water table and deeper supply wells in principal aquifers in urban areas were sampled to determine the effect of urban activities on ground-water quality [12]. The effects of urban land use can be indicated by detections of nitrate (from sewage or fertilizers) and synthetic organic compounds (pesticides and VOCs). In Las Vegas Valley, 32 shallow monitoring wells and 22 supply wells in underlying, deeper principal aquifers were sampled. In the Reno-Sparks area, 28 shallow monitoring wells and 18 supply wells in underlying, deeper principal aquifers were sampled.

NAWQA samples from principal aquifers in urban areas generally did not contain nitrate or synthetic organic compounds at levels that pose a risk to human health. Other parts of principal aquifers not sampled during this study, however, are contaminated [1]. Small concentrations of synthetic organic compounds were present in many water-supply wells, which indicates that some water from the shallow water-table aquifers is moving into the principal aquifers. Because the shallow water-table aquifers were contaminated in urban areas of the Study Unit, the potential exists for water and accompanying contaminants to make their way into principal aquifers [12].

Contamination of principal aquifers may be enhanced by certain natural and human-induced factors. Areas where ground water moves downward due to natural conditions or ground-water withdrawals, and where no confining layers separate the shallow water-table and deeper principal aquifers, are susceptible to contamination. Even in areas with a protective confining layer, several mechanisms exist that could compromise the integrity of the confining layers and allow migration of contaminants into the principal aquifers used for water supply. Among these mechanisms are overpumping of an aquifer, causing subsidence and disturbance of a confining layer; breaking of a well casing due to subsidence; improper well construction; and downward movement of water in abandoned or nonpumping wells. Artificial recharge is another mechanism that can move contaminants into ground-water supplies.

Nitrate Was High in the Shallow Aquifers Beneath the Las Vegas Urban Area

Nitrate contamination of ground water in urban areas can be caused by excess fertilizer application and by sewage from septic systems or leaky sewer pipes. These sources of contamination commonly affect shallow water-table aquifers [43]. Once the shallow water-table aquifer is contaminated, it becomes a source of contaminants to the deeper principal aquifer.

Shallow water-table aquifers in urban areas within the NVBR Study Unit had a wide range of nitrate concentrations. In Las Vegas, the median nitrate concentration (4.4 mg/L as N) for 32 monitoring wells tapping the shallow aquifer was more than double the national NAWQA median. Twelve percent of the samples equaled or exceeded the nitrate MCL [44] of 10 mg/L as N [7]. In the Reno-Sparks area, nitrate concentrations (median, 0.9 mg/L as N) were about equal to the national median.

NAWQA samples from principal aquifers in urban areas within the NVBR Study Unit had nitrate concentrations that were less than the national NAWQA median. No NAWQA water sample from deeper principal aquifers in urban areas of the NVBR Study Unit exceeded the MCL for nitrate.

Pesticides Were Commonly Detected in Aquifers Beneath the Reno-Sparks Urban Area

Forty-seven percent of the water samples from shallow monitoring wells in urban areas (Reno-Sparks and Las Vegas areas) had pesticide detections. Triazine herbicides were the most commonly detected compounds and included atrazine, deethyl atrazine (a degradation product of atrazine), prometon, and simazine. The Reno-Sparks area had a higher frequency of pesticide detections (68 percent) than the Las Vegas area (28 percent). Two or more pesticides were detected in 39 percent of the samples from the Reno-Sparks area [45] and in 9 percent of the samples from the Las Vegas area. All detections of pesticides were at concentrations that did not exceed available MCLs. Pesticide occurrences in samples from wells in shallow water-table aquifers were more prevalent in urban areas than in agricultural areas within the NVBR Study Unit. As a result of the pesticide detections by the NVBR NAWQA study, the Nevada Division of Agriculture is cooperating with the U.S. Geological Survey to develop a network for monitoring pesticides in shallow ground water [46]. The Nevada Division of Agriculture also is reviewing NVBR NAWQA data to evaluate pesticide registrations for Nevada.

In urban land-use areas, 44 percent of the samples from supply wells in the principal aquifer in the Reno-Sparks area and 14 percent from the Las Vegas area contained pesticides at low concentrations (less than 0.1 µg/L). Six different compounds, mostly triazine herbicides, were detected. Two or more pesticides were detected in 22 percent of the supply wells sampled in the Reno-Sparks area. Effects of multiple pesticides at low levels are not known.

VOCs Were Detected in About 50 Percent of the Sampled Wells

More than 50 percent of the samples taken from shallow monitoring wells had detections of one or more VOCs [12]. Three general types of VOCs commonly were detected in shallow ground water: solvents, THMs, and MTBE. Chloroform, a THM, was detected in samples from the Las Vegas (68 percent) and Reno-Sparks (21 percent) urban areas. Samples exceeded MCLs [7] for the chlorinated solvents tetrachloroethylene (three samples) and trichloroethylene (one sample), and two samples exceeded the USEPA drinking water advisory (20-40 µg/L) for MTBE [34].

Shallow monitoring well in Reno-Sparks urban area, October 1995. Photograph by Michael S. Lico, U.S. Geological Survey.

VOCs were detected in 45 percent of the samples taken from supply wells in principal aquifers in urban areas. Among the 12 compounds detected, chloroform was the most common (39 percent of the samples). Chloroform was detected more commonly in Las Vegas (50 percent of the samples) than in the Reno-Sparks area (28 percent). Other VOCs detected in samples from principal aquifers in urban areas were tetrachloroethylene (13 percent), trichlorofluoromethane (8 percent), and a few other THMs in one or two samples each. Individual THM concentrations ranged from 0.2 to 23 µg/L, and combined concentrations did not exceed the MCL of 80 µg/L [7]. One sample from the principal aquifer beneath the Las Vegas urban area had a tetrachloroethylene concentration (21 µg/L) greater than the MCL of 5 µg/L [7].

Agriculture is a predominant land use in parts of the Carson River Basin (Carson Valley and Carson Desert) and of minor importance in the Las Vegas Valley and Truckee River Basin. Surface- and ground-water resources can be affected by irrigation drainage, nutrients (from fertilizers), and pesticides.

Irrigating crops in Carson Valley with treated sewage effluent, May 1996. Photograph by Michael S. Lico, U.S. Geological Survey.

Irrigation Drainage Contributed Dissolved Solids, Arsenic, Boron, Molybdenum, and Uranium to Wetlands in Carson Desert

Dissolved solids, arsenic, boron, molybdenum, and uranium are dissolved from desert soils by irrigation within Carson Desert. Previous studies [8,47] and one completed by the NVBR NAWQA in cooperation with the Department of the Interior National Water Quality Irrigation Program [9] have documented contamination of surface water by irrigation drainage in Carson Desert.

Dissolved-solids, arsenic, boron, and molybdenum concentrations commonly exceeded aquatic-life criteria for water in Carson Desert wetlands [47]. These wetlands are an important area for migratory birds in the Pacific flyway. Concentrations of most constituents were greater in drainwater during the nonirrigation season (November-March) than during the irrigation season (April-October) because the flow is dominated by shallow ground-water discharge. Selenium does not appear to be an issue in irrigation drainage in Carson Desert, although it is in other parts of the Nation [48].

Irrigated agriculture in Carson Desert, July 1989. Photograph by Michael S. Lico, U.S. Geological Survey.

Loads (or quantities) of dissolved solids, boron, and arsenic delivered to wetlands in Carson Desert are important because evapotranspiration can greatly concentrate them and high concentrations are detrimental to aquatic life. Loads of chemical constituents generally were greater during the irrigation season than during the nonirrigation season [9]. The estimated yields (or load per unit area) of these constituents differed greatly among drain systems in Carson Desert (fig. 10). Yields are important because they help identify areas that are contributing most of the loads of constituents. Five specific areas have been identified as the greatest contributors of potentially toxic constituents to the drain systems [9].

Evidence Suggests Nutrient Enrichment in Some Agricultural Areas

Agricultural practices commonly include the application of fertilizer to increase plant growth and yield.

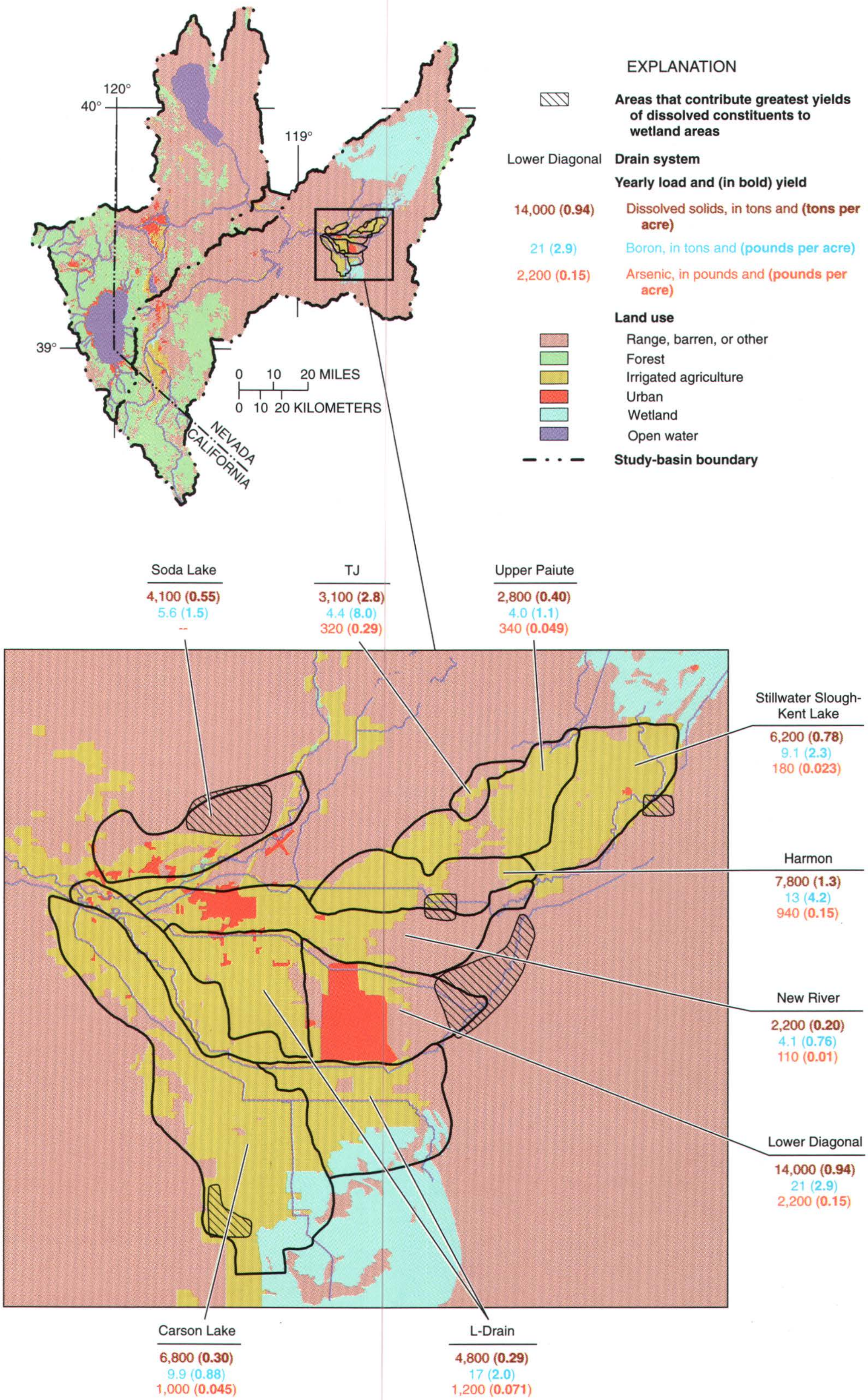


Figure 10. Loads of dissolved solids, boron, and arsenic delivered by agricultural drain systems in the Carson Desert during 1995 differed greatly.

