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Salinity of Nevada's Terminal Lakes: History, Mystery, and Restoration

Kip K. Allander; Supervisory Hydrologist; NV Water Science Center (kalland@usgs.gov)

2020 MSSC Summit:

February 27, 2020, Las Vegas NV

Nevada's Remnants of Lake Lahontan

Benson (2013)

Pyramid Lake

Winnemucca Lake

Walker Lake

Trump (2004)

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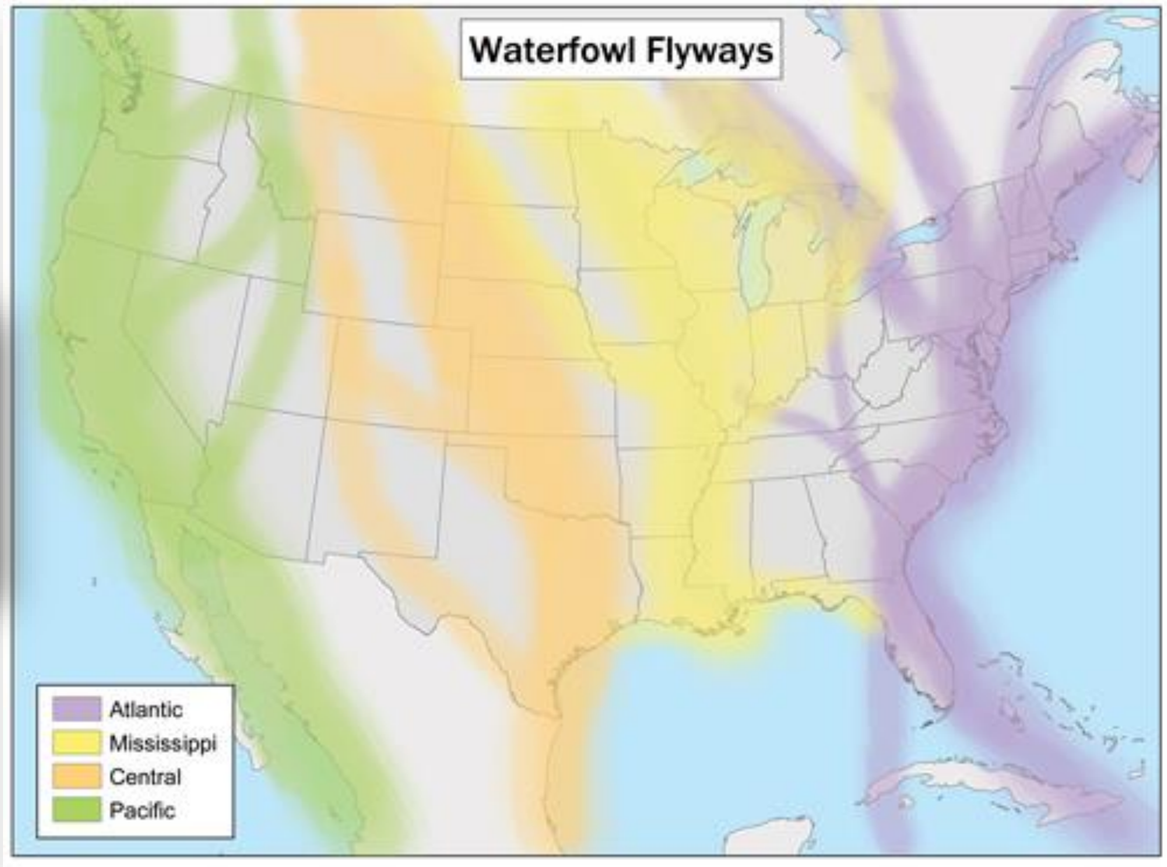
Pacific Flyway



USFWS

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Fisheries

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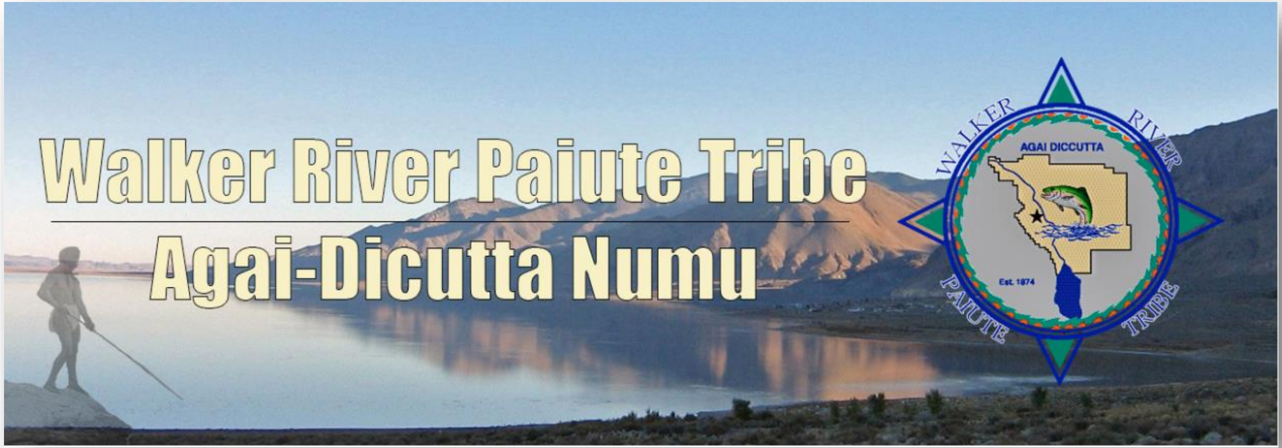
Indigenous People and Culture

Cui-Ui Dicutta Numu (Pyramid Lake Paiute Tribe)



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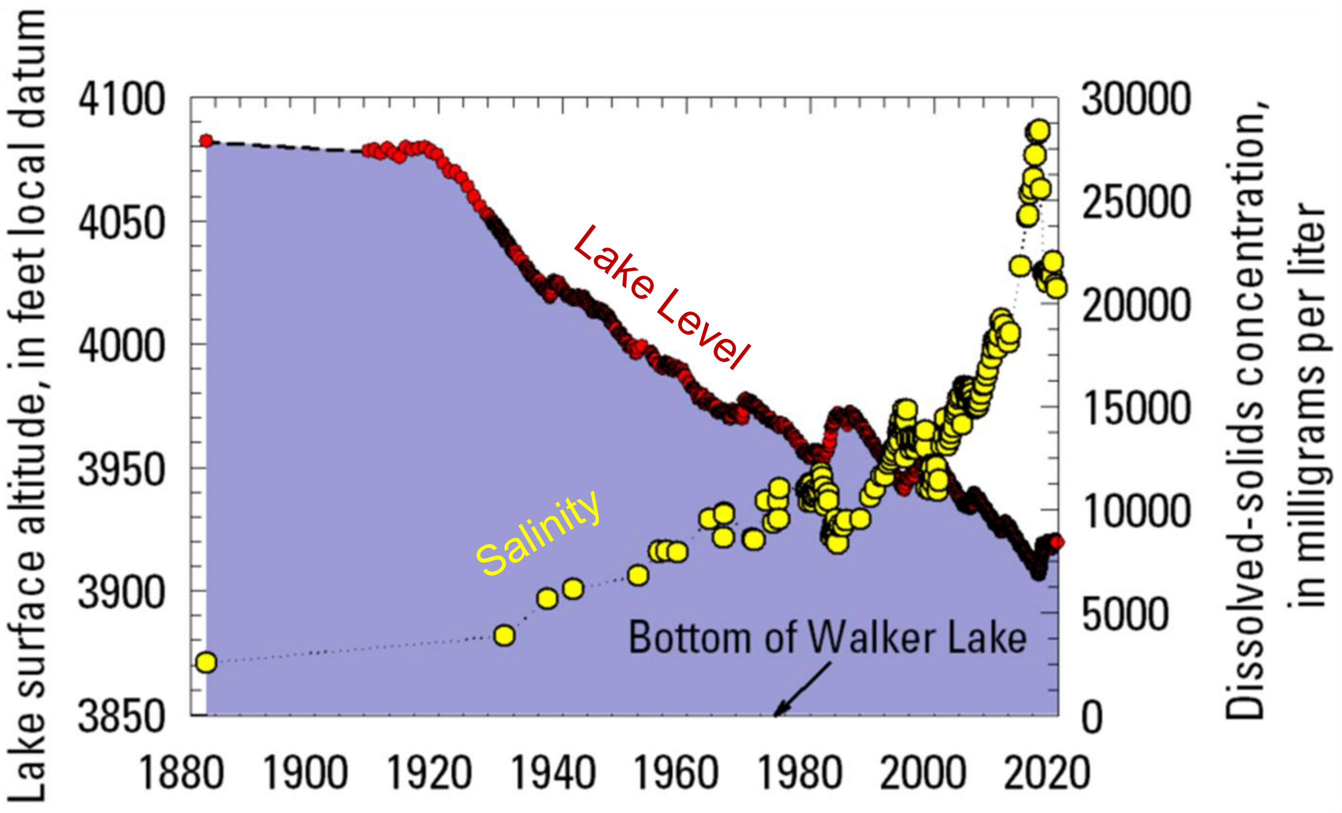
Problem with Terminal Lakes. Salinity is highly sensitive to changes in storage.



