Snow Survey Centennial Celebration
1906-2006

The First Western Water Supply Forecast at Lake Tahoe:
Ending the Tahoe Water War.

The mountainous West and snow:

The Western US is a fairly arid region, with mountain ranges spanning from Mexico to Canada, and from the Pacific Ocean to the Colorado Rockies, ending where the Great Plains begin. In addition, the precipitation in the area comes in a seasonal fashion, with wet cool winters following hot dry summers. These mountain ranges scrape the underbelly of the clouds capturing the rain and snow from the storms off the Pacific as they begin their eastward movement across the continent. The higher the mountains, the more snow and rain are captured, thereby creating a hierarchical precipitation regime, with dry valleys and wet cold snow-filled mountains. When the West was settled, the people invariably used the flat river valleys between the mountains to farm and live, and looked to the mountains to provide the summer water from snowmelt. Reservoirs were built to control the timing of the streamflow and regulate the streamflow to continue at a higher level throughout the dry summer months for municipal and agricultural use. Water became the lifeblood of the West, where in Mark Twain's immortal words "…whiskey is for drinking and water is for fighting over."

Western Snow Surveys Begin:

Among those pondering the snow in the mountains that supply the lifeblood of the West was Dr James E. Church, a professor of Literature at the University of Nevada, Reno. Dr. Church noted that the snow in the Sierra Nevada Mountains around Lake Tahoe was a natural reservoir not unlike man made ones that stored water until needed in the spring and summer. His curiosity about snow lead him to begin his work on snow and water in the Sierra Nevada, that feed the Reno, Nevada area.

In 1906, Dr. Church's snow survey work began with a systematic measurement of snow on Mount Rose and then expanded to the surrounding areas. This early extensive snow survey network was established by 1909-1910. This early system of sampling snow was developed along defined course locations of individual samples spaced at regular intervals. These early snow courses were located in or close to areas that were tributaries of Lake Tahoe or the Truckee River on the California – Nevada border. Dr. Church's original idea was to use the snow survey measurements to develop some relationship of high altitude forests to the conservation of snow. Early in the development of this work he was approached by H. H. Barter, an engineer in the employ of the Stone and Webster Engineering Corporation of Boston, who asked if the results of these snow surveys could be used

to predict the rise of water in Lake Tahoe. Dr. Church was unable to answer Mr. Barter, but this question stuck with him. This spurred him on to find a way to measure the water content in the snow, and led to the development of the Mount Rose Sampler. Early snow surveys occurred on April 1 of each year and a record was kept of each survey. The relationship of snow surveys to streamflow has been the main purpose of such surveys since this time.