Summary of pesticide compounds detected in surface- and ground-water and bottom-sediment samples in and near agricultural areas in the Carson River Basin, 1992-95

[Concentrations listed are maximum for that site and are expressed in micrograms per liter for water samples and micrograms per kilogram for bottom-sediment samples; --, no sample collected]

Location	Pesticide compounds detected and concentration		Number of samples	
	Water samples	Bottom-sediment samples	Water	Bottom sediment
Surface water				
Carson River in headwater area upstream from Carson Valley agriculture (East Fork and West Fork of the Carson River)	pebulate, 0.009	no detections	8	1
Carson River downstream from Carson Valley agriculture (between Carson City and Lahontan Reservoir)	atrazine, 0.029; carbofuran, 0.033; diazinon, 0.032; deethyl atrazine, 0.010; prometon, 0.005; simazine, 0.005	no detections	12	2
Carson River downstream from Carson Desert agriculture	2,4-D, 1.5; atrazine, 0.008; cyanazine, 0.028; deethyl atrazine, 0.008; EPTC, 0.016; pebulate, 0.009; prometon, 0.058; simazine, 0.007	DDE, 1.2	8	1
Irrigation drains in Carson Desert agricultural area (19 sites)	2,4-D, 1.6; atrazine, 0.023; carbofuran, 0.026; chlorpyrifos, 0.006; cyanazine, 0.019; deethyl atrazine, 0.009; EPTC, 0.042; malathion, 0.018; prometon, 0.023; propargite, 0.003; simazine, 0.005; tebuthiuron, 0.022	not analyzed	19	--
Ground water				
Shallow ground water in Carson Valley agricultural area (20 sites)	atrazine, 1.2; bromacil, 0.020; deethyl atrazine, 0.032; simazine, 0.13	not analyzed	20	--
Shallow ground water in Carson Desert agricultural area (10 sites)	acetochlor, 0.023; deethyl atrazine, 0.003; simazine, 0.016	not analyzed	10	--

Fertilizer can contain nitrogen and phosphorus in varying amounts. Less than 1 ton of nitrogen per square mile is applied to crops in western Nevada [49], in contrast to 7 tons or more per square mile in the upper Midwestern United States. Alfalfa, a legume that fixes its own nitrogen from the atmosphere, is the major crop grown in Carson Desert and does not need additional fertilizer after the plants are established. Animal manure also can contribute nitrogen to water in parts of the NVBR study area. An estimated 1 to 2 tons of nitrogen per square mile is contributed annually to Carson Valley by animal manure [49]. Less than 1 ton of nitrogen per square mile is contributed annually by this source in Carson Desert. These inputs of nitrogen are low compared to the rest of the Nation.

Nutrients were enriched in the Carson River downstream from the Carson Valley and Carson Desert. Median concentrations of nitrate, total phosphorus, and orthophosphate from October 1969 through April 1990 were enriched at Carson River sites downstream from Carson Valley [28]. During most of that period, treated sewage was discharged into the Carson River (this practice was stopped in 1987); thus, agriculture in Carson Valley was not the only source of nutrients during that period. Concentrations of ammonia, total phosphorus, and orthophosphate in the Carson River upstream from Lahontan Reservoir (fig. 3) had decreased since the 1980s.

Data collected during this cycle of NAWQA show that ammonia and nitrate concentrations in the Carson River upstream from Carson Valley were the same as those downstream from Carson Valley (medians, 0.01 and less than 0.05 mg/L as N, respectively). A slight increase in ammonia concentrations above background was evident in samples collected in Carson Desert. The median concentration of orthophosphate upstream from Carson Valley was 0.01 mg/L as P. Orthophosphate concentrations increased downstream from Carson Valley to 0.08 mg/L as P and downstream from Carson Desert to 0.15 mg/L as P.

A retrospective analysis of nutrient data collected from October 1969 through April 1990 [50] showed that shallow ground-water samples from beneath agricultural areas in the Carson River Basin had orthophosphate concentrations (median, 0.22 mg/L) that were greater than those from beneath urban areas (median, 0.04 mg/L for Las Vegas and Reno-Sparks combined). In comparison to other land uses (urban, range, and wetlands), ammonia and nitrate were not present in high concentrations beneath agricultural areas. In 8 of 45 shallow monitoring wells in agricultural areas, nitrate exceeded the MCL of 10 mg/L as N [7]. Ground-water samples collected from monitoring wells in the shallow aquifers during this cycle of NAWQA had median concentrations of nitrate of 0.16 and 0.66 mg/L as N for Carson Valley and Carson Desert, respectively. These concentrations were less than those in urban areas of the Study Unit [12].

Wetlands in Carson Desert, December 1988. Photograph by Michael S. Lico, U.S. Geological Survey.

Pesticides Were Present at Low Levels in Agricultural Areas

Pesticides commonly are used by farmers to enhance the yield of crops by controlling insects, weeds, and fungi. The Carson River system has been somewhat affected by pesticide applications. A retrospective analysis of available data from October 1969 to April 1990 [51] showed that pesticides were present in the Carson River downstream from the Carson Valley agricultural area. Results from surface-water samples taken upstream from Lahontan Reservoir showed detections of 2,4-D, γ-BHC, chlordane, DDD, DDE, DDT, diazinon, endrin, heptachlor, and carbaryl.

Samples collected from the Carson River upstream from Carson Valley agricultural area had only one pesticide detected. However, downstream from Carson Valley, but upstream from Lahontan Reservoir, six pesticides were detected in 12 water samples. Downstream from Carson Desert agricultural activities, eight pesticides were detected at two sites. **Apparently, drainage from agricultural fields and other areas has contributed pesticides to the Carson River system, although at concentrations less than available MCLs.**

Results of pesticide analysis for samples collected during 1995 from irrigation drains in the Carson Desert agricultural area [9] show the presence of pesticides in 17 of 19 samples. In all, 12 pesticides were detected. Drains at the downstream ends of their respective drainage systems tended to have water with a greater number of pesticides than those more upstream in the systems. Two of these downstream sites had six pesticides detected. Atrazine, simazine, and prometon were the most commonly detected pesticides. All pesticide detections were less than 1 μg/L except one value of 1.6 μg/L for 2,4-D. Concentrations detected did not exceed MCLs or aquatic-life criteria.

During this cycle of NAWQA, bottom-sediment samples were collected from surface-water sites to determine whether organochlorine pesticides had been contributed from upstream activities. Except for one sample, pesticides were not detected in bottom sediment collected in the Carson River. In this one sample, collected downstream from the Carson Desert agricultural area, DDE was detected. Previous investigators [22,47] reported detections of pesticides in bottom sediment collected from wetlands downstream from the Carson Desert agricultural area.

Shallow ground-water quality also may be affected by agricultural use of pesticides. During 1994-95, shallow ground-water samples were collected from 30 monitoring wells beneath agricultural areas in the Carson River Basin as part of the NAWQA study. Five samples from Carson Valley and three from Carson Desert had detections of pesticides at low concentrations (less than 1 μg/L), except for one sample that had 1.2 μg/L of atrazine, which was less than the MCL of 3 μg/L [7]. The most commonly detected pesticides were triazine herbicides, including atrazine, deethyl atrazine (a degradation product of atrazine), and simazine.

The two major, historical mining areas in the Carson River Basin, the Leviathan Mine and the Comstock Lode (fig. 11), were operationally related for a time even though they were in widely separated parts of the basin [52]. The Leviathan Mine, in the California part of the East Fork Carson River drainage, produced copper sulfate used to refine silver from ore originating in the Comstock mines. The Leviathan Mine operated intermittently until 1962. During the Leviathan's active years, about 22 million tons of overburden containing large amounts of sulfide minerals were discarded in the area around the mine [5]. Bryant Creek, a tributary to the East Fork Carson River, drains most of the area occupied by the Leviathan Mine and enters the East Fork Carson River downstream from the Nevada-California border. Bryant Creek (fig. 3) and several of its tributaries receive acidic drainage and sediment from the mine area.

In 1859, a silver- and gold-rich ore body (Comstock Lode) was discovered in the Carson River Basin, near what is now Virginia City, Nev. This discovery began a 20-year period (1860-80) of intensive ore processing in the upper and middle parts of the Carson River Basin. During this 20-year period, about 7,500 tons of elemental mercury were lost, mostly downstream from Carson City where mercury amalgamation was used to recover silver and gold from bulk ore [6]. High-grade silver ore was processed in stamp mills that were located along 8 mi of the Carson River beginning about 1,500 ft upstream from the Carson City sampling site (site 3). Ore tailings still exist along the Carson River,

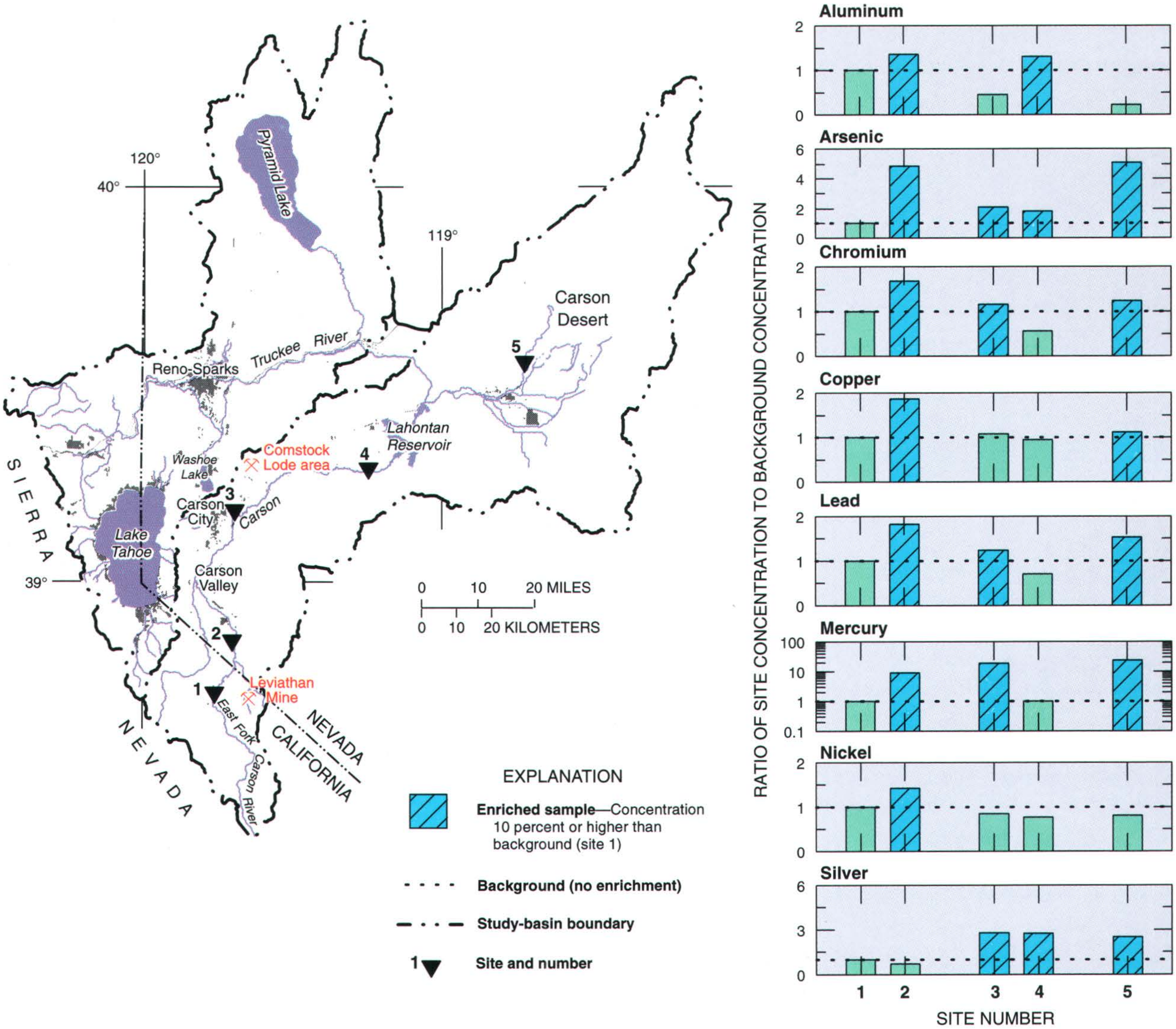


Figure 11. Carson River bottom sediments were enriched with aluminum, arsenic, copper, chromium, lead, mercury, and nickel from the Leviathan Mine and other mines; downstream from the Comstock Lode mining area, mercury and silver were enriched.

East Fork Carson River upstream from Carson Valley, September 1993. Photograph by Stephen J. Lawrence, U.S. Geological Survey.

especially in the flood plains, and continue to erode into the river during periods of high streamflow.

The acidic drainage and erosion from the Leviathan Mine have enriched trace-element concentrations in stream-bottom sediment in the East Fork Carson River downstream from its confluence with Bryant Creek. Stream-bottom sediment at site 2 (fig. 11) was enriched with aluminum, arsenic, chromium, copper, lead, mercury, and nickel compared to upstream background concentrations [39]. The Leviathan Mine is probably the source of enriched aluminum, arsenic, chromium, copper, lead, and nickel [39]. Mercury in stream-bottom sediment of the East Fork Carson River probably was not from the Leviathan Mine (Thomas J. Suk, California Regional Water Quality Control Board, personal commun., 1997). Although the source of mercury is not known, geothermal discharge to the river and natural deposits and historical mining [53] of cinnabar (mercury sulfide) are two possible sources. This area is within one of three regions, worldwide, with economically extractable deposits of mercury ore [57].

The effects of Comstock-era mining were seen in bottom sediments throughout the lower Carson River and in Lahontan Reservoir. Stream-bottom sediment near and downstream from Carson City (sites 3, 4, and 5; fig. 11) was enriched from 3 to 25 times in silver or mercury compared to site 1, the upstream background site [39]. Mercury coexists with silver in the ore tailings because it was used in the amalgamation process to separate the silver and gold from crushed ore during the Comstock era. Mercury contamination is well documented in the lower Carson River from Carson City to the Carson Desert [54,55,56,57].