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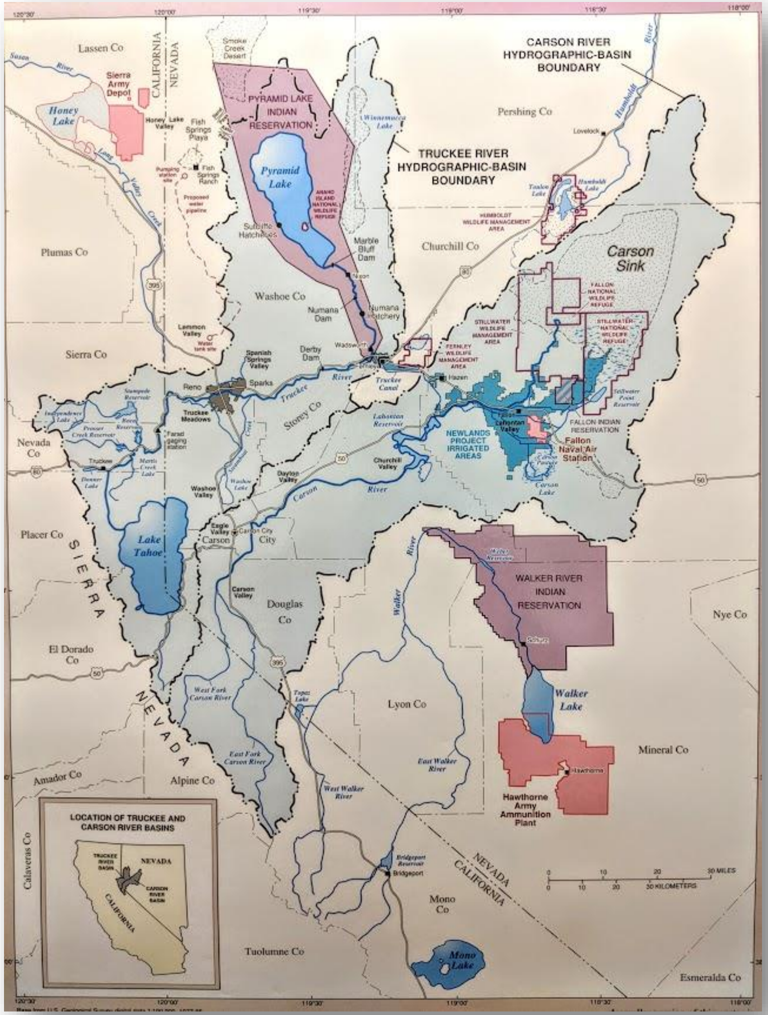
Truckee, Carson, Walker River systems



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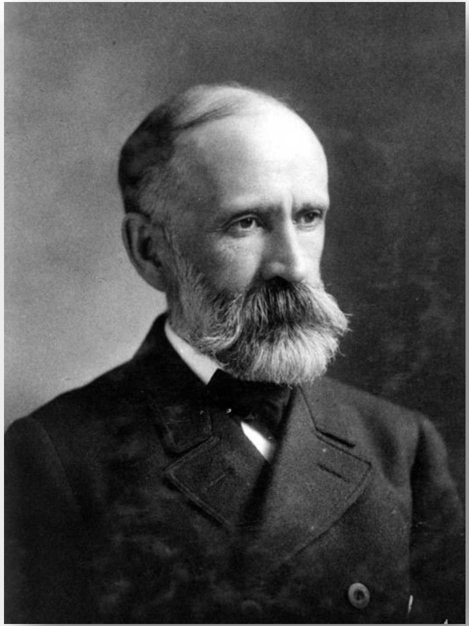
Trionfante and Peltz (1993)

Geologic Investigation by Israel C. Russell 1882 - 1883



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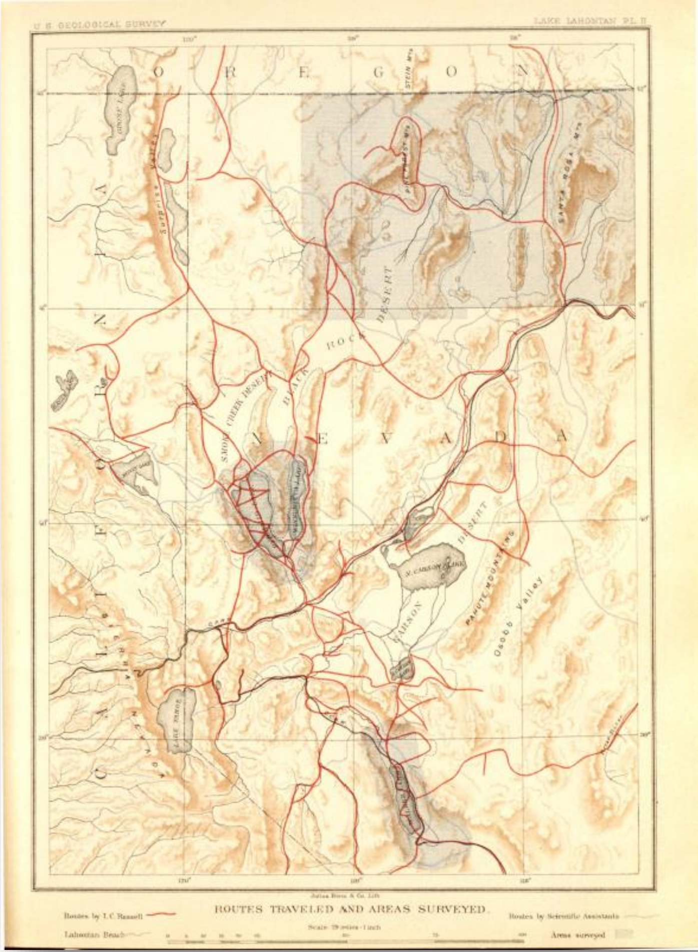
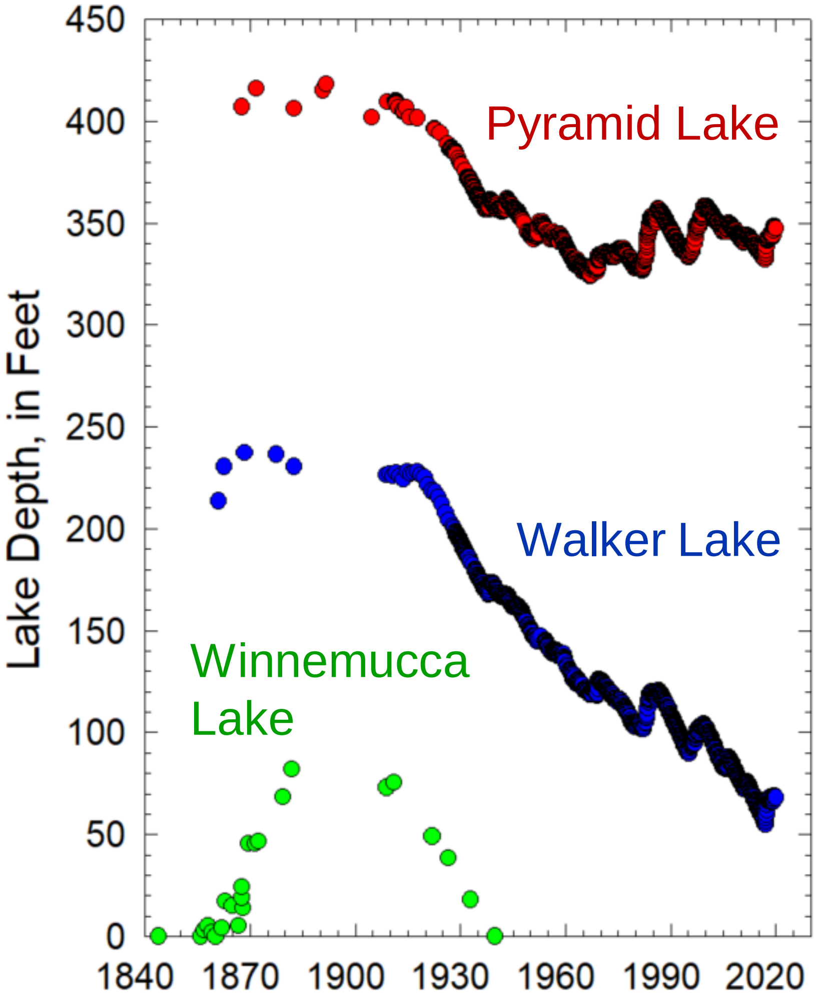


