U.S. Geological Survey
Fact Sheet FS-115-95

Water Budget and Salinity of Walker Lake,Western Nevada

Walker Lake (fig. 1) is one of the rare perennial, terminal lakes in the Great Basin of the western United States. The lake is the terminus for all surface-water and ground-water flow in the Walker River Basin Hydrographic Region (fig. 2) that is not consumed by evaporation, sublimation, or transpiration.

The concentration of dissolved solids (salts) in the lake and the lake-surface altitude fluctuate primarily in response to the amounts of water entering and evaporating from the lake. Because Walker Lake is a terminal sink—it has no documented surface- or ground-water outflow—dissolved solids that enter it accumulate as the lake water evaporates. Declining lake levels, owing to natural and anthropogenic processes, have resulted in most Great Basin terminal lakes being too saline to support fish. In Nevada, the only terminal lakes that contain fish are Pyramid Lake, Ruby Lake, and Walker Lake. Dissolved-solids concentration in Walker Lake increased from about 2,500 milligrams per liter (mg/L) in 1882 (Russell, 1885, p. 70) to 13,300 mg/L in July 1994 (U.S. Geological Survey analysis), as the lake-surface altitude declined from about 4,080 to 3,944 feet (ft) above sea level (fig. 3). This dramatic increase in dissolved-solids concentration threatens the Walker Lake ecosystem and the fish that depend on this ecosystem.

Streamflow in Walker River Basin

In most years, Walker River is the primary source of water for Walker Lake. Flow in the river is mainly from precipitation in the eastern Sierra Nevada of California. Streamflow from the Sierra Nevada has averaged 327,000 acre-feet per year (acre-ft/yr) for 55 years, 1939-93 (table 1 and fig. 2, total for sites 1 and 5).

All flow data in table 1 are adjusted to the 55-year period of continuous record (1939-93) at site 4 (fig. 2), because, although this site does not have the longest streamflow record, no upstream reservoirs or irrigation diversions exist and streamflow has been measured continuously at the site since 1939. Long-term average annual flows were estimated by comparing the average annual flow at a stream-gaging station with the average annual flow at site 4 for years of concurrent record. Then, this partial record was adjusted to a long-term average using the 55-year average at site 4.

Streamflow is measured approximately where the principal streams enter and exit each valley (fig. 2). Little ground water flows between valleys, so the difference between streamflow entering and exiting a valley can be used to estimate the consumption of surface water in the valley (table 2). Streamflow is consumed by evaporation and transpiration from irrigated crops and pasture land, natural vegetation, and water surfaces. River water also recharges ground-water aquifers.