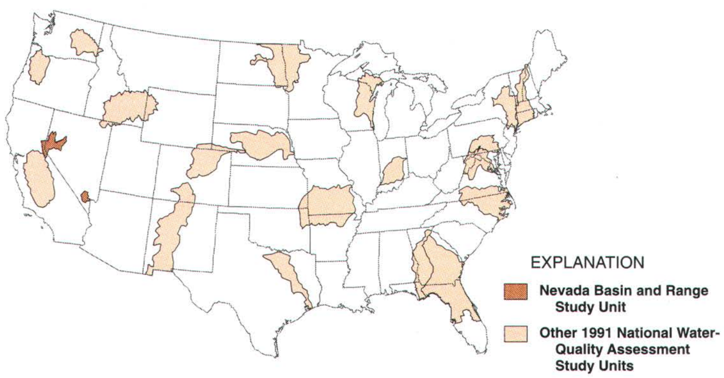
Stream-bottom sediment collected upstream from Lahontan Reservoir (site 4) in 1992 by NAWQA personnel contained mercury concentrations that were much lower than those previously measured at this site [39]. Mercury concentrations in the previously collected bottom-sediment samples [54,55,56] were 3 to 40 times higher than in the bottom-sediment samples collected in 1992. These previous samples [54,55] included the top of 1.5 to 3 inches of bottom sediment, whereas bottom-sediment samples from the top 1 inch were collected in 1992. Thus, the sample collected in 1992 could be more influenced by the recent erosion of soil with low mercury concentrations than were samples from previous studies.

Before the construction of Lahontan Reservoir in 1915 and during wet years since then, Carson River water and sediment were deposited in Carson Desert, the natural terminus of the river. The stream-bottom sediment collected at site 5 in Carson Desert (fig. 11) was greatly enriched in silver and mercury [39].

Mining activity associated with the Comstock Lode in the Truckee River Basin was limited to processing ore around Washoe Lake (fig. 3), the headwater of Steamboat Creek that is tributary to the Truckee River downstream from the Reno-Sparks urban area. Ore from the Comstock mines was transported to the stamp mills near Washoe Lake and processed using mercury amalgamation.

Mercury concentrations in Truckee River stream-bottom sediment were much less than in those of the Carson River [39]. However, Truckee River bottom sediments were enriched by 20 to 25 times in mercury downstream from its confluence with Steamboat Creek, as compared to an upstream background site [39]. The enrichment may be a result of mercury lost during ore processing in Washoe Valley and mercury in the discharge of geothermal water to Steamboat Creek [24,25].

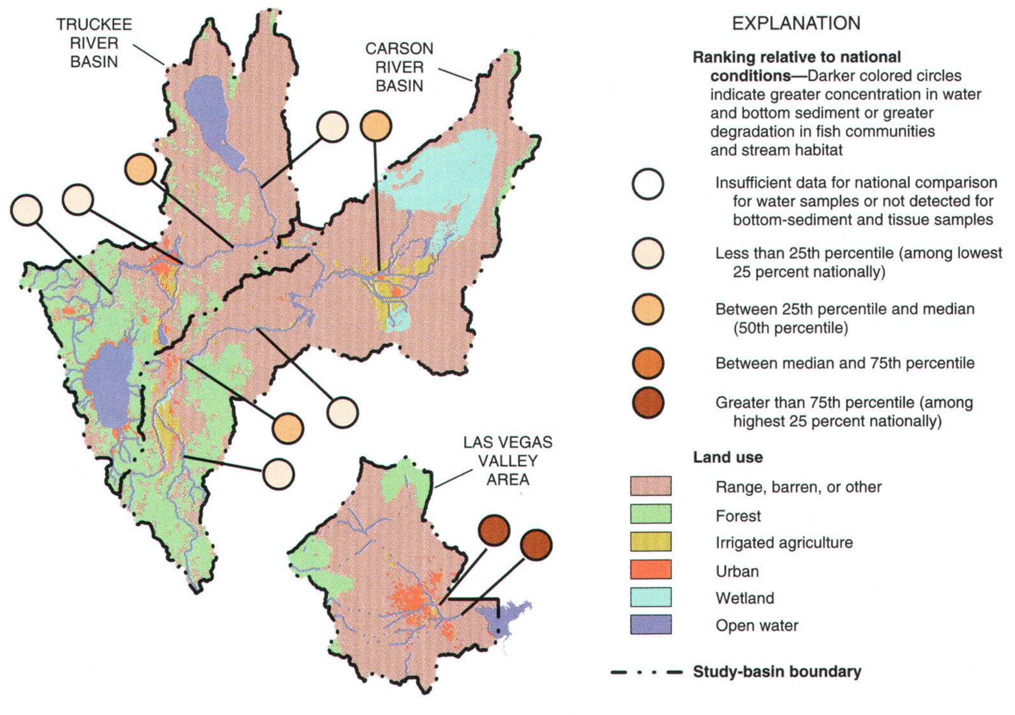
Seven Major Water-Quality Characteristics Were Evaluated for Stream Sites in Each NAWQA Study Unit.



Summary scores for each characteristic were computed for all sites that had adequate data. Scores for each site in the Nevada Basin and Range Study Unit were compared with scores for all sites sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA sites. Water-quality conditions at each site also are compared to established criteria for protection of aquatic life. Applicable criteria are limited to nutrients and pesticides in water, and semivolatile organic compounds, organochlorine pesticides and PCBs in sediment. (Methods used to compute rankings and evaluate aquatic-life criteria are described by Gilliom and others [58].)

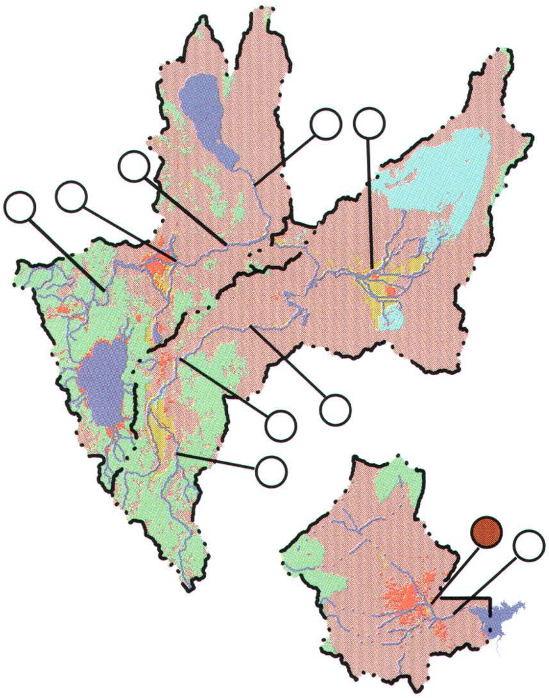
Nutrients Were Higher Than the National Median in Las Vegas Wash but Were Lower in the Carson and Truckee Rivers

Nutrient concentrations in surface-water samples from two sites on Las Vegas Wash were greater than the national 75th percentile. The flow at the upstream site is primarily from urban drainage. The downstream site, which receives urban drainage and discharge of tertiary-treated sewage, had a nutrient concentration above the national 99th percentile. All NAWQA samples from this site exceeded the aquatic-life criterion for un-ionized ammonia [29]. However, more recent measurements by other agencies during 1996-97 (Steven W. Miller, City of Las Vegas, written commun., 1998) indicate that un-ionized ammonia concentrations are now below the aquatic-life criteria because of full implementation of tertiary treatment.



Nutrient concentrations in surface-water samples from all sites in the Carson and Truckee River Basins were below the national median. Five of the eight sites had nutrient concentrations below the national 25th percentile. Two of those five, which are in forested headwater areas, had nutrient concentrations below the national 10th percentile. Two sites on the Carson River downstream from agricultural areas in Carson Valley and Carson Desert had nutrient concentrations between the national 25th percentile and median— higher than the concentrations at sites in the forested headwater areas. Nutrient concentrations at one site on the Truckee River, several miles downstream from the discharge of tertiary-treated sewage effluent from the Reno-Sparks urban area, were the highest measured on the Truckee River, but were less than the national median.

Pesticides in Las Vegas Wash Were Greater Than the National 75th Percentile



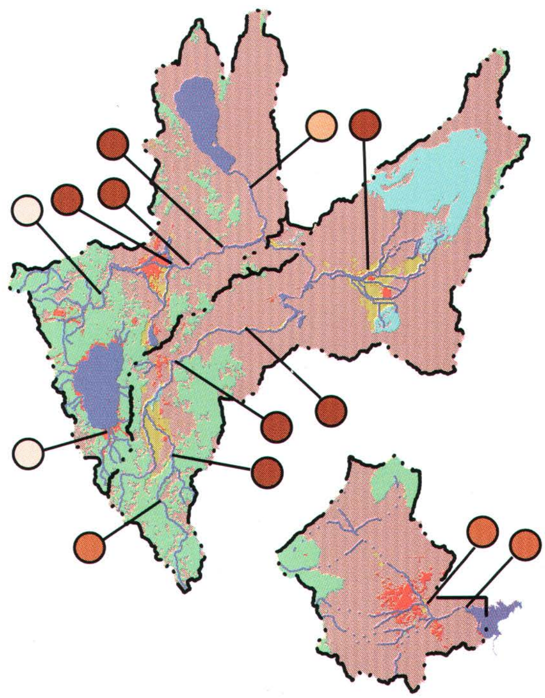
Pesticides were commonly detected in water samples from Las Vegas Wash. The Las Vegas Wash site is downstream from most of the urban area, thus, most flow at the site is urban drainage. It is upstream from the discharge of tertiary-treated sewage. Pesticide concentrations at this site were greater than the national 75th percentile. Diazinon and malathion concentrations exceeded aquatic-life criteria [32,33] in 47 and 25 percent of the samples from this site, respectively. Las Vegas Wash transports these pesticides to Las Vegas Bay of Lake Mead, which is a National Recreation Area administered by the National Park Service. Although water samples for pesticide analyses were collected at additional sites in Las Vegas Valley and in the Carson and Truckee River Basins [31], the number of samples and duration of sampling were insufficient for national comparisons [58].

Trace Elements in Bottom Sediment Downstream From Mineral Deposits, Historical Mining Activities, and Urban Areas Were Greater Than the National Median

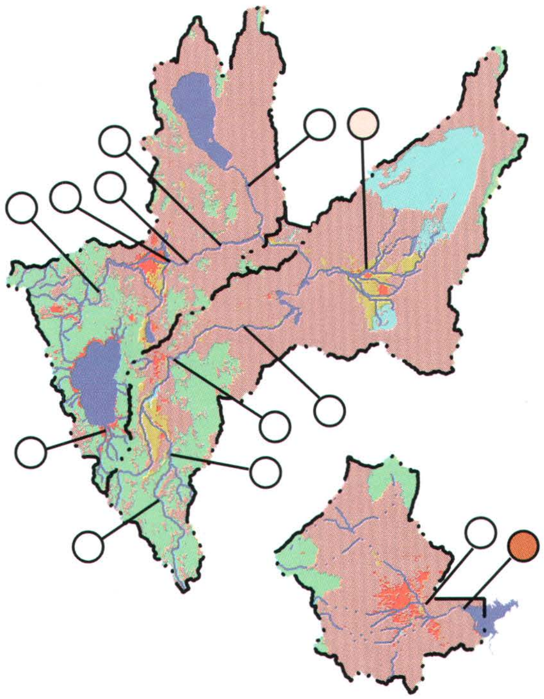
Trace elements (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc) were greater than the national median in bottom sediment at some sites in the Study Unit. Trace-element concentrations in bottom sediment at two sites downstream from the Las Vegas urban area, Las Vegas Wash and Las Vegas Bay in Lake Mead, were between the national median and 75th percentile. These sites are affected by urban drainage and sewage effluent.

Trace-element concentrations, particularly arsenic and mercury, in the bottom sediment at all sites in the Carson River Basin were greater than the national median. Mercury was present in the upstream forested headwater site of the East Fork Carson River because of naturally occurring mercury ore (cinnabar) [53]. This area is within one of three regions, worldwide, with economically extractable deposits of mercury ore [57]. Arsenic and mercury were much higher at the downstream site on the East Fork Carson River and the three sites on the Carson River, all of which are downstream from historical mining areas. Concentrations at these four sites exceeded the national 75th percentile.

Bottom sediment from two sites in the forested headwater area of the Truckee River Basin had trace-element concentrations less than the national median. Trace elements, particularly lead, copper, and zinc, in the sediments at three of the six sites in the Truckee River Basin were greater than the national 75th percentile. Those three sites are downstream from the Reno-Sparks urban area. Cadmium, chromium, copper, lead, and zinc are common in water and bottom sediments affected by urban activities [36,37,38].



Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs) Were Not Detected at 11 of 13 Sampled Sites

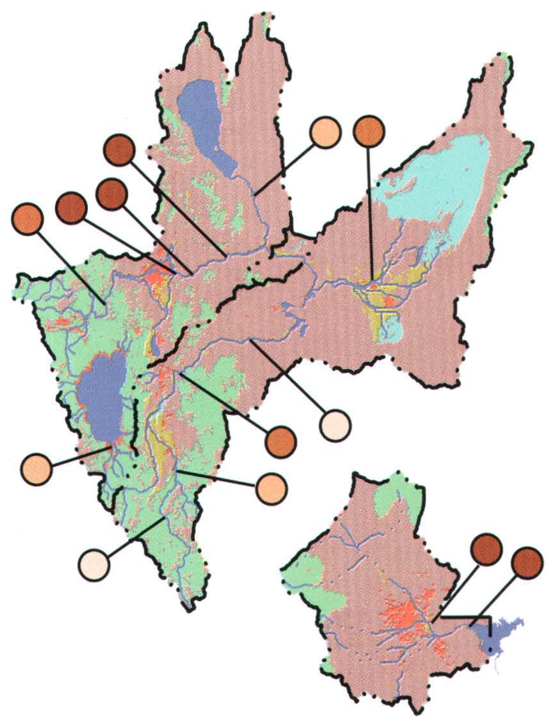


Concentrations of organochlorine pesticides and PCBs were not detected at 11 of the 13 sites where those compounds were analyzed in bottom sediment and clam tissue. Three degradation products of DDT were detected in Las Vegas Bay of Lake Mead, which receives urban drainage and sewage effluent from the Las Vegas urban area. The concentrations at that site were between the national median and 75th percentile. A degradation product of DDT was detected at one site in the lower Carson River [31], downstream from agricultural activities in Carson Desert; the concentration was less than the national 25th percentile.

Semivolatile Organic Compounds (SVOCs) in Bottom Sediment Downstream From Urban Areas Were Greater Than the National 75th Percentile

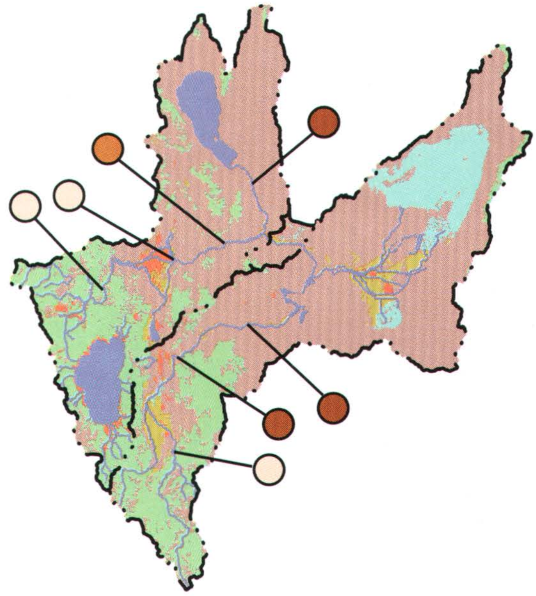
In the three study basins, 8 of 13 sites had bottom-sediment concentrations of semivolatile organic compounds (SVOCs) that were greater than the national median. The concentrations of SVOCs at two sites downstream from the Las Vegas urban area were greater than the national 75th percentile. Streamflow at the upstream site is primarily urban drainage. The downstream site is affected by the discharge of treated sewage as well.

Two sites in the Carson River Basin had concentrations of SVOCs between the national median and 75th percentile. Both sites are downstream from small cities and agricultural areas. Three sites in the Truckee River Basin had SVOC concentrations in bottom sediment that were greater than the national 75th percentile. These sites are downstream from the Reno-Sparks urban area. The upstream site is affected by urban drainage and the two downstream sites are affected by urban drainage and treated sewage effluent. Three of four sites in forested headwater areas of the Carson and Truckee River Basins had concentrations that were less than the national median.



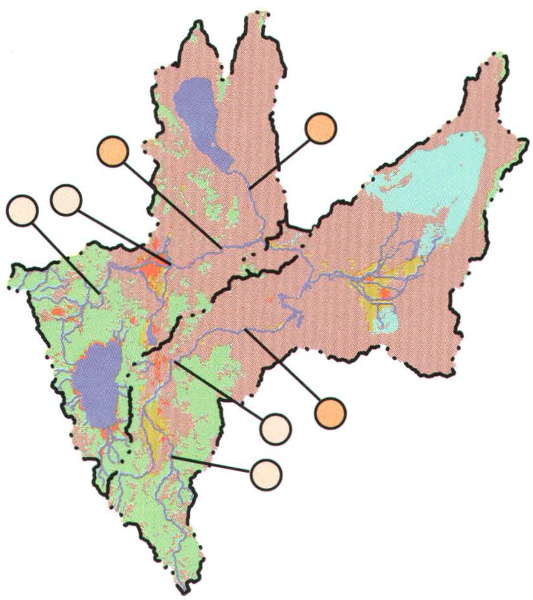
Fish Communities in Lower Reaches of the Carson and Truckee Rivers Were More Degraded Than the National Median

The degradation indices for fish communities were based on the number of non-native and omnivorous fish, the number of fish tolerant to human disturbance, and the number of fish with external parasites or lesions. Fish communities were not evaluated in Las Vegas Wash because it was primarily a conduit for urban drainage and tertiary-treated sewage effluent. However, a study of endocrine systems of common carp by the NVBR NAWQA, National Park Service, and U.S. Fish and Wildlife Service in 1995 showed evidence of endocrine disruption in Las Vegas Wash and Las Vegas Bay of Lake Mead as compared to Callville Bay, an upstream background site in Lake Mead [42]. Evidence of endocrine disruption included high levels of a male sex hormone in female carp from Las Vegas Wash, low levels of a male sex hormone in male carp from Las Vegas Bay, and the presence of an egg protein, which should be found only in females, in high percentages of male carp from Las Vegas Wash and Bay. Synthetic organic compounds detected in the water column, bottom sediment, and carp tissue from Las Vegas Wash and Bay have been shown to cause these effects in previous investigations of other areas [42].



Fish communities in the Carson and Truckee River Basins were degraded in the lower parts of both rivers. The attributes common to sites with degraded fish communities were low-gradient stretches of river, warm water temperature, sand to gravel stream bottom, streamflow depleted by major water diversions, and large populations of algae and aquatic plants. At three of the seven sites in both basins, the degradation indices for fish communities were less than the national 25th percentile, indicating little or no degradation. Two of those sites were in forested headwater areas. The attributes common to these three sites that seemed to favor native fish communities were cool water temperatures, high-gradient stretches of river, gravel to cobble stream bottom, low nutrient concentrations, little or no aquatic plant growth, and no major water diversions. The degradation indices for fish communities at the remaining four sites were greater than the national median; three of the four were greater than the national 75th percentile. The degraded fish communities at these four sites were composed of a high proportion of non-native fish species. Native fish at these sites had external parasites and lesions.

Stream Habitat at All Sites on Carson and Truckee River Systems Was Better Than the National Median



Stream-habitat degradation was evaluated at seven sites in the Study Unit. The indices of stream habitat for all seven sites were less than the national median, indicating they were less degraded. Habitat-degradation indices were based on riparian vegetation, stream modification, bank stability, and bank erosion. Stream habitat was not evaluated in Las Vegas Valley because most streams there have been channelized, leveed, or otherwise altered in some way and probably differ greatly from their pre-urban character. The indices for four sites, two each in the Carson and the Truckee River Basins, were less than the national 25th percentile, indicating little or no habitat degradation. Of those four sites, one site in each basin is in a forested headwater area. All four sites had the following attributes in common: located in the middle to upper parts of the basin, little or no streambank erosion, streambanks highly stable with either dense stands of vegetation or broad areas of embedded boulders and cobbles. Habitat indices for the remaining three sites (one on the Carson River and two on the Truckee River) were between the national 25th percentile and median. The stream habitats at these three sites had the following attributes in common: located in the lower parts of the basin, low to moderate streambank erosion, moderately stable streambanks with moderate vegetation density, and some areas of embedded boulders and cobbles.

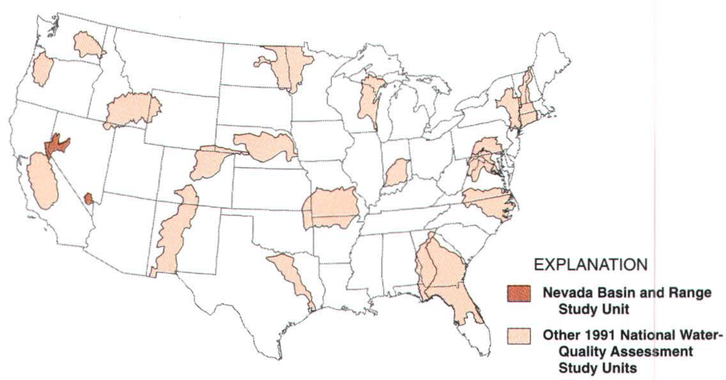
CONCLUSIONS

Compared to other NAWQA Study Units:

- Nutrients and pesticides in Las Vegas Wash downstream from the Las Vegas urban area were greater than the national median, probably because almost all of the streamflow is from the discharge of urban drainage and tertiary-treated sewage.
- Nutrients in surface water in the Carson and Truckee River Basins were less than the national medians. This probably is because crops grown in the Carson River Basin do not require heavy applications of fertilizer, agriculture is minimal in the Truckee River Basin, no sewage and little urban drainage is discharged to the Carson River, and natural streamflow in the Truckee River dilutes the discharge of tertiary-treated sewage and urban drainage from the Reno-Sparks area.
- Trace elements and semivolatile organic compounds in bottom sediment downstream from the Las Vegas and Reno-Sparks urban areas were greater than the national medians, probably as a result of urban activities.
- Trace elements in bottom sediment downstream from natural mineral deposits and historical mining activities in the Carson River Basin were greater than the national median.
- Organochlorine compounds in bottom sediment downstream from the Las Vegas urban area were greater than the national median, probably as a result of urban activities.
- Fish communities in the lower parts of the Carson River, between Carson City and Lahontan Reservoir, and Truckee River, downstream from Reno-Sparks, were more degraded than the national median.
- Stream habitat in the Carson and Truckee Rivers was less degraded than the national median.

Wetlands in Carson Valley, November 1993. Photograph by Michael S. Lico, U.S. Geological Survey.

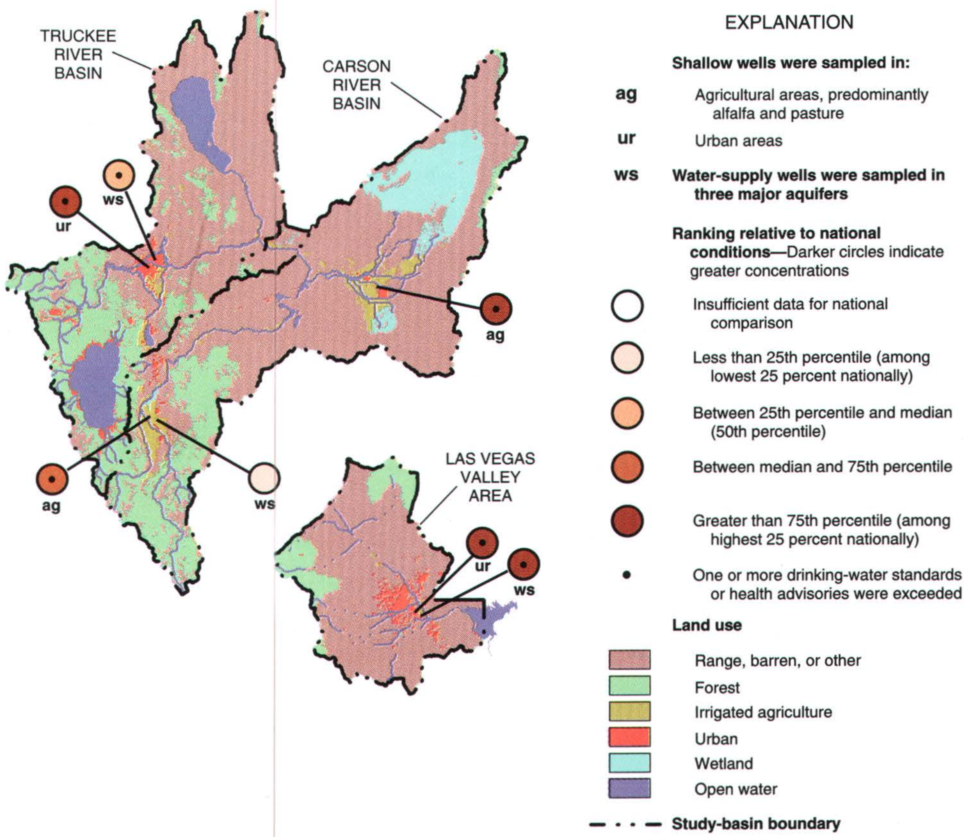
Five Major Water-Quality Characteristics Were Evaluated for Ground-Water Studies in Each NAWQA Study Unit



Ground-water resources were divided into two categories: (1) drinking-water aquifers, and (2) shallow ground water underlying agricultural or urban areas. Summary scores were computed for each characteristic for all aquifers and shallow ground-water areas that had adequate data. Scores for each aquifer and shallow ground-water area in the Nevada Basin and Range Study Unit were compared with scores for all aquifers and shallow ground-water areas sampled in the 20 NAWQA Study Units during 1992–95. Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA ground-water studies. Water-quality conditions for each drinking-water aquifer also are compared to established drinking-water standards and criteria for protection of human health. (Methods used to compute rankings and evaluate standards and criteria are described by Gilliom and others [58].)