Russell (1885)

USGS

Historic Lake Levels



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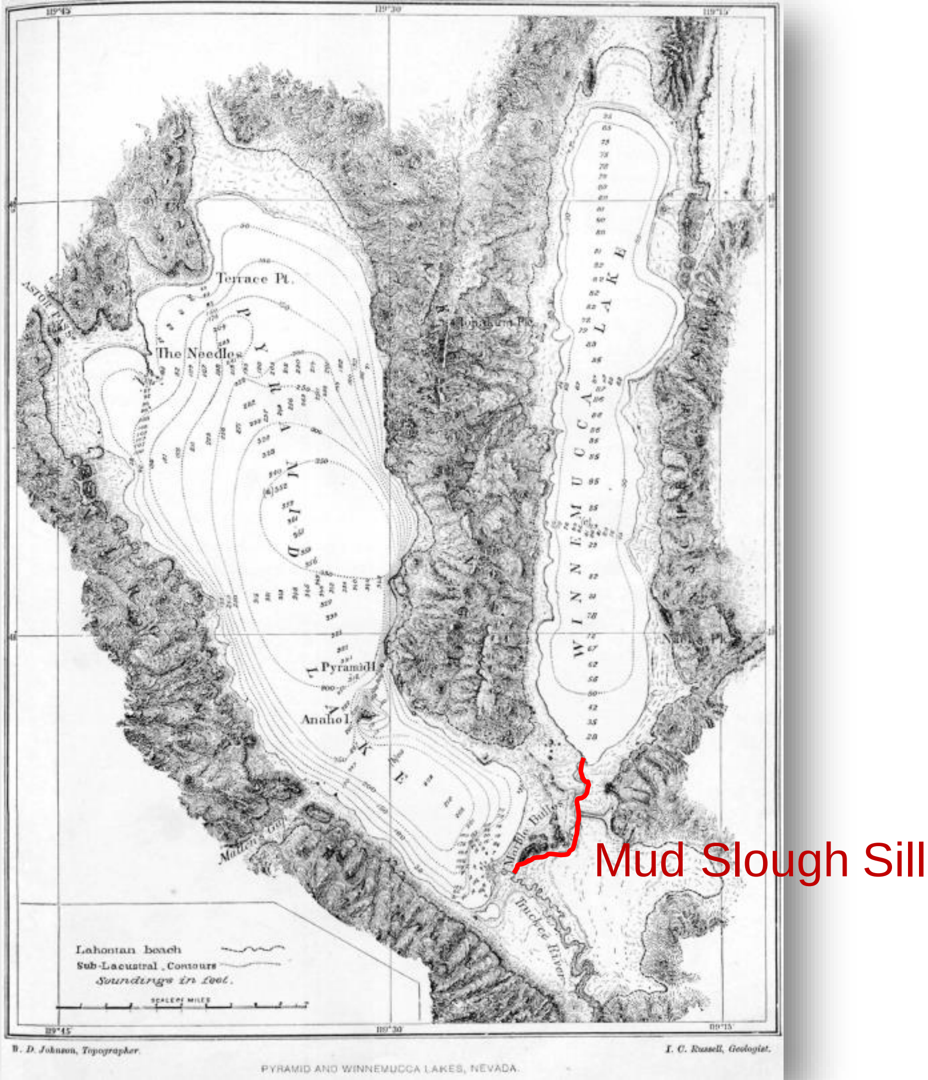
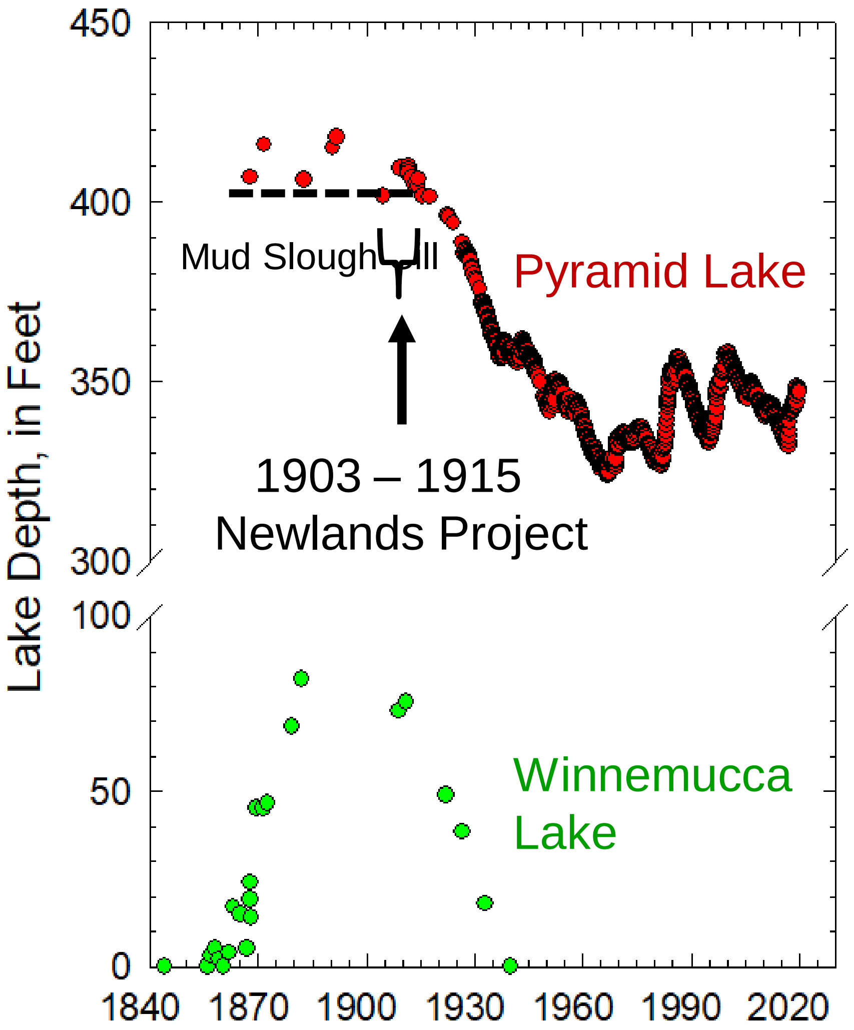
Pyramid and Winnemucca Lakes