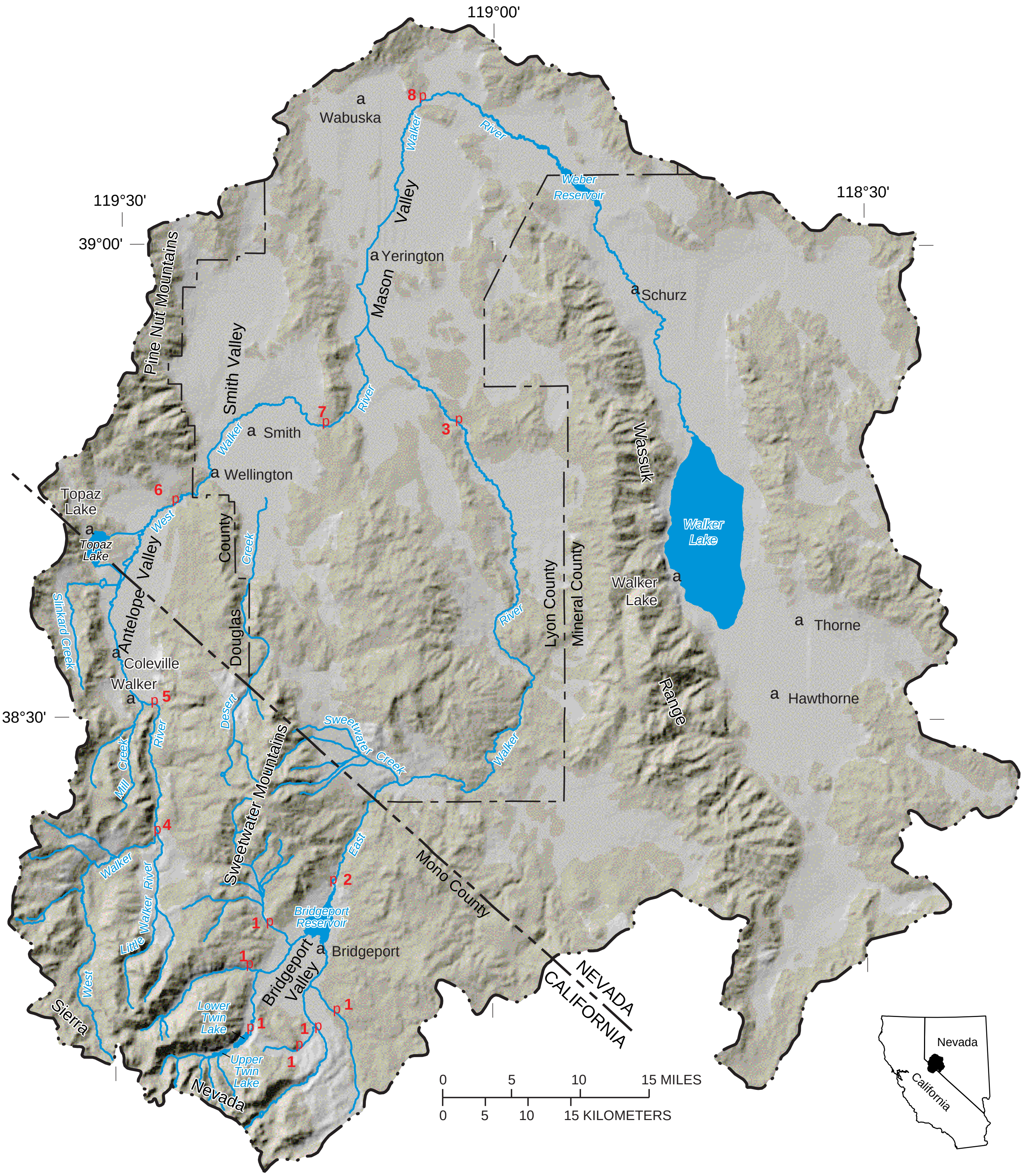
In some valleys, local streams also contribute surface-water flow. Thus, estimates of surface-water consumption in table 2 are minimum values, because local streamflow in valleys may not have been measured. In Smith Valley, 8,700 acre-ft/yr of Desert Creek flow has been included in the water budget. In Antelope Valley, the contribution from Mill and Slinkard Creeks is unknown, so the difference of 15,000 acre-ft between average inflow and outflow underestimates total surface-water consumption.

Water Budget for Walker Lake

Walker Lake volume decreased from 8,660,000 acre-ft in 1908 to 2,060,000 acre-ft in 1994—an average 76,000 acre-ft/yr. Walker Lake lost an average of 59,000 acre-ft/yr during 1939-93—less than during 1908-94 mainly because of decreasing lake-surface area.

The average annual volume of water entering Walker Lake from Walker River during 1939-93 was estimated to be

Figure 1. Walker Lake, June 1971; southward view from west shore; lake-surface altitude, 3,974 feet (30 feet above level of July 1994). Photograph by Steve Van Denburgh, U.S. Geological Survey.



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

EXPLANATION

- **Basin-fill deposits**
- **Bedrock**
- **Basin boundary**
- p 4 **Stream-gaging station and site number (table 1)**

Geology from Jennings (1977), Stewart and Carlson (1978)

Figure 2. Geographic setting, geology, and stream-gaging stations in the Walker River Basin.