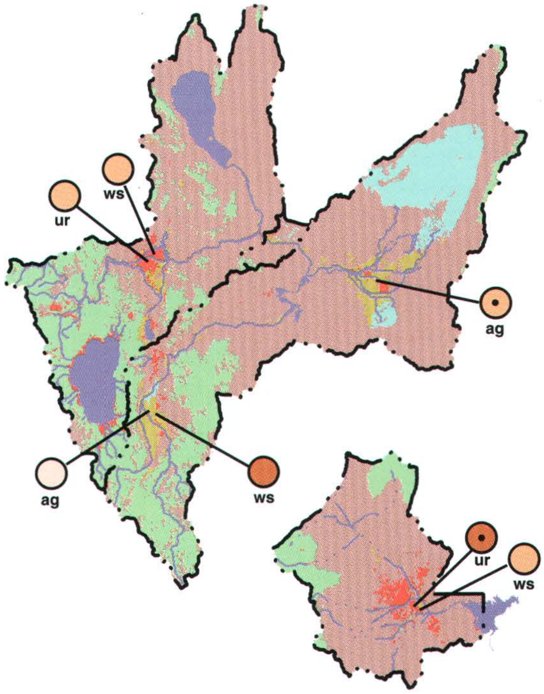
Dissolved Solids in Las Vegas Valley Water-Supply Wells Were Greater Than the National 75th Percentile

Dissolved-solids concentrations in deeper supply wells and shallow monitoring wells in Las Vegas Valley and shallow monitoring wells in Carson Desert and Reno-Sparks area were greater than the 75th percentile of NAWQA sites nationwide. Dissolved-solids concentrations in supply wells in Carson Valley and the Reno-Sparks area were less than the national median. The SMCL (500 mg/L) was exceeded in some samples from all areas except Carson Valley supply wells. Shallow monitoring wells in basin areas (Las Vegas Valley and Carson Desert) had the highest frequency of exceedence (97 and 70 percent, respectively); these high concentrations were caused by dissolution of evaporite minerals (salts) and their concentration in ground water by evapotranspiration.

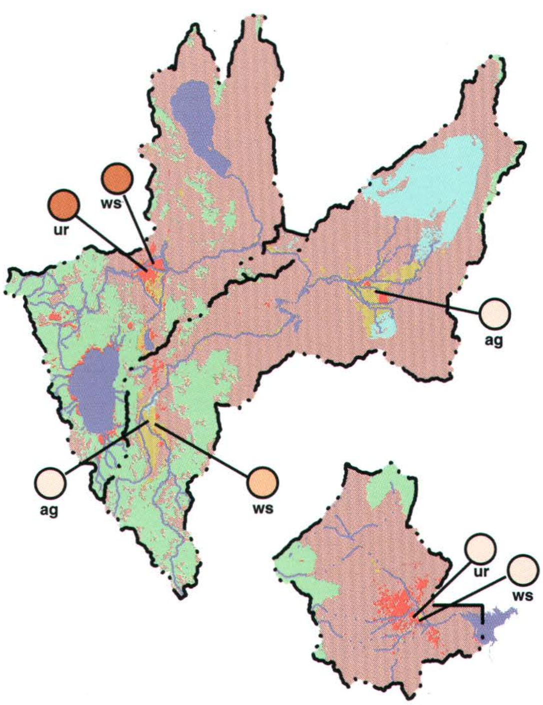


Nitrate in Samples From Water-Supply Wells Approached the National Median

Nitrate concentrations in Study Unit water-supply wells were close to the national median for NAWQA drinking-water supply wells. Shallow monitoring wells in agricultural areas (Carson Valley and Carson Desert) had nitrate concentrations less than the national median, and those in urban areas (Las Vegas and Reno-Sparks) had concentrations near or greater than the national median. In the NVBR Study Unit, high nitrate concentrations were uncommon and possibly were due to fertilizer application, septic systems, or leaking sewer pipes in urbanized areas. Concentrations of nitrate did not exceed the MCL for any NAWQA samples collected from water-supply wells in the Study Unit.



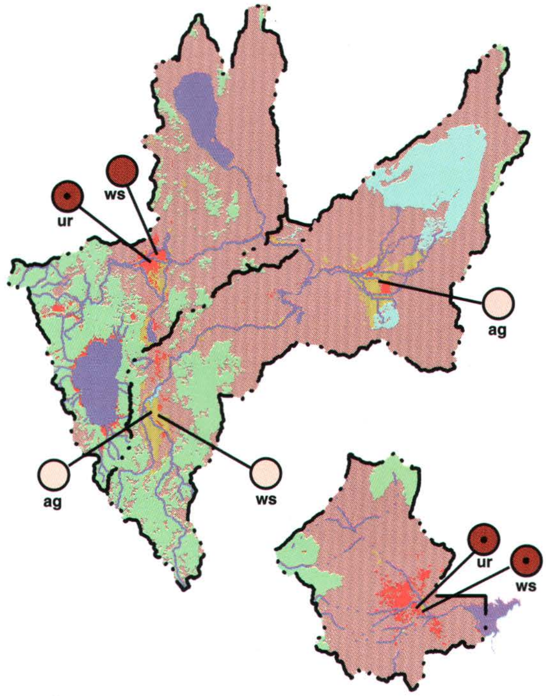
Pesticides in the Reno-Sparks Urban Area Were Detected More Frequently Than the National Median



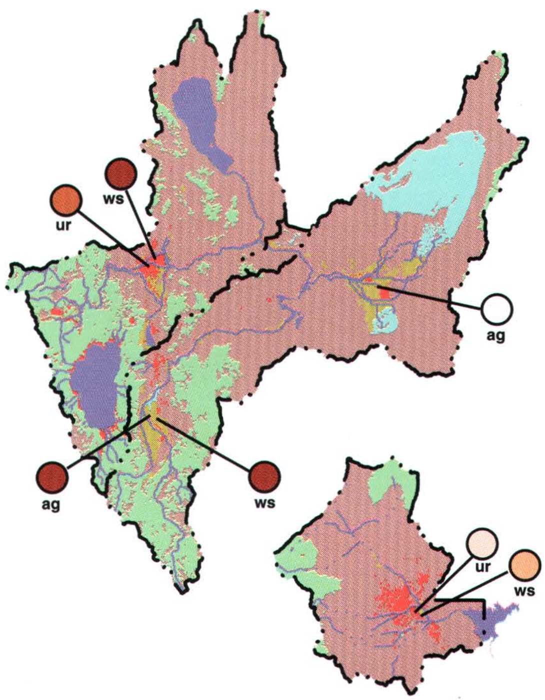
The frequencies of pesticide detections in samples from water-supply and shallow monitoring wells in the Reno-Sparks urban area were between the national NAWQA median and the 75th percentile. Pesticides used on urban landscapes are leached into ground water by irrigation. In all areas sampled, except the Reno-Sparks urban area, pesticides were detected in ground-water samples less frequently than the national median.

Volatile Organic Compounds (VOCs) in the Las Vegas and Reno-Sparks Urban Areas Were Detected More Frequently Than the National 75th Percentile

The frequencies of detection for VOCs in the urban areas of Las Vegas and Reno-Sparks (both water-supply wells and shallow monitoring wells) were greater than the 75th percentile of NAWQA wells nationwide. Trihalomethanes (THMs), chlorinated solvents, and a gasoline oxygenate (MTBE) were the most frequently detected VOCs. Concentrations of several VOCs in water from supply wells in the Las Vegas urban area and from shallow monitoring wells in Las Vegas and Reno-Sparks urban areas exceeded MCLs (the chlorinated solvents—tetrachloroethylene and trichloroethylene) or a drinking water advisory (MTBE). Water-supply wells and shallow wells in agricultural areas had less frequent detections of VOCs than the 25th percentile of NAWQA wells nationwide.



Radon in Carson Valley and Reno-Sparks Urban Area Water-Supply Wells was Greater Than the National 75th Percentile

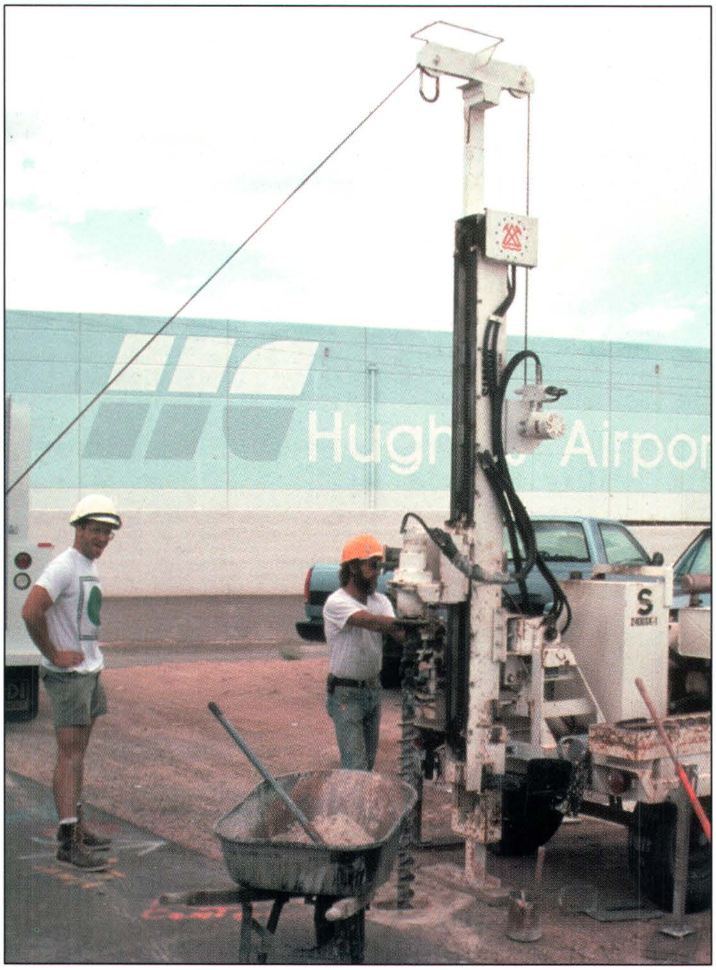


Radon, a decay product of uranium in granitic rocks in the Study Unit, occurs naturally in soils. Radon concentrations in water from supply and shallow monitoring wells in the Las Vegas urban area were less than the national median. Concentrations in water from supply wells in Carson Valley and the Reno-Sparks area and shallow monitoring wells in Carson Valley exceeded the 75th percentile of NAWQA sites nationwide. Shallow monitoring wells in the Reno-Sparks area had radon concentrations greater than the national median. Carson Valley and Reno-Sparks area soils were derived, in part, from granitic rocks in the Sierra Nevada.

CONCLUSIONS

Compared to other NAWQA Study Units:

- The frequencies of pesticide detections in water-supply and shallow monitoring wells in the Reno-Sparks urban area exceeded the national NAWQA median, probably because of landscape pesticide applications that subsequently were leached by irrigation into the ground water.
- Dissolved-solids concentrations in water from wells in basin areas (Las Vegas Valley and Carson Desert) exceeded the 75th percentile for the NAWQA Program because of the dissolution of evaporite minerals and the concentration of dissolved constituents by evapotranspiration.
- Nitrate concentrations did not exceed the MCL in any of the samples from water-supply wells.
- The frequencies of VOC detections in ground water beneath urban areas were among the highest sampled by the NAWQA Program.
- Ground water in Carson Valley and Reno-Sparks had radon concentrations greater than the national NAWQA median; concentrations in most samples were greater than 75 percent of the national NAWQA samples. Radon occurs naturally in soils throughout the Study Unit, but it is especially high in soils derived from granitic rocks of the Sierra Nevada.



A shallow monitoring well being installed in the Las Vegas urban area, August 1993. Photograph by Kenneth J. Covay, U.S. Geological Survey.

Environmental Subareas Were Identified for Investigation

The NVBR Study Unit was divided into subareas representing important combinations of natural and human factors. A conceptual model of basin and range hydrology was used to develop a framework of primary subareas (headwater and basin areas). Headwater areas (fig. 3) were defined as mountains and adjacent areas where precipitation is adequate to provide ground-water recharge and streamflow (yielding 0.2 inch or more of annual runoff [59]). Basin areas do not receive adequate precipitation for appreciable ground-water recharge and streamflow, but can receive recharge and streamflow from upstream headwater areas. Natural discharge in the Study Unit is by stream outflow from and evapotranspiration in the Las Vegas Valley and by only evapotranspiration in the Carson and Truckee River Basins (hydrologically closed basins characterized by internal drainage).

Secondary subareas were developed by subdividing the two primary subareas (headwater and basin areas) into land uses that represent more natural conditions (forest and range) or human activities (urban and agricultural land use; fig. 5). Water resources in the environmental subareas were then identified for study. Principal surface-water resources included in the investigation were Las Vegas Wash and Lake Mead, the Carson River, and the Truckee River (fig. 3). Principal aquifers (fig. 3) were defined as unconsolidated deposits beneath valleys with 100 ft or more of saturated thickness [60,61,62] and containing ground water with less than 1,000 mg/L of dissolved solids [63,64].