Russell (1885)

USGS

Major events effecting water supply of Pyramid Lake



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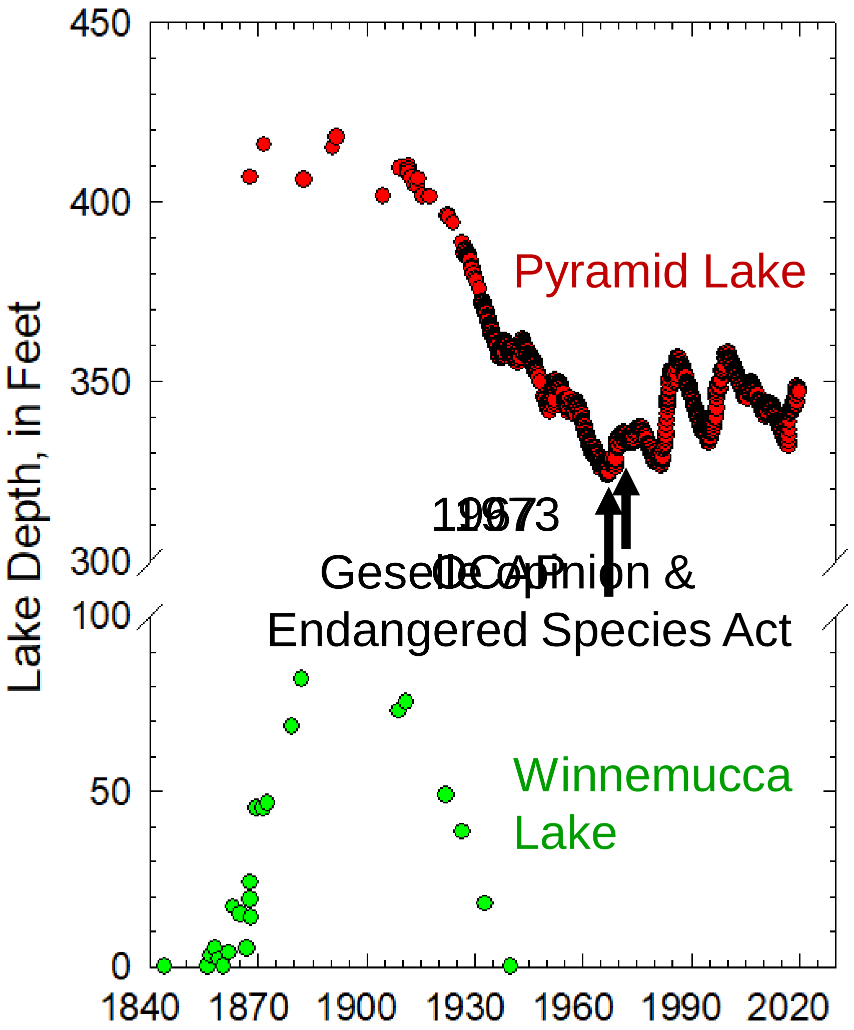
Newlands Project

USBR

(Simpson and others, 2015)