Table 1. Average annual flow for gaging stations on principal streams, 1939-93

[Data from U.S. Geological Survey. Averages for sites 1-3 and 5-8 are partly estimated on basis of complete 1939-93 record for site 4 (see text); all averages are rounded to nearest 1,000 acre-feet]

Site No. (fig. 2)	Site description	Average annual flow, 1939-93 (acre-feet)	Period of full-year record
1	Total of six streams flowing into Bridgeport Valley	132,000	1954-74
2	East Walker River below Bridgeport Reservoir	107,000	1923, 1926-93
3	East Walker River above Strosnider Ditch	105,000	1948-77
4	West Walker River below Little Walker River	185,000	1939-93
5	West Walker River near Coleville	195,000	1916-36, 1958-93
6	West Walker River at Hoye Bridge	180,000	1921, 1926-28, 1958-93
7	West Walker River near Hudson	133,000	1915-23, 1948-77
8	Walker River near Wabuska	128,000	1903-04, 1921-22, 1926-34, 1939-40, 1944-87, 1990-93

76,000 acre-ft. This estimate was obtained by using an average lake area of 40,600 acres for 1939-93; an evaporation rate of 4.1 feet per year (ft/yr; Koch and others, 1979, p. 48), which yields 166,000 acre-ft/yr of evaporation; and a precipitation rate for Walker Lake of 4.9 inches per year (in/yr) [average precipitation at Hawthorne, Schurz, and Thorne, 1939-93 (National Weather Service data), adjusted to the 44 years of record at Hawthorne], which gives 17,000 acre-ft/yr of direct lake-surface precipitation; local surface-water inflow of 3,000 acre-ft/yr (Everett and Rush, 1967, p. 26; Rush, 1970; Boyle Engineering Corporation, 1976, table 4.2); and ground-water inflow of 11,000 acre-ft/yr (Schaefer, 1980, p. 31), which is primarily recharge from Walker River. The flow of 76,000 acre-ft is less than the 85,000 acre-ft estimated by Rush (1970) for 1919-65 and greater than the 69,600 acre-ft estimated by Schaefer (1980, p. 32) for 1903-77.

On the basis of streamflow data for 1939-93, an average 52,000 acre-ft of Walker River water was consumed annually between the Wabuska gaging station and Walker Lake. River water was consumed by evaporation from the river surface and Weber Reservoir, evapotranspiration from natural vegetation and irrigated lands, and recharge to ground water.

Table 2. Surface water consumed within valleys for average annual streamflows, 1939-93.

[Acre-feet per year, rounded]

Valley	Inflow	Outflow	Con-sumed
Bridgeport	132,000	107,000	25,000
Antelope	195,000	180,000	15,000
Smith	189,000	133,000	56,000
Mason	238,000	128,000	110,000

A water budget for Walker Lake using the estimated average annual 55-year flow of Walker River into Walker Lake, ground-water inflow, and local surface-water inflow, combined with estimates of average annual precipitation and evaporation for the July 1994 lake-surface altitude of 3,944 ft (area of 33,300 acres) is presented in table 3. The water budget shows that, assuming hydrologic conditions remain the same as 1939-93, about 33,000 acre-ft/yr of water in excess of the long-term average is needed to maintain the 1994 lake-surface altitude.

Lake Salinity

The dissolved-solids concentration of Walker Lake changes primarily in response to changes in lake volume that result from fluctuating lake-surface altitude (fig. 3). Dissolved solids in Walker River, local surface-water inflow, ground-water inflow, and precipitation falling on the lake, salts carried into the lake by wind, and salts moving upward into the lake from lake-bottom sediments add to the dissolved-solids content of the lake. However, because evaporation removes water and leaves dissolved solids, the dominant control on lake dissolved-solids concentration is the amount of water in the lake. This is indicated for Walker Lake by the close correspondence between changes in dissolved-solids concentration and changing lake-surface altitude (fig. 3).