Headwater areas are primarily forest and basin areas are primarily range. The principal headwater urban area is Reno-Sparks and the principal headwater agricultural area is Carson Valley. The principal basin urban area is the Las Vegas urban area and the principal basin agricultural area is Carson Desert.

Effects of Urban and Agricultural Activities Were Focus of Investigations

Stream-chemistry data collection included a Bottom Sediment and Tissue Study, Basic and Intensive Fixed-Site networks, and a Surface-Water Synoptic Study (fig. 13). The Bottom Sediment and Tissue Study was done early in the Study Unit investigation and included sites being considered for selection as Basic and Intensive Fixed Sites. Basic Fixed Sites were located on streams downstream from forested headwater areas, urban and agricultural headwater areas, urban and agricultural basin areas, major sources of treated sewage effluent, and at downstream sites that integrate streamflow from throughout the study basins. An Intensive Fixed Site was operated to sample drainage from the Las Vegas urban area. The Surface-Water Synoptic Study increased the areal coverage of the Fixed-Site networks and provided additional data on pesticides and trace elements.

Stream-ecology activities included Fixed-Site Reach Assessments and Ecological Synoptic Studies (fig. 13). Fixed-Site Single-Reach Assessments were made at all Basic Fixed Sites in the Carson and Truckee River Basins. Fixed-Site Three-Reach Assessments were made at the farthest upstream Carson and Truckee River Basic Fixed Sites, to serve as reference sites, and at one downstream integrator site on each stream, to serve as trend sites. Ecological Synoptic Studies of benthic invertebrates and algae were completed in the Carson Valley agricultural area and the Reno-Sparks urban area to evaluate land-use effects.

Ground-water-chemistry activities included Land-Use Studies and Study-Unit Surveys (fig. 13). Land-Use Studies of shallow ground water were completed in the Las Vegas basin urban area, the Carson Valley headwater agricultural area, the Carson Desert basin agricultural area, and the Reno-Sparks headwater urban area. The Study-Unit Surveys sampled principal aquifers in the Las Vegas urban area, Carson Valley, and Reno-Sparks urban area.

Special studies of irrigation drainage and endocrine disruption were made with assistance from cooperating agencies (fig. 13). The Department of the Interior National Irrigation Water Quality Program provided financial resources for a joint investigation with the NVBR NAWQA to quantify loads of potentially toxic constituents and to document contributing source areas in irrigated lands of the Carson Desert [9]. The National Park Service provided financial assistance and participated with the U.S. Fish and Wildlife Service in a joint investigation with the NVBR NAWQA to identify synthetic organic compounds in Las Vegas Wash and Las Vegas Bay of Lake Mead and to evaluate carp endocrine systems with respect to estrogenic effects that could be caused by synthetic organic compounds [42].

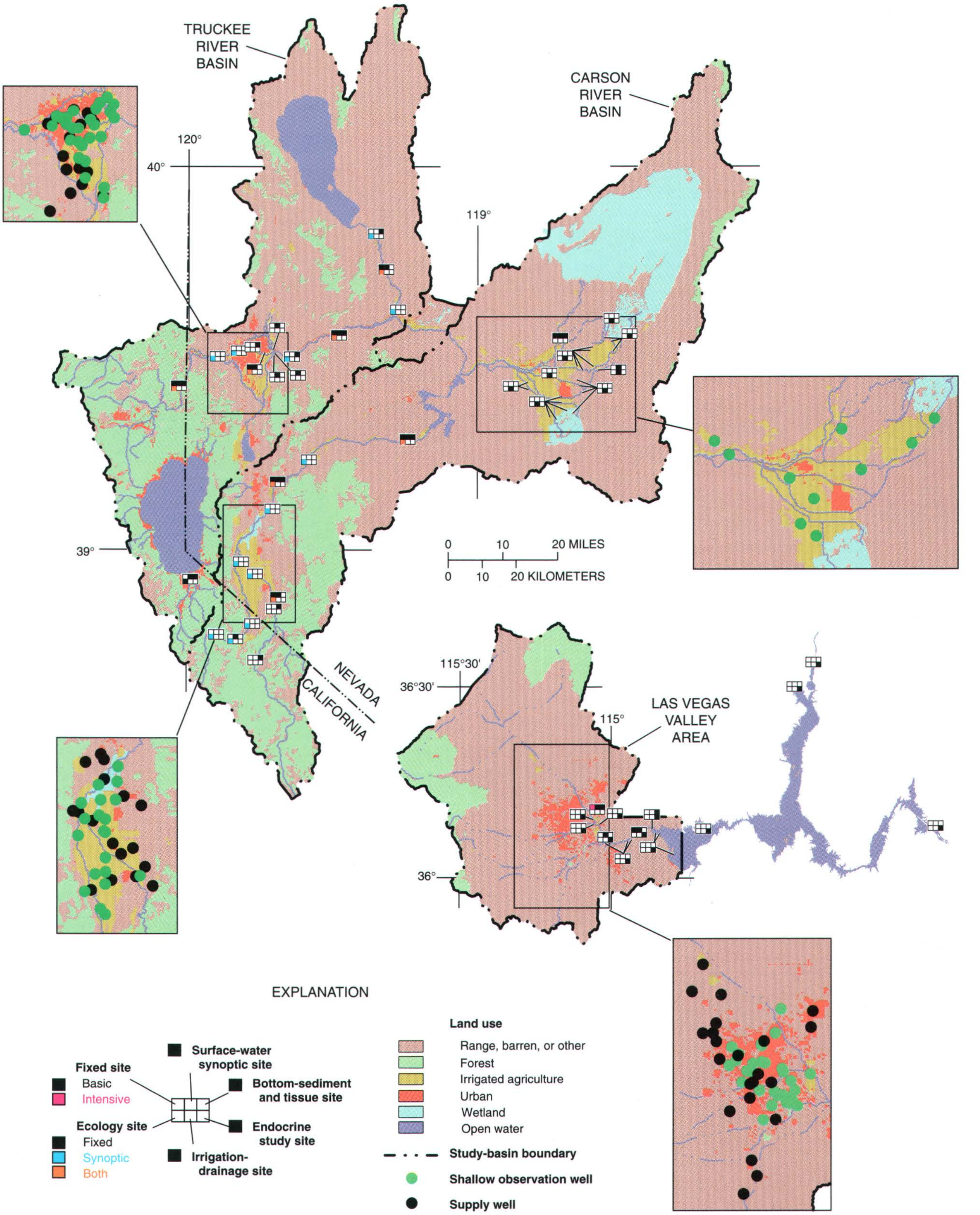


Figure 13. Study unit stream-chemistry, stream-ecology, and ground-water-chemistry sites, and areas of special studies were chosen to represent environmental subareas characterized by selected natural conditions and human activities.

Summary of data collection in the Nevada Basin and Range Study Unit, 1992-96

Study component	What data were collected and why	Types of sites sampled	Number of sites	Sampling frequency and period
		Stream chemistry		
Basic Fixed Sites	Streamflow, major chemical constituents, nutrients, organic carbon, suspended sediment, pH, temperature, and specific conductance to describe areal and temporal differences.	Stream sites representing hydrologic conditions, land use (forest, urban, and agriculture), and treated sewage effluent.	9	Monthly (Apr. 1993- Mar. 1995).
Intensive Fixed Sites	In addition to Basic Fixed Site data, dissolved pesticides and trace elements to describe concentrations from urban activities.	Stream site representing runoff from urban land use.	1	Biweekly and during storm runoff (Apr. 1993-Mar. 1995).
Synoptic Study	Intensive Fixed Site data to determine areal and temporal variability of pesticides and trace elements during spring runoff and irrigation.	All basic and intensive sites and seven additional sites to improve areal coverage.	17	Biweekly (2 sites) and monthly (15 sites); May-Aug. 1994.
Bottom Sediment and Tissue Study	Organochlorine compounds, semivolatile compounds, and trace elements to determine occurrence.	Basic and Intensive Fixed Sites and seven additional sites.	13	Once in 1992.
		Stream ecology		
Fixed-Site Reach Assessment	Fish, benthic invertebrates, algae, and aquatic and riparian habitat to assess conditions.	Stream reaches at Basic Fixed Sites.	8	Once in 1993; annually for trend sites (1994-96).
Synoptic Study	Benthic invertebrates and algae to assess effects of urban and agricultural land use.	Carson (Carson Valley) and Truckee (Reno-Sparks) River.	19	Once in 1994 and once in 1995.
		Ground-water chemistry		
Study-Unit Survey	Major chemical constituents, nutrients, trace elements, radon-222, volatile organic compounds, dissolved organic carbon, pesticides, phenols, and MBAS[a] to assess principal aquifer systems.	Existing supply wells in principal aquifers in Las Vegas area, Reno-Sparks area, and Carson Valley.	57	Once in 1995.
Land-Use Studies	Study-Unit Survey data to assess effects of urban and agricultural land use on shallow ground water.	Shallow observation wells in urban (Las Vegas and Reno-Sparks) and agricultural (Carson Valley and Carson Desert) areas.	90[b]	Once in Las Vegas (1993), and once in Reno-Sparks, Carson Valley, and Carson Desert (1994).
		Special studies		
Irrigation Drainage	Streamflow, major chemical constituents, nutrients, trace elements, and pesticides in water and trace elements in bottom sediment to determine major sources and loads.	Irrigation drains in Carson Desert.	22	Water chemistry (3 times), pesticides and bottom sediment (once); Feb.- Sept. 1995.
Endocrine Disruption	Organochlorine pesticides, PCBs, dioxins, furans, and semivolatile organic compounds in water, bottom sediment, semipermeable membrane devices, and carp to determine occurrence. Sex-steroid hormones in carp to assess endocrine systems.	Las Vegas Wash and Las Vegas Bay, Callville Bay, Colorado River inlet, Virgin River inlet, and Muddy River inlet of Lake Mead.	16	Once, 6 sites in 1995 and 10 sites in 1996.

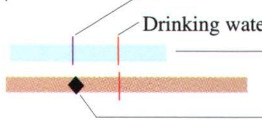
[a]MBAS (methylene blue active substances), synthetic detergents or surfactants, occur in natural water almost exclusively as a result of pollution.

[b]Additional data from a pilot NAWQA study of the Carson River Basin were used to help determine land-use effects on shallow ground water in Carson Valley and Carson Desert [19].

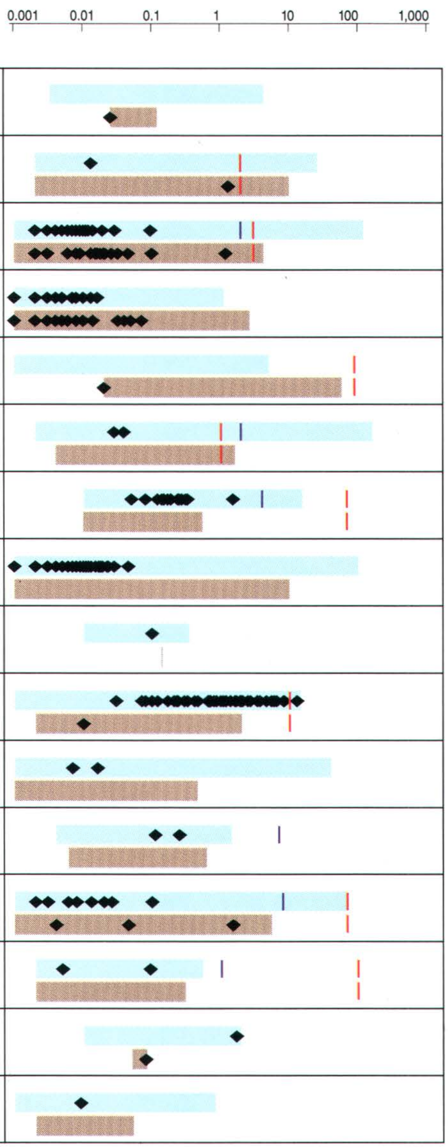
The following tables summarize data collected for NAWQA studies from 1992-95 by showing results for the Nevada Basin and Range Study Unit compared to the NAWQA national range for each compound detected. The data were collected at a wide variety of places and times. In order to represent the wide concentration ranges observed among Study Units, logarithmic scales are used to emphasize the general magnitude of concentrations (such as 10, 100, or 1,000), rather than the precise number. The complete dataset used to construct these tables is available upon request.