Major events effecting water supply of Pyramid Lake



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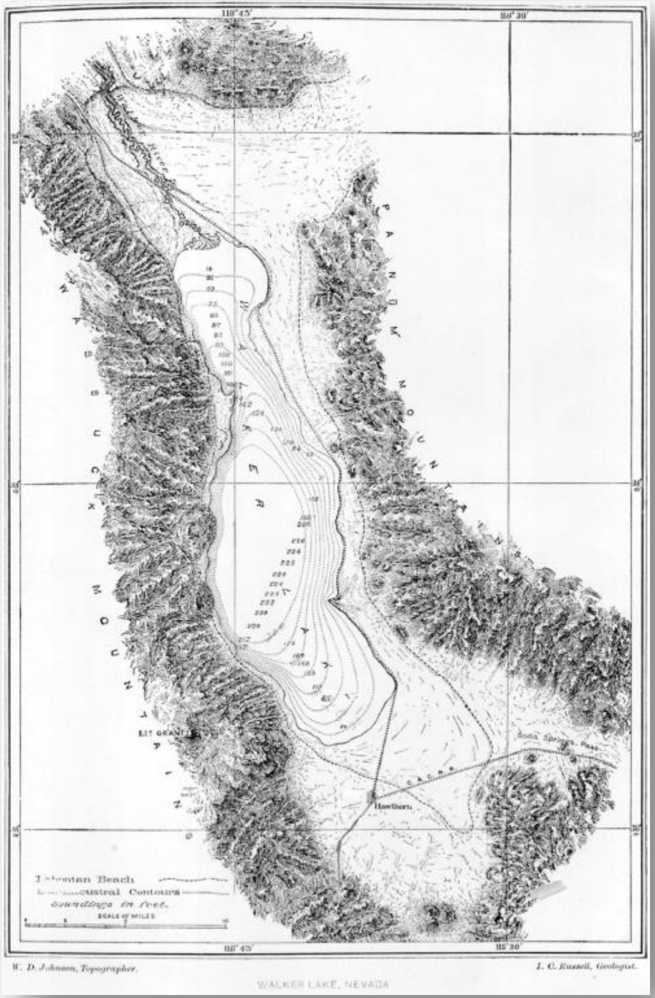
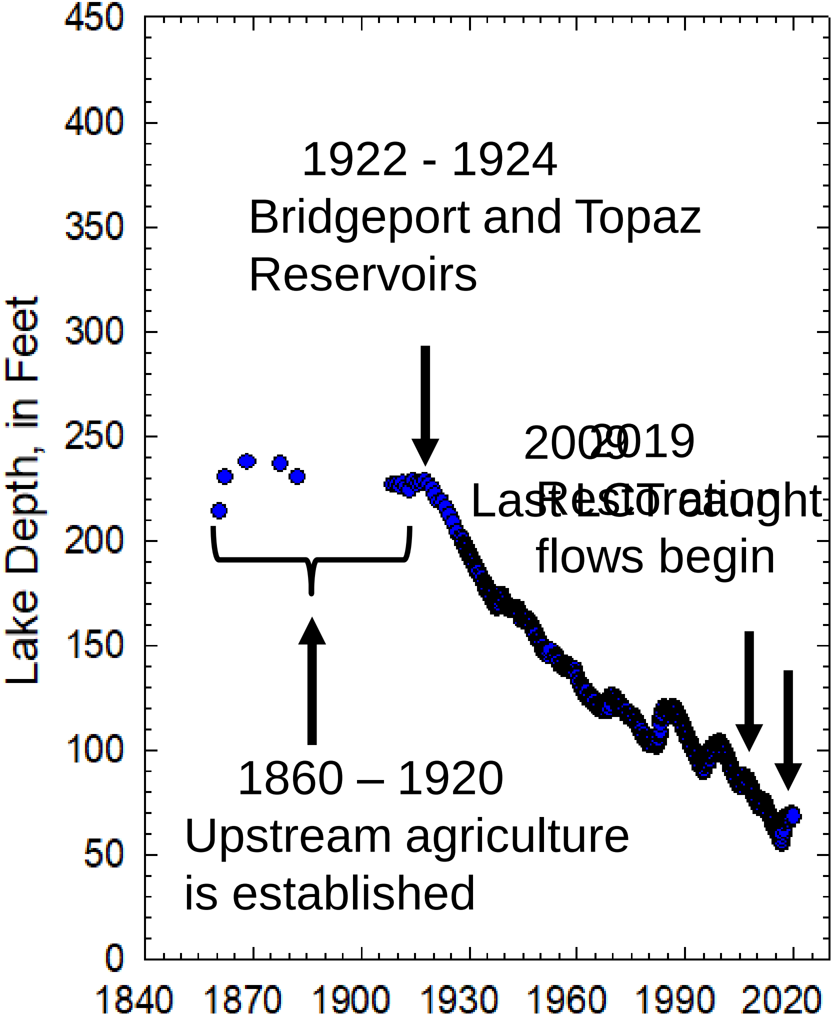
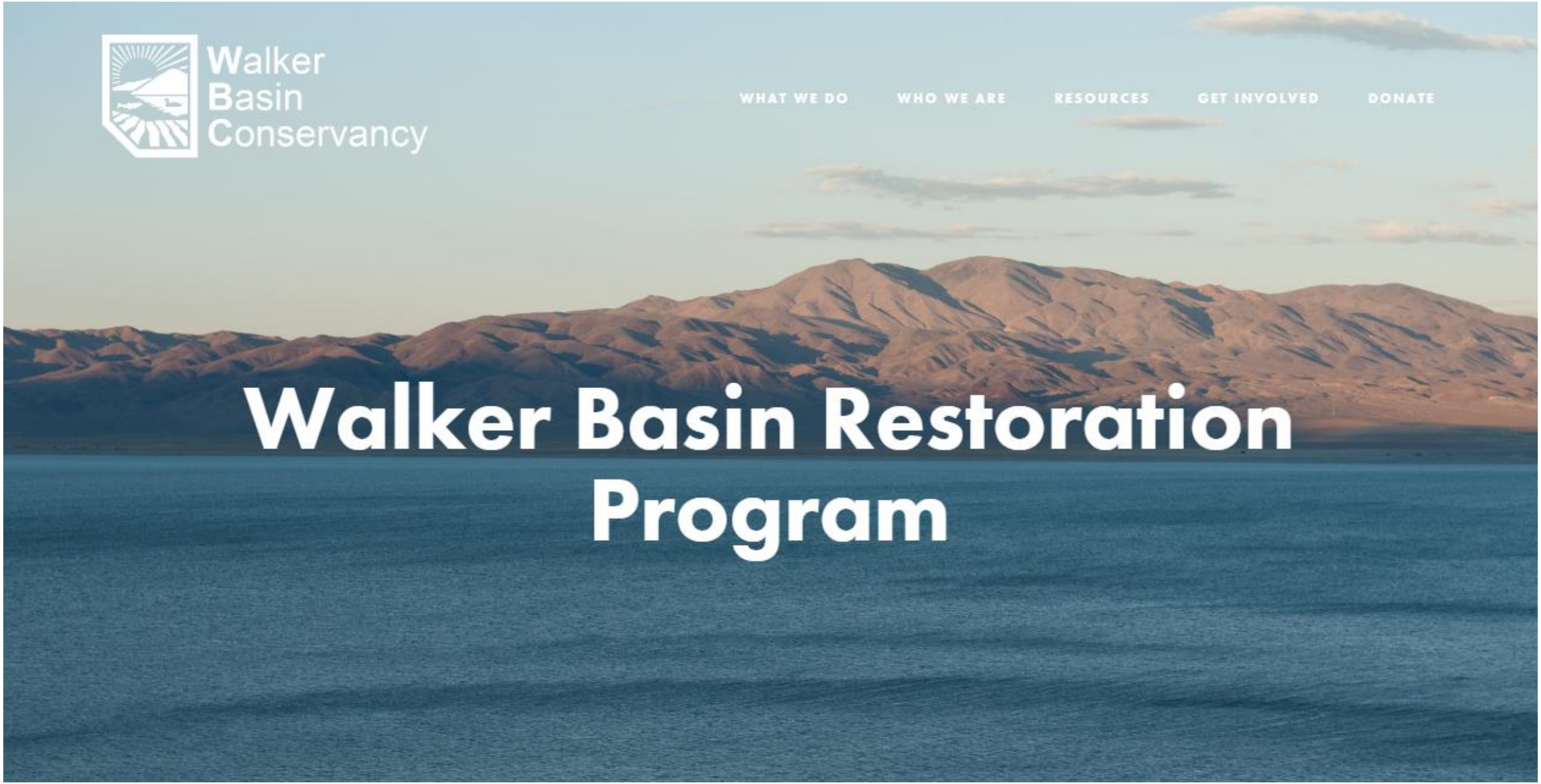
Walker Lake



Russell (1885)

Major events effecting water supply of Walker Lake




Walker
Basin
Conservancy
WHAT WE DO
WHO WE ARE
RESOURCES
GET INVOLVED
DONATE
Walker Basin Restoration Program

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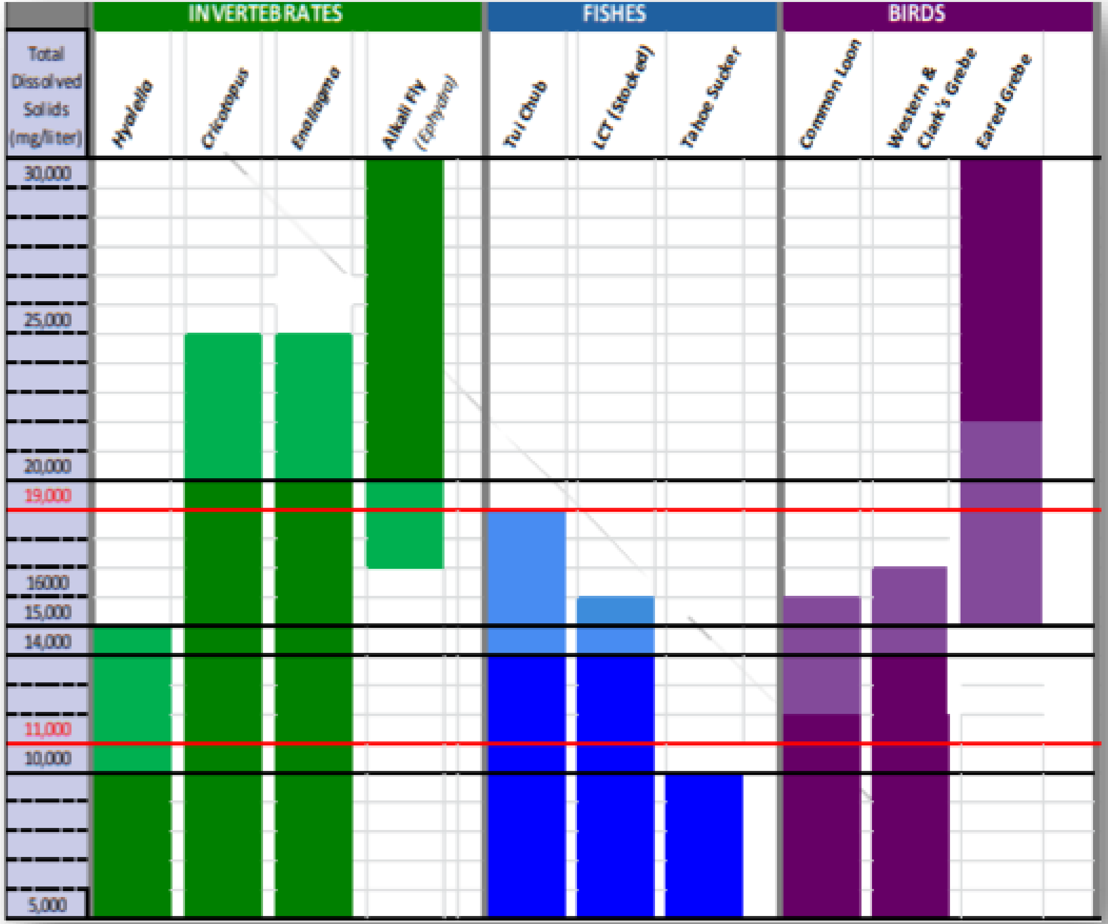
Walker Lake Salinity Effects on Key Indicator Species