To maintain the dissolved-solids concentration at the current (July 1994) level of 13,300 mg/L, about 33,000 acre-ft/yr more water than the long-term average is needed (table 3). To reduce the 1994 dissolved-solids concentration to 10,000 mg/L, the lake-surface altitude would need to be raised approximately 20 ft—to 3,964 ft—which is equivalent to about 700,000 acre-ft of water. Then, to maintain this lake level, an additional 47,000 acre-ft/yr more water than the long-term average would be needed, assuming 1939-93 hydrologic conditions.

An estimated average 66,000 tons of dissolved solids have been added to Walker Lake annually between 1882 and 1994. Thus, even with a stable lake-surface altitude, dissolved-solids concentration will slowly increase because Walker Lake is a terminal sink.

Table 3. Walker Lake water budget for long-term average annual surface-water inflow, ground-water inflow, and lake-surface precipitation and evaporation rates, and for lake-surface area as of July 1994

[Acre-feet per year, rounded]

Budget component	Estimated quantity
Inflow	
Walker River	76,000
Local surface water	3,000
Ground water	11,000
Precipitation (4.9 in/yr)	14,000
Total	104,000
Outflow	
Evaporation (4.1 ft/yr)	137,000
Difference	-33,000

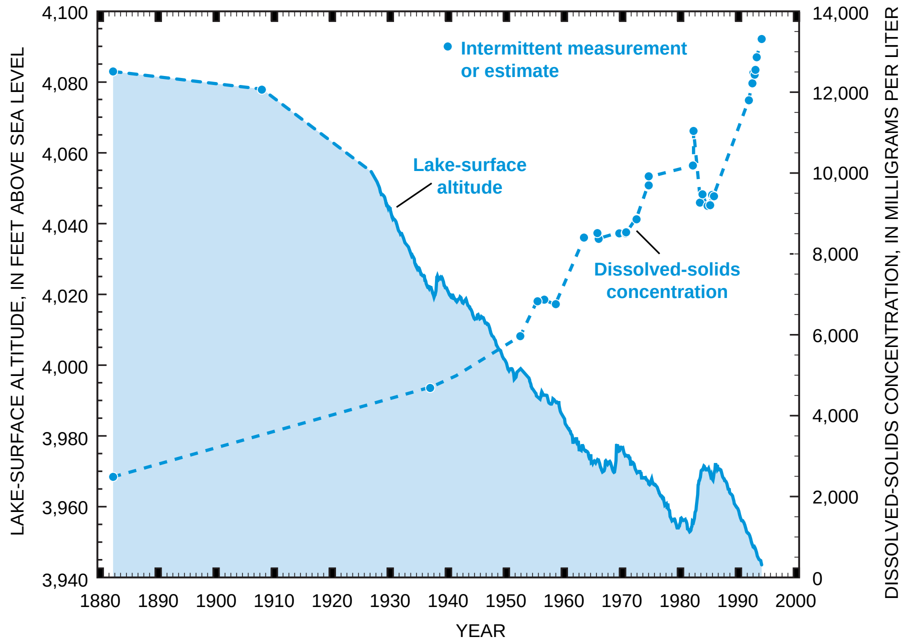


Figure 3. Dissolved-solids concentrations and lake-surface altitudes for Walker Lake, 1882-1994. Dissolved-solids data are from Russell (1885, p. 70), Benson and Spencer (1983, p. 35), Nevada Department of Environmental Protection, Desert Research Institute, and U.S. Geological Survey WATSTORE data base. Lake-altitude data are from Rush (1970) and U.S. Geological Survey WATSTORE data base.

In 1994, Walker Lake contained an estimated 37,000,000 tons of dissolved solids.

Walker Lake has gone dry several times during the last 10,000 years (Benson, 1988, p. 1; Larry Benson, U.S. Geological Survey, oral commun., 1994), in response to changes in climatic and hydrologic conditions. Thus, current conditions in the Walker Lake basin may not persist in the future, as demonstrated by the past.

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Prepared in cooperation with the Walker River Paiute Tribe