Concentrations of herbicides, insecticides, volatile organic compounds, and nutrients detected in ground and surface waters of the Nevada Basin and Range Study Unit. [mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; %, percent; <, less than; - -, not measured]

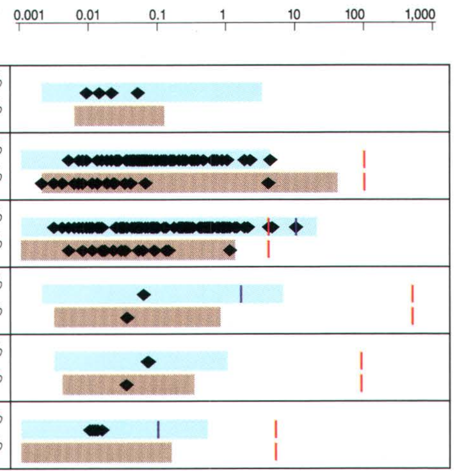
EXPLANATION



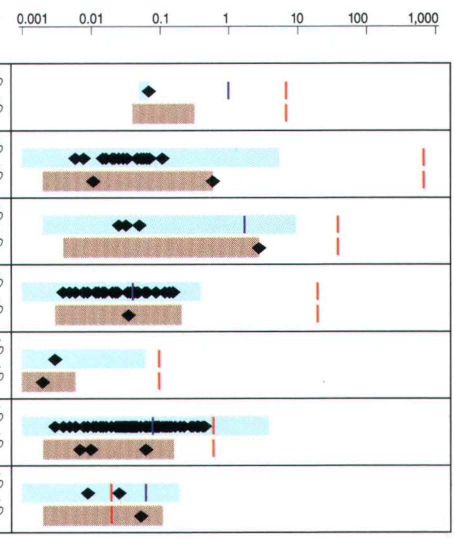
Herbicide	Rate of detection [b]	Concentration, in µg/L
Acetochlor	0% 1%	
Alachlor	1% 1%	
Atrazine	8% 10%	
Deethyl atrazine[c] (metabolite of atrazine)	3% 5%	
Bromacil	0% 1%	
Cyanazine	2% 0%	
2,4-D	11% 0%	
DCPA	20% 0%	
Dichlorprop	1% 0%	
Diuron	38% 1%	
EPTC	1% 0%	
Linuron	2% 0%	
Metolachlor	4% 1%	
Metribuzin	1% 0%	
Oryzalin	1% 1%	
Pebulate	<1% 0%	



Herbicide	Rate of detection [b]	Concentration, in µg/L
Pendimethalin	2% 0%	
Prometon	54% 6%	
Simazine	56% 11%	
Tebuthiuron	1% 1%	
Terbacil[c]	2% 1%	
Trifluralin	8% 0%	



Insecticide	Rate of detection [b]	Concentration, in µg/L
Aldicarb sulfone[c]	1% 0%	
Carbaryl[c]	13% 1%	
Carbofuran[c]	2% 1%	
Chlorpyrifos	15% 1%	
p,p'-DDE	<1% <1%	
Diazinon	59% 1%	
Dieldrin	1% 1%	



Insecticide	Rate of detection [b]	Concentration, in µg/L (0.001 – 0.01 – 0.1 – 1 – 10 – 100 – 1,000)
Fonofos	<1% 0%	
alpha-HCH	2% 0%	
gamma-HCH	2% 0%	
Malathion	27% 1%	
Methomyl	1% 0%	

Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L (0.01 – 0.1 – 1 – 10 – 100 – 1,000 – 10,000 – 100,000)
Methyl *tert*-butyl[d] ether (MTBE)	-- 7%	
Tetrachloroethene (Perchloroethene)	-- 12%	

Volatile organic compound	Rate of detection [b]	Concentration, in µg/L (0.01 – 0.1 – 1 – 10 – 100 – 1,000)
1,1,1-Trichloroethane	-- 1%	
1,1,2-Trichloro-1,2,2-trifluoroethane	-- 1%	
1,1-Dichloroethene	-- 1%	
1,2-Dichlorobenzene	-- 1%	
1,2-Dichloroethane	-- 1%	
Benzene	-- 1%	
Bromochloromethane	-- 1%	
Dibromomethane	-- 1%	
Dichlorodifluoromethane	-- 2%	
Dichloromethane	-- 1%	
total Trihalomethanes	-- 31%	
Trichloroethene (TCE)	-- 5%	
Trichlorofluoromethane	-- 4%	
trans-1,2-Dichloroethene	-- 1%	

Nutrient	Rate of detection [b]	Concentration, in mg/L (0.01 – 0.1 – 1 – 10 – 100 – 1,000 – 10,000 – 100,000)
Dissolved ammonia	84% 73%	
Dissolved ammonia plus organic nitrogen as nitrogen	61% 27%	
Dissolved phosphorus as phosphorus	79% 67%	
Dissolved nitrite plus nitrate	58% 90%	

Other	Rate of detection [b]	Concentration, in pCi/L (1 – 10 – 100 – 1,000 – 10,000 – 100,000)
Radon 222	-- 100%	

Herbicides, insecticides, volatile organic compounds, and nutrients not detected in ground and surface waters of the Nevada Basin and Range Study Unit.

Herbicides

2,4,5-T
2,4,5-TP
2,4-DB
2,6-Diethylaniline (Metabolite of Alachlor)
Acifluorfen
Benfluralin
Bentazon
Bromoxynil
Butylate
Chloramben
Clopyralid
Dacthal mono-acid (Dacthal metabolite)
Dicamba
Dinoseb
Ethalfluralin
Fenuron
Fluometuron
MCPA
MCPB
Molinate
Napropamide
Neburon
Norflurazon
Picloram
Pronamide
Propachlor
Propanil
Propham
Thiobencarb
Triallate
Triclopyr

Insecticides

3-Hydroxycarbofuran (Carbofuran metabolite)
Aldicarb sulfoxide (Aldicarb metabolite)
Aldicarb
Azinphos-methyl
Disulfoton
Ethoprop
gamma-HCH
Methiocarb
Methyl parathion
Oxamyl
Parathion
Phorate
Propargite
Propoxur
Terbufos
cis-Permethrin

Volatile organic compounds

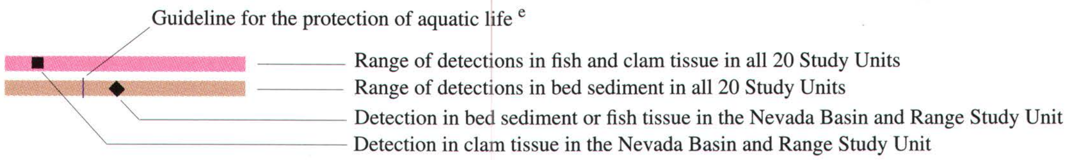
1,1,1,2-Tetrachloroethane
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dichloroethane
1,1-Dichloropropene
1,2,3-Trichlorobenzene
1,2,3-Trichloropropane
1,2,4-Trichlorobenzene
1,2,4-Trimethylbenzene
1,2-Dibromo-3-chloropropane
1,2-Dibromoethane
1,2-Dichloropropane
1,3,5-Trimethylbenzene
1,3-Dichlorobenzene
1,3-Dichloropropane
1,4-Dichlorobenzene
1-Chloro-2-methylbenzene
1-Chloro-4-methylbenzene
2,2-Dichloropropane
Bromobenzene
Bromomethane
Chlorobenzene
Chloroethane
Chloroethene
Chloromethane
Dimethylbenzenes
Ethenylbenzene
Ethylbenzene
Hexachlorobutadiene
Isopropylbenzene
Methylbenzene
Naphthalene
Tetrachloromethane
cis-1,2-Dichloroethene
cis-1,3-Dichloropropene
n-Butylbenzene
n-Propylbenzene
p-Isopropyltoluene
sec-Butylbenzene
tert-Butylbenzene
trans-1,3-Dichloropropene

Nutrients

No non-detects

Concentrations of semivolatile organic compounds, organochlorine compounds, and trace elements detected in fish and clam tissue and bed sediment of the Nevada Basin and Range Study Unit. [µg/g, micrograms per gram; µg/kg, micrograms per kilogram; %, percent; <, less than; - -, not measured]

EXPLANATION

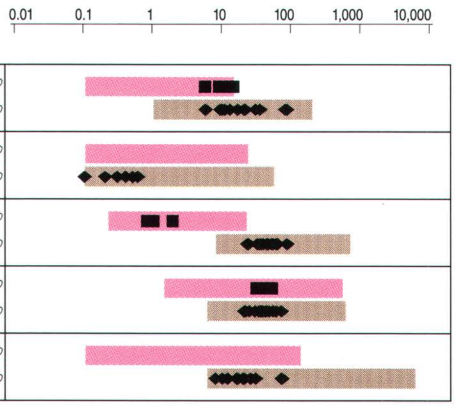


Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1 – 100,000)
2,2-Biquinoline	-- 14%	
2,6-Dimethylnaphthalene	-- 71%	
3,5-Dimethylphenol	-- 7%	
Anthracene	-- 13%	
Benz[*a*]anthracene	-- 20%	
Benzo[*a*]pyrene	-- 20%	
Benzo[*b*]fluoranthene	-- 27%	
Benzo[*c*]cinnoline	-- 7%	
Benzo[*ghi*]perylene	-- 7%	
Benzo[*k*]fluoranthene	-- 27%	
Butylbenzylphthalate	-- 13%	
Chrysene	-- 20%	
Di- *n* -butylphthalate	-- 87%	
Di- *n* -octylphthalate	-- 29%	
Diethylphthalate	-- 47%	

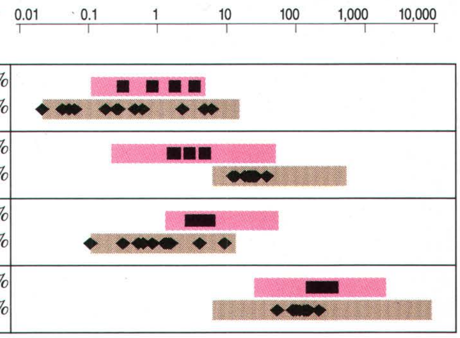
Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1 – 100,000)
Dimethylphthalate	-- 13%	
Fluoranthene	-- 33%	
Indeno[1,2,3- *cd*]pyrene	-- 14%	
Isoquinoline	-- 14%	
Phenanthrene	-- 29%	
Phenol	-- 71%	
Pyrene	-- 33%	
bis(2-Ethylhexyl)phthalate	-- 87%	
p-Cresol	-- 79%	

Organochlorine compound (Trade name)	Rate of detection [b]	Concentration, in µg/kg (0.01 – 100,000)
p,p'-DDE	0% 13%	
total-DDT	0% 13%	

Trace element	Rate of detection [b]	Concentration, in µg/g
Arsenic	100% 100%	
Cadmium	0% 100%	
Chromium	100% 100%	
Copper	100% 100%	
Lead	0% 100%	



Trace element	Rate of detection [b]	Concentration, in µg/g
Mercury	100% 100%	
Nickel	100% 100%	
Selenium	100% 100%	
Zinc	100% 100%	



Semivolatile organic compounds, organochlorine compounds, and trace elements not detected in fish and clam tissue and bed sediment of the Nevada Basin and Range Study Unit.

Semivolatile organic compounds

1,2,4-Trichlorobenzene
1,2-Dichlorobenzene
1,2-Dimethylnaphthalene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,6-Dimethylnaphthalene
1-Methyl-9H-fluorene
1-Methylphenanthrene
1-Methylpyrene
2,3,6-Trimethylnaphthalene
2,4-Dinitrotoluene
2,6-Dinitrotoluene
2-Chloronaphthalene
2-Chlorophenol
2-Ethylnaphthalene
2-Methylanthracene
4,5-Methylenephenanthrene
4-Bromophenyl-phenylether
4-Chloro-3-methylphenol
4-Chlorophenyl-phenylether
9H-Carbazole
9H-Fluorene
Acenaphthene
Acenaphthylene
Acridine
Anthraquinone
Azobenzene
C8-Alkylphenol
Dibenz [*a,h*] anthracene
Dibenzothiophene
Isophorone
N-Nitrosodi-*n*-propylamine
N-Nitrosodiphenylamine
Naphthalene
Nitrobenzene
Pentachloronitrobenzene
Phenanthridine
Quinoline
bis (2-Chloroethoxy)methane

Organochlorine compounds

Aldrin
Chloroneb
DCPA
Dieldrin
Endosulfan I
Endrin
Heptachlor epoxide (Heptachlor metabolite)
Heptachlor
Hexachlorobenzene
Isodrin
Mirex
PCB, total
Pentachloroanisole (PCA, pentachlorophenol metabolite)
Toxaphene
alpha-HCH
beta-HCH
cis-Permethrin
delta-HCH
gamma-HCH
o,p'-Methoxychlor
p,p'-Methoxychlor
total-Chlordane
trans-Permethrin

[a] Selected water-quality standards and guidelines [58].
[b] Rates of detection are based on the number of analyses and detections in the Study Unit, not on national data. Rates of detection for herbicides and insecticides were computed by only counting detections equal to or greater than 0.01 µg/L in order to facilitate equal comparisons among compounds, which had widely varying detection limits. For herbicides and insecticides, a detection rate of "<1%" means that all detections are less than 0.01 µg/L, or the detection rate rounds to less than 1 percent. For other compound groups, all detections were counted and minimum detection limits for most compounds were similar to the lower end of the national ranges shown. Method detection limits for all compounds in these tables are summarized in [58].
[c] Detections of these compounds are reliable, but concentrations are determined with greater uncertainty than for the other compounds and are reported as estimated values [66].
[d] The guideline for methyl *tert*-butyl ether is between 20 and 40 µg/L; if the tentative cancer classification C is accepted, the lifetime health advisory will be 20 µg/L [58].
[e] Selected sediment-quality guidelines [58].

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The terms in this glossary were compiled from numerous resources. Some definitions have been modified and may not be the only valid ones for these terms.