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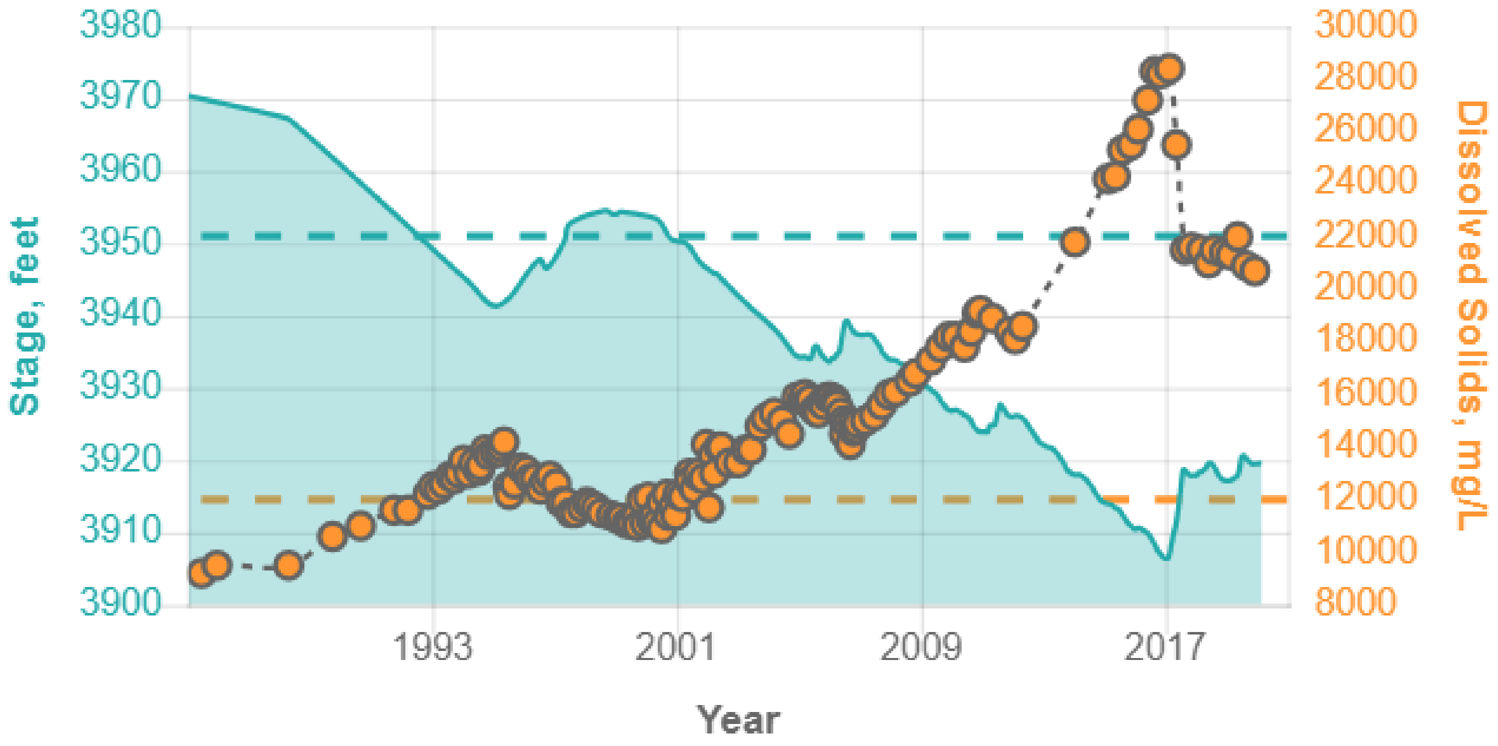
The Nature Conservancy (2013)

Restoration targets: 12,000 mg/L TDS; 3,951 foot level



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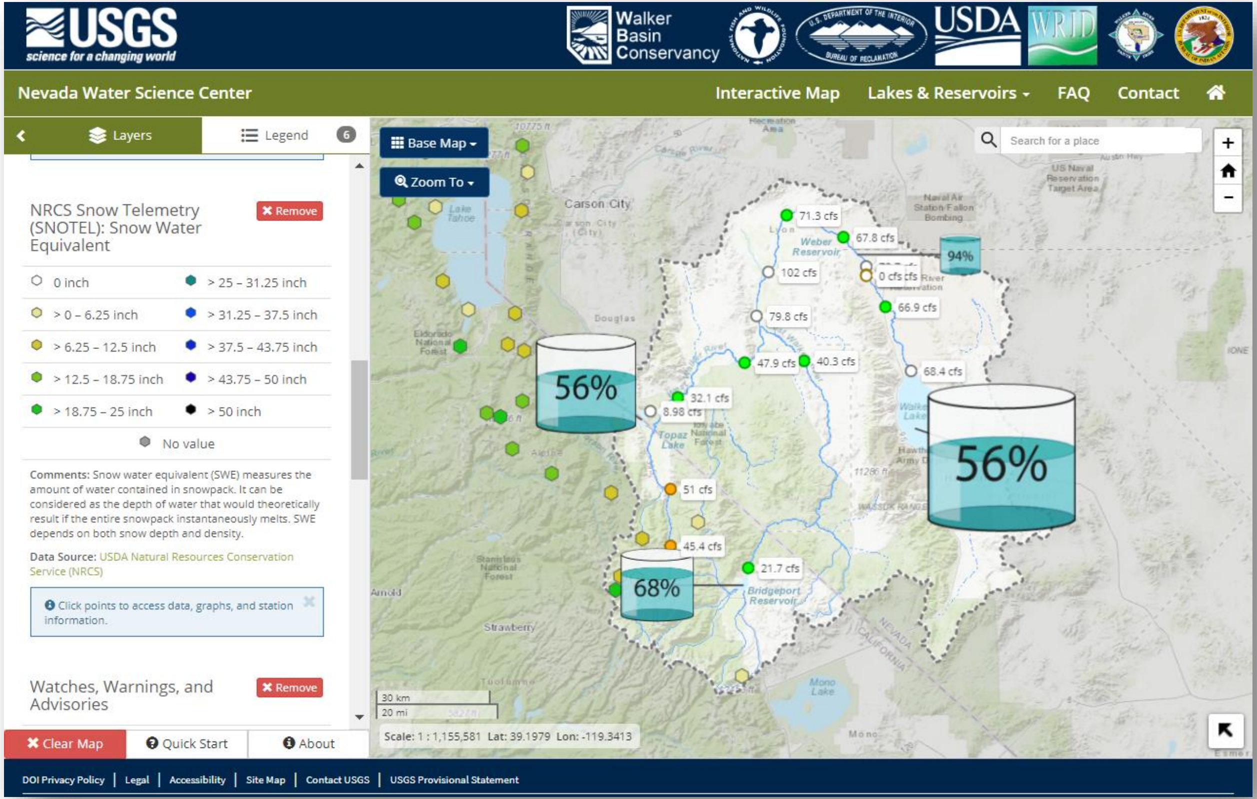
Walker Basin Hydro Mapper



Scan me

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https://webapps.usgs.gov/walkerbasinhydromapper

Walker Lake and the Mystery of the Missing Salt

Walker Lake Salt Budget

$$WR_i + GWi + PPTi + LBi + SLi - (GW_o + PPTo + LBo + BIOo + SLo) = \Delta\, Salt\ Mass$$

Salt Inflows:

WR_i - Walker River

GW_i - Groundwater

PPT_i - Precipitation

LB_i - Lakebed sediments

SL_i - Shoreline sediments

Salt Outflows:

GW_o - Groundwater

PPT_o - Precipitation of salt minerals

LB_o - Lakebed sediments

BIO_o - Biologic processes (diatoms)

SL_o - Shoreline sediments

Salt Budget Estimate in 1995

+66,000 Tons/yr

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.