Amalgamation - The dissolving or blending of a metal (commonly gold and silver) in mercury to separate it from its parent material.

Anomalies - As related to fish, externally visible skin or subcutaneous disorders, including deformities, eroded fins, lesions, and tumors.

Aquatic-life criteria - Water-quality guidelines for protection of aquatic life. Often refers to U.S. Environmental Protection Agency water-quality criteria for protection of aquatic organisms.

Aquifer - A water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Artificial recharge - Augmentation of natural replenishment of ground-water storage by some method of construction, spreading of water, or by pumping water directly into an aquifer.

Background concentration - A concentration of a substance in a particular environment that is indicative of minimal influence by human (anthropogenic) sources.

Basic Fixed Sites - Sites on streams at which streamflow is measured and samples are collected for temperature, salinity, suspended sediment, major ions and trace elements, nutrients, and organic carbon to assess the broad-scale spatial and temporal character and transport of inorganic constituents of streamwater in relation to hydrologic conditions and environmental settings.

Basin area - Areas that do not receive adequate precipitation for ground-water recharge and streamflow. These areas can receive recharge and streamflow from upstream headwater areas.

Basin and Range physiography - A region characterized by a series of generally north-trending mountain ranges separated by alluvial valleys.

Bedrock - General term for consolidated (solid) rock that underlies soils or other unconsolidated material.

Benthic invertebrates - Insects, mollusks, crustaceans, worms, and other organisms without a backbone that live in, on, or near the bottom of lakes, streams, or oceans.

Bottom (*bed*) sediment - The material that temporarily is stationary in the bottom of a stream or other watercourse.

Bottom sediment and tissue studies - Assessment of concentrations and distributions of trace elements and hydrophobic organic contaminants in streambed sediment and tissues of aquatic organisms to identify potential sources and to assess spatial distribution.

Carbonate rocks - Rocks (such as limestone or dolostone) that are composed primarily of minerals (such as calcite and dolomite) containing the carbonate ion (CO_3^{2-}).

Channelization - Modification of a stream, typically by straightening the channel, to provide more uniform flow; often done for flood control or for improved agricultural drainage or irrigation.

Chlorinated solvent - A volatile organic compound containing chlorine. Some common solvents are trichloroethylene, tetrachloroethylene, and carbon tetrachloride.

Confining layer - A layer of sediment or lithologic unit of low permeability that bounds an aquifer.

Confluence - The flowing together of two or more streams; the place where a tributary joins the main stream.

Consolidated rock - Metamorphic, sedimentary, or igneous (granitic or volcanic) rock that typically form mountainous uplands and underlie unconsolidated deposits in valleys.

Constituent - A chemical or biological substance in water, sediment, or biota that can be measured by an analytical method.

Contamination - Degradation of water quality compared to original or natural conditions due to human activity.

Degradation products - Compounds resulting from transformation of an organic substance through chemical, photochemical, and (or) biochemical reactions.

Dissolved solids - Amount of minerals, such as salt, that are dissolved in water; amount of dissolved solids is an indicator of salinity.

Drainage basin - The portion of the surface of the Earth that contributes water to a stream through overland runoff, including tributaries and impoundments.

Drinking water advisory - A non-regulatory document that analyzes the available cancer and non-cancer data on a contaminant and recommends acceptable levels.

Endocrine system - The collection of ductless glands in animals that secrete hormones, which influence growth, gender, and sexual maturity.

Enriched - The addition of an element or chemical compound so that its total concentration is at least 10 percent greater than the concentration at a background site.

Evaporite minerals (deposits) - Minerals or deposits of minerals formed by evaporation of water containing salts. These deposits are common in arid climates.

Evapotranspiration - A collective term that includes water lost through evaporation from the soil and surface-water bodies and by plant transpiration.

Fertilizer - Any of a large number of natural or synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its fertility.

Fish community - Fish species that interact in a common area.

Geothermal - Relating to the Earth's internal heat; commonly applied to springs or vents discharging hot water or steam.

Granitic rocks - Coarse-grained igneous rock.

Headwater area - Mountains and adjacent areas where precipitation is adequate to provide ground-water recharge and streamflow.

Human health advisory (HA)- Non-regulatory levels of contaminants in drinking water that may be used as guidance in the absence of regulatory limits. Advisories consist of estimates of concentrations that would result in no known or anticipated health effects (for carcinogens, a specified cancer risk) determined for a child or for an adult for various exposure periods.

Hydrograph - Graph showing variation of water elevation, velocity, streamflow, or other property of water with respect to time.

Intensive Fixed Sites - Basic Fixed Sites with increased sampling frequency during selected seasonal periods and analysis of dissolved pesticides for 1 year. Most NAWQA Study Units have one to two integrator Intensive Fixed Sites and one to four indicator Intensive Fixed Sites.

Irrigation drainage - The part of irrigation applied to the surface that is not consumed by evapotranspiration or uptake by plants and that migrates to an aquifer or surface-water body.

Load - A material or constituent in solution, in suspension, or in transport; usually expressed in terms of mass or volume.

Main stem - The principal course of a river or a stream.

Maximum contaminant level (MCL) - Maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCLs are enforceable standards established by the U.S. Environmental Protection Agency.

Mean - The average of a set of observations, unless otherwise specified.

Median - The middle or central value in a distribution of data ranked in order of magnitude. The median is known also as the 50th percentile.

Metamorphic rocks - Rocks that have formed in the solid state in response to pronounced changes of temperature, pressure, and chemical environment.

Nutrient - Element or compound essential for animal and plant growth including nitrogen and phosphorus.

Occurrence and distribution assessment - Characterization of the broad-scale spatial and temporal distributions of water-quality conditions in relation to major contaminant sources and background conditions for surface water and ground water.

Organic material - Natural material derived from plants and animals.

Organochlorine compound - Synthetic organic compounds containing chlorine. As generally used, refers to compounds containing mostly or exclusively carbon, hydrogen, and chlorine. Examples include organochlorine insecticides and polychlorinated biphenyls.

Overburden - Soil or rock overlying a valuable mineral deposit.

Pesticide - A chemical applied to crops, rights of way, lawns, or residences to control weeds, insects, fungi, nematodes, rodents or other "pests."

Phenols - A class of organic compounds containing an aromatic ring and hydroxyl groups. Phenols are used in the production of phenolic resins, germicides, herbicides, fungicides, pharmaceuticals, dyes, plastics, and explosives.

Phthalate esters - A class of organic compounds containing an aromatic ring, oxygen, and other organic groups. Phthalates are used as plasticizers, to manufacture products from polymers of vinyl chloride, propylene, ethylene, and styrene.

Polychlorinated biphenyls (PCBs) - A mixture of chlorinated derivatives of biphenyl, marketed under the trade name Aroclor with a number designating the chlorine content (such as Aroclor 1260). PCBs were used in transformers and capacitors for insulating purposes and in gas pipeline systems as a lubricant. Further sale for new use was banned by law in 1979.

Polycyclic aromatic hydrocarbon (PAH) - A class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, fossil fuels, and natural or anthropogenic introduction of uncombusted coal and oil. PAHs include benzo(a)pyrene, fluoranthene, and pyrene.

Principal aquifer - Unconsolidated deposits with more than 100 feet of saturated thickness and dissolved solids less than 1,000 mg/L. The primary sources of ground water for public supply and irrigation.

Secondary maximum contaminant level (SMCL) - The maximum contamination level in public water systems that, in the judgment of the U.S. Environmental Protection Agency (USEPA), are required to protect the public welfare. SMCLs are secondary (nonenforceable) drinking-water regulations established by the USEPA for contaminants that may adversely affect the odor or appearance of such water.

Sediment - Particles, derived from rocks or biological materials, that have been transported by a fluid or other natural process, and are suspended or settled in water.

Sedimentary rocks - Rocks formed by the accumulation of sediment in water or from air.

Sediment quality guideline - Threshold concentration above which there is a high probability of adverse effects on aquatic life from sediment contamination, determined using modified USEPA [44] procedures.

Semipermeable membrane device - Passive sampling devices for organochlorine and semivolatile organic compounds. They are low-density polyethylene tubes filled with fish lipid. The fish lipid sequesters dissolved compounds from water.

Semivolatile organic compound (SVOC) - Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalate esters, and polycyclic aromatic hydrocarbons (PAHs).

Shallow water-table aquifer - Unconsolidated deposits containing water whose surface is at atmospheric pressure. In the Study Unit, these aquifers are not typically used as public supply.

Species - Populations of organisms that may interbreed and produce fertile offspring having similar structure, habits, and functions.

Stream reach - A continuous part of a stream between two specified points.

Study-Unit Survey - Broad assessment of the water-quality conditions of the major aquifer systems of each Study Unit. The Study-Unit Survey relies primarily on sampling existing wells and, wherever possible, on existing data collected by other agencies and programs. Typically, 20 to 30 wells are sampled in each of three to five aquifer subunits.

Subsidence - Compression of soft aquifer materials in a confined aquifer due to pumping of water from the aquifer. Subsidence has occurred in Las Vegas Valley within the Study Unit.

Sulfide mineral - A mineral with reduced forms of sulfur usually combined with another element such as iron (pyrite, FeS_2). Sulfide minerals often produce sulfuric acid when exposed to the atmosphere and water.

Synoptic study - A short-term investigation of specific water-chemistry or ecological conditions during selected seasonal or hydrologic conditions to provide improved resolution for critical water-quality conditions.

Synthetic organic compounds - Compounds that are manmade and contain carbon. Common synthetic organic compounds are pesticides, volatile organic compounds such as solvents, gasoline components, and trihalomethanes, phenols, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and pthtalate esters.

Tailings - Rock that remains after processing ore to remove the valuable minerals.

Tertiary-treated sewage - The third phase of treating sewage that removes nitrogen and phosphorus before it is discharged.

Tolerant species - Those species that are adaptable to (tolerant of) human effects on the environment.

Trace element - An element found in only minor amounts (concentrations less than 1.0 microgram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Triazine herbicide - A class of herbicides containing a symmetrical triazine ring (a nitrogen-heterocyclic ring composed of three nitrogens and three carbons in an alternating sequence). Examples include atrazine, prometon, and simazine.

Tributary - A river or stream flowing into a larger river, stream, or lake.

Trihalomethanes (THM) - A group of volatile organic compounds containing one carbon atom, one hydrogen atom, and three halide (fluorine, chlorine, bromine, and iodine) atoms. Common THMs include chloroform, bromoform, and dichlorofluoromethane. These compounds can be a result of chlorination processes in water-supply wells.

Unconsolidated deposit - Deposit of loosely bound sediment that typically fills topographically low areas. These deposits are common in valleys throughout the Study Unit and typically form principal aquifers when saturated.

Un-ionized ammonia - The neutral form of ammonia in water. The un-ionized ammonia is present as NH_4OH in an amount dependent on ammonia concentration, temperature, and pH. As water temperature and pH are increased, the proportion of un-ionized ammonia increases.

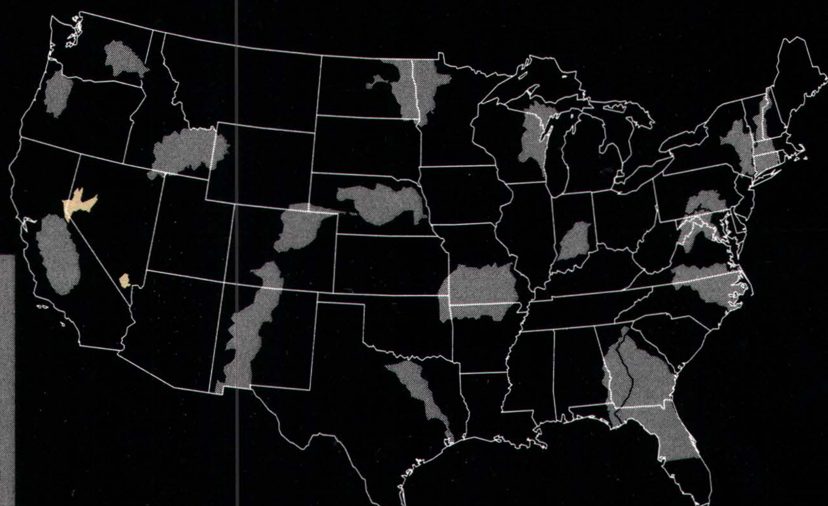
Urban drainage - Water derived from runoff or shallow ground-water discharge from urban areas.

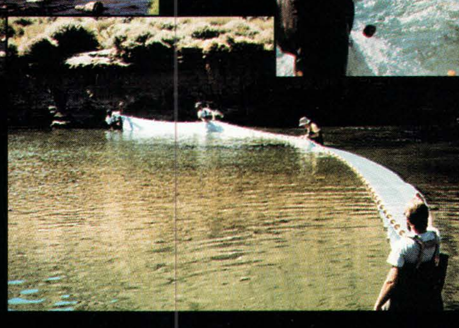
Volatile organic compounds (VOCs) - Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

Water table - The point below the land surface where ground water is first found and below which the earth is saturated. Depth to the water table varies widely across the country.

NAWQA

National Water-Quality Assessment (NAWQA) Program
Nevada Basin and Range





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