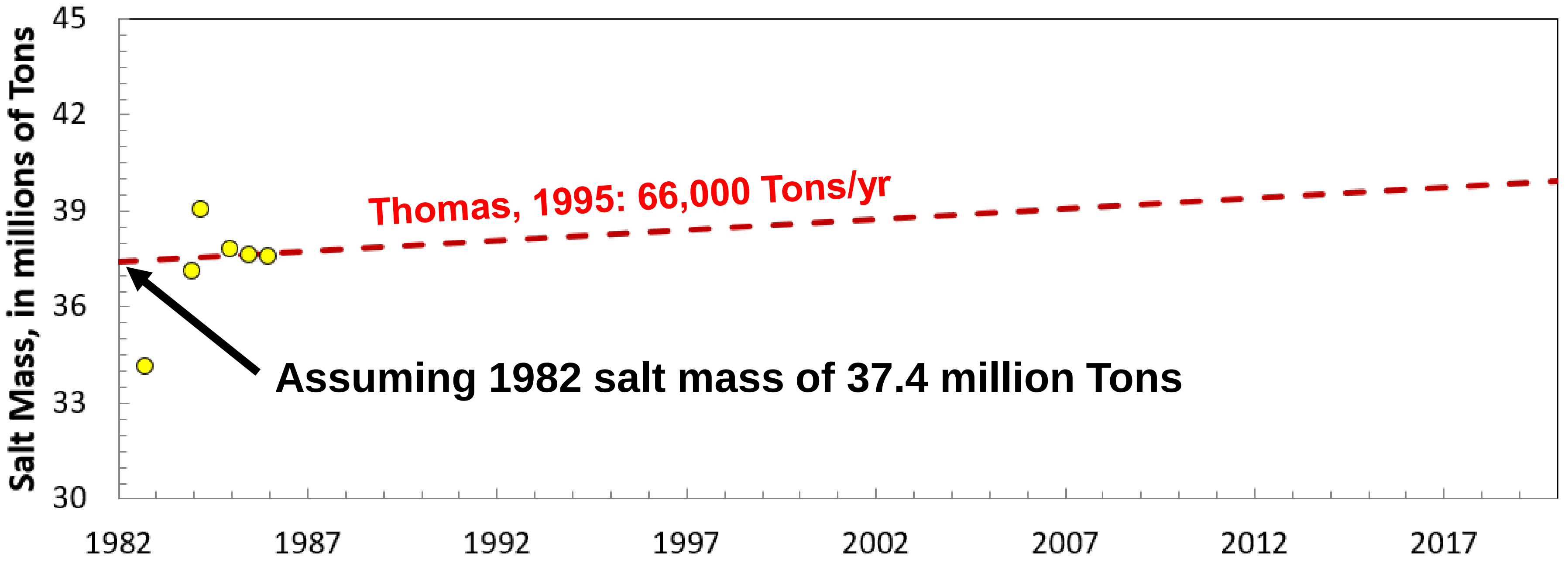
The average annual volume of water entering Walker Lake from Walker River during 1939-93 was estimated to be

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.

Thomas, 1995

USGS

Estimated Trend of Salt Mass in Walker Lake



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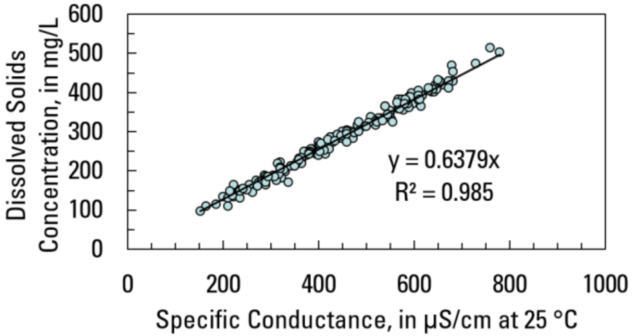
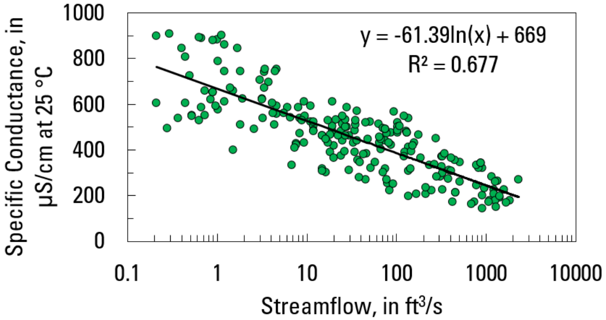
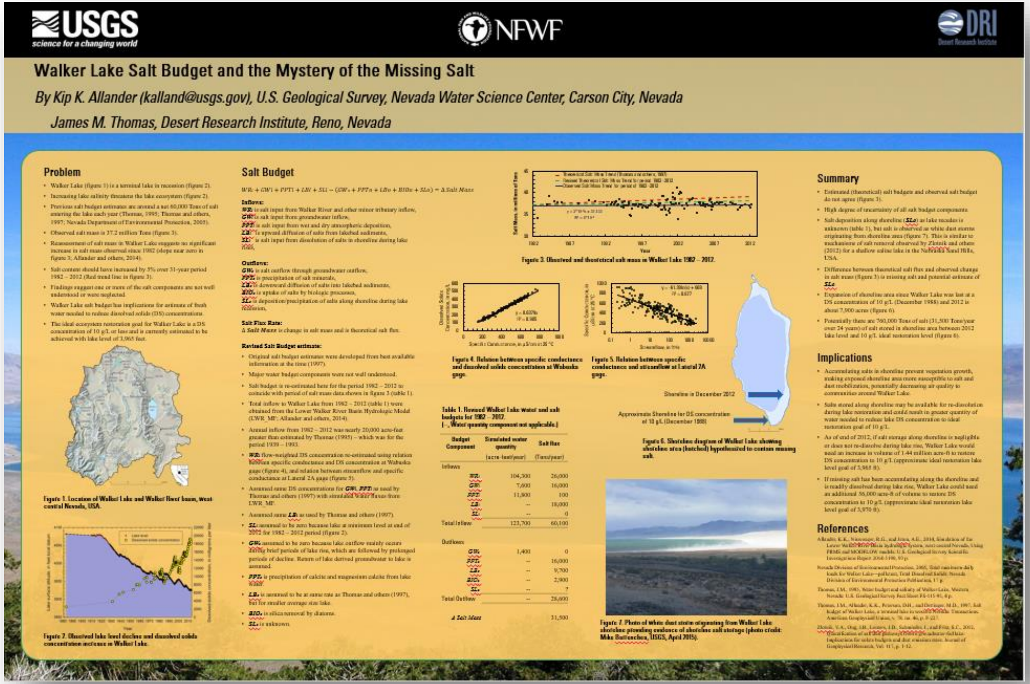
Revised Salt Budget Estimate in 2015







Allander and Thomas, 2015

+32,000 Tons/yr

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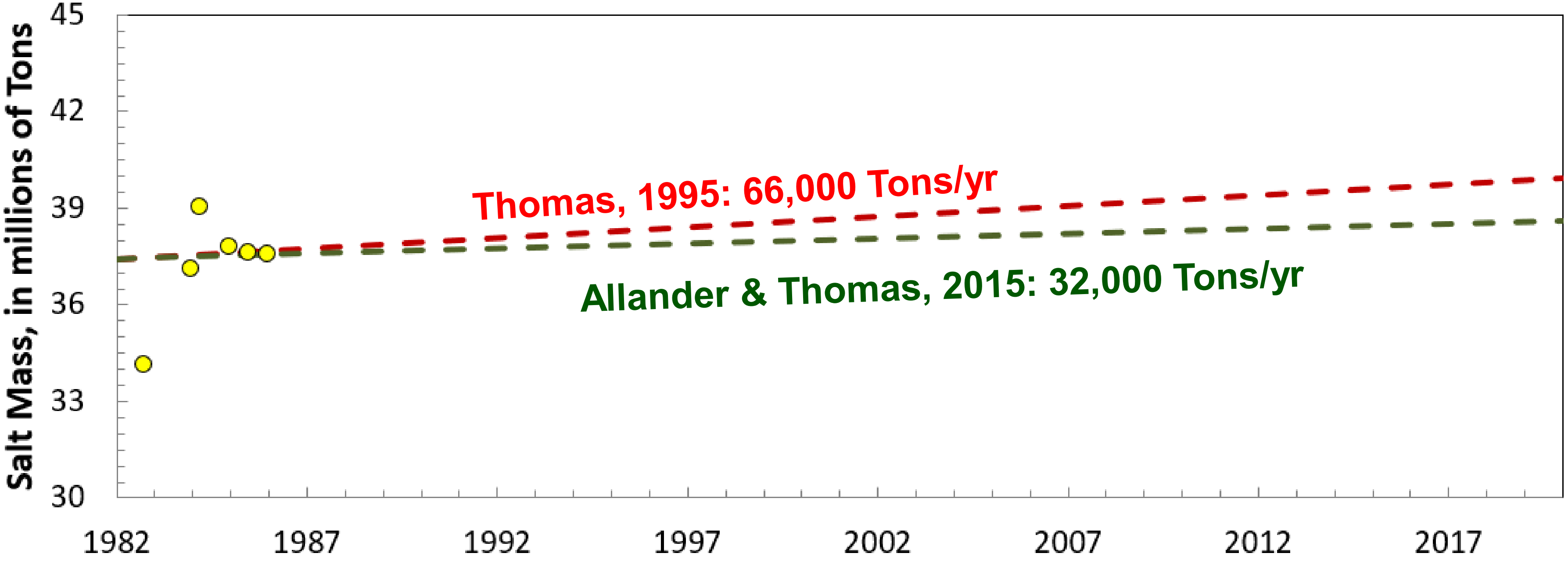
Estimated Trend of Salt Mass in Walker Lake



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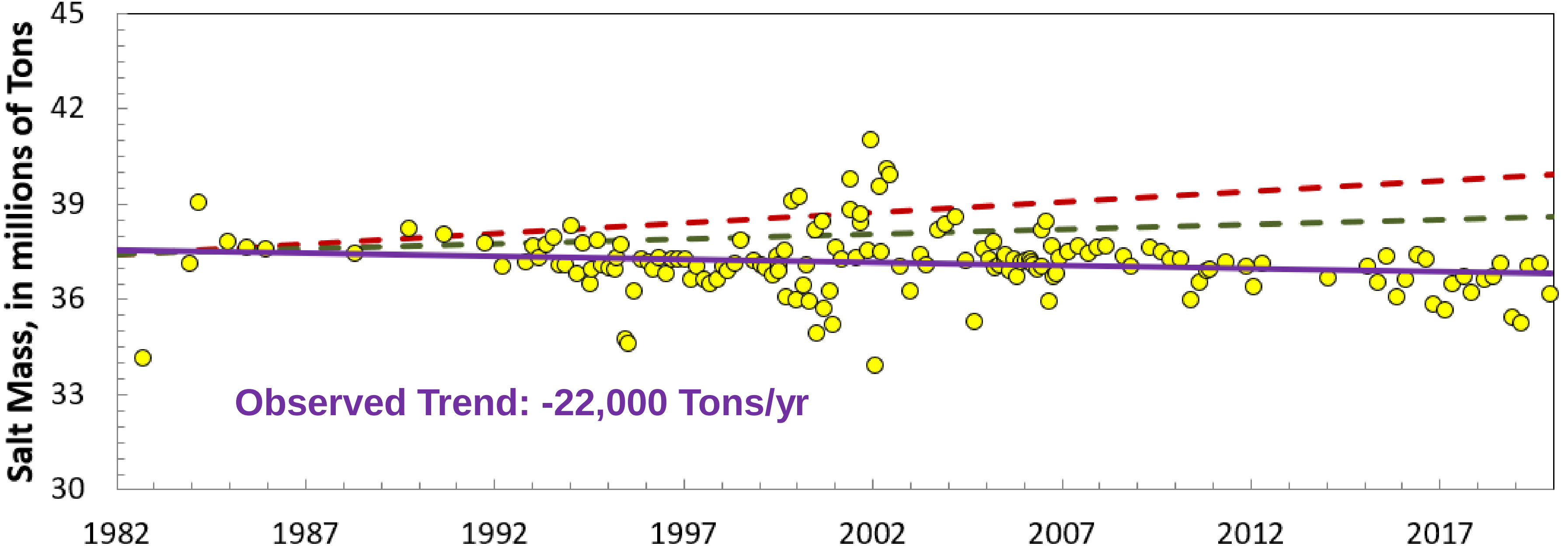
Observed Trend of Salt Mass in Walker Lake



Walker Lake and the Mystery of the Missing Salt

Walker Lake is losing ~50,000 Tons/yr more salt than expected.

Unknown chemical precipitation?

Is it shoreline deposition?

Will salt re-dissolve when lake level's rise?

Barrenchea, USGS, 2015

Summary

- Nevada's remaining Terminal Lakes are important to migratory water fowl, fisheries, and Native American Cultures.
- Pyramid Lake levels and function has stabilized.
- Winnemucca Lake is really an ephemeral lake and virtually no chance it will return in modern times.
- Walker Lake fishery is gone but may recover to a viable fishery again someday.
- Salt mass in Walker Lake is decreasing but unknown where salt is going and if it will effect restoration.

USGS

Thank You.

References

Allander, K.K., Thomas, J.M., 2015, Walker Lake Salt Budget and the Mystery of the Missing Salt: Sixth International Limnogeology Congress, Reno NV, June 15 – 19, 2015. https://doi.org/10.13140/RG.2.2.21904.81920.

Benson, L., Smoot, J., Lund, S., Mensing, S., Foit, F., Rye, R., 2013, Insights from a synthesis of old and new climate-proxy data from the Pyramid and Winnemucca lake basins, for the period 48 to 11.5ka: Quaternary International, V 310, P. 62–82. https://doi.org/10.1016/j.quaint.2012.02.040.

Russell, I.C., 1885, Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada: U.S. Geological Survey Monograph 11, 288 p. https://doi.org/10.3133/m11.

Simpson, K., Sterle, K., Singletary, L., McCarthy, M., Kauneckis, D., Dettinger, M., 2015, Role of Collaborative Modeling and Participatory Research in Understanding Challenges that Water Scarcity in a Changing Climate Pose for Agriculture: ISEA, Nigde, Turkey; May 22, 2015.

Thomas, J.M., 1995, Water budget and salinity of Walker Lake, Western Nevada: U.S. Geological Survey Fact Sheet FS–115–95, 4 p. https://doi.org/10.3133/fs11595

Trionfante, J.V., Peltz, L.A., 1993, Hydrologic Features of the Truckee and Carson River Basins and Adjacent Areas, Western Nevada and Eastern California: U.S. Geological Survey OFR 93-368, 1 map. https://doi.org/10.3133/ofr93368

The Nature Conservancy, 2013, Conservation Assessment for Walker Lake in Mineral County, Nevada: The Nature Conservancy, 50 p. https://www.walkerbasin.org/resources-and-reports.

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