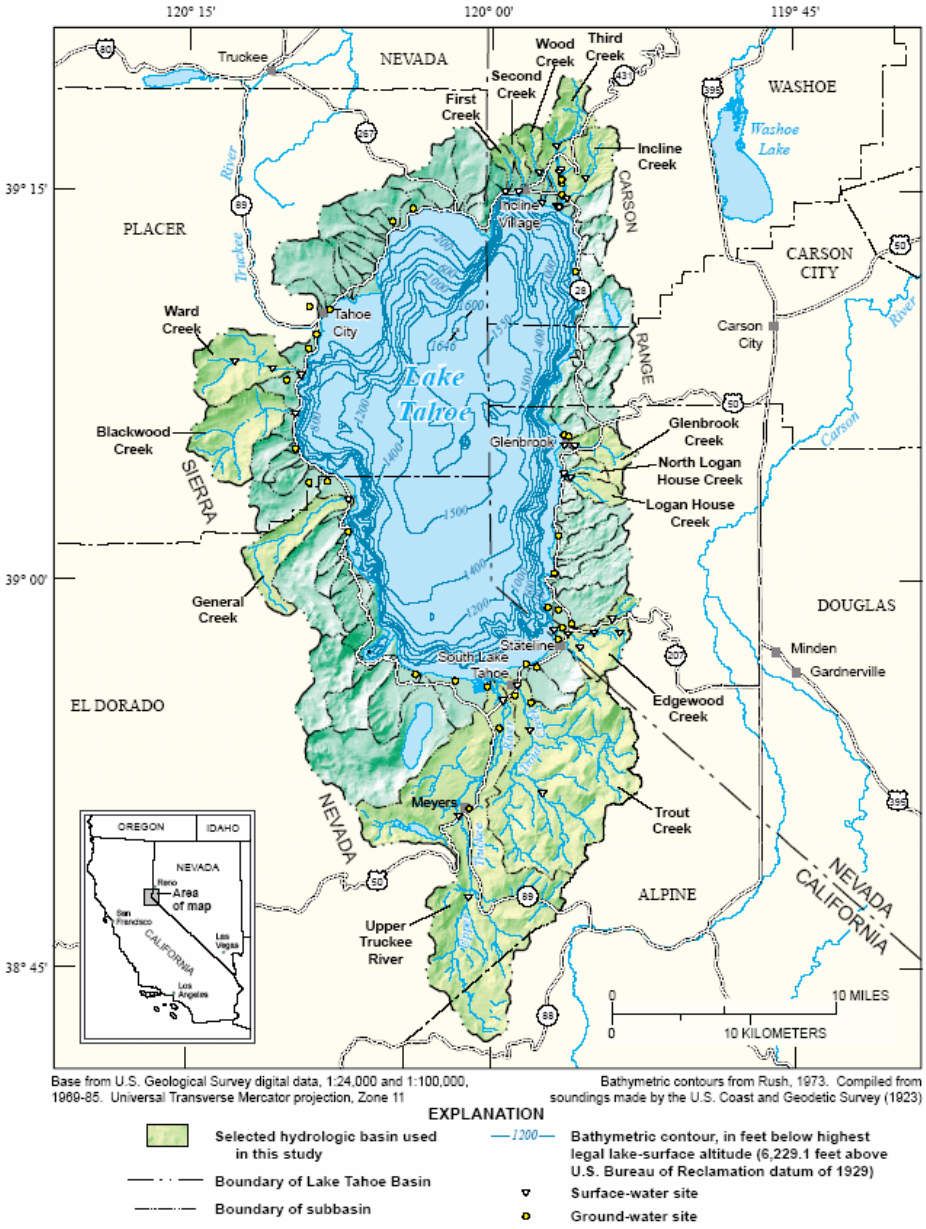


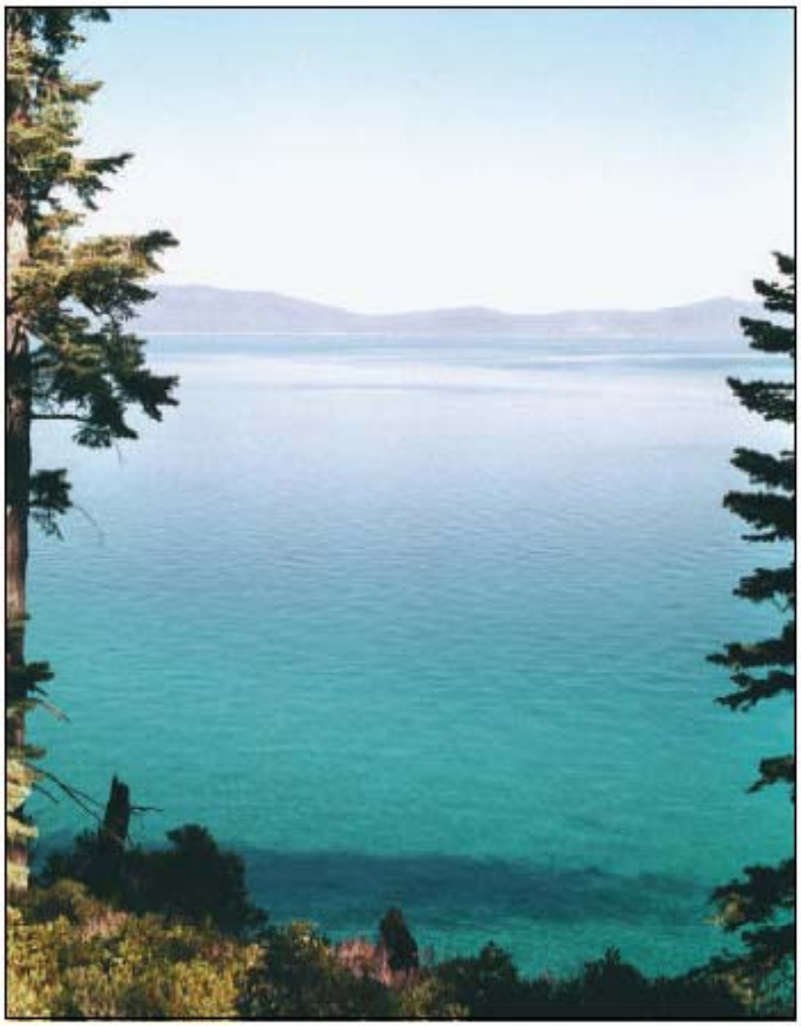
Figure 1. Geographic setting, hydrologic basins, bathymetry, and surface-water and ground-water monitoring sites in the Lake Tahoe Basin.

The History of and facts about Lake Tahoe:

Lake Tahoe was discovered by John C. Freemont in 1844, known only to the regional Native Americans before that. Lake Tahoe is 192.7 mi^2 with a contributing area of land of 506 mi^2. Lake Tahoe Dam operates the lake's upper 6.1 feet and regulates the amount of water released from the lake into the Truckee River at Tahoe City. The

present day 18 foot high dam was built in 1913 by the Bureau of Reclamation and the Truckee River General Electric Company, predecessor of Sierra Pacific Power Company. The usable storage capacity of Lake Tahoe is 744,600 Acre-feet, though the lake stores an additional 122 million acre-feet below the lake rim. The average depth of the lake is 1000 feet deep and is the second deepest lake in the U.S. The lake has been noted for its beauty and clarity by such notable people as Mark Twain and John C. Freemont. Significant changes to the lake began in the 1860s when the area was extensively logged for timber for the booming mining industry of the Comstock Lode in Virginia City, NV. The very first dam was reported to have been constructed in 1871 or 1874. The early dams were used to regulate the water level for streamflow control to transport the logs downstream.

Subsequently, the United States government initiated a series of complex water rights litigation and negotiation to use and operate the dam at Lake Tahoe in 1915 to use the water for the Newlands Project for agricultural water supply. Today, the lake is operated by the Truckee-Carson Irrigation District for the Bureau of Reclamation under contract.



Lake Tahoe, September 1996; eastward view from Rubicon Point, California. Photograph by Timothy G. Rowe, U.S. Geological Survey.

Mark Twain's remarks from his book "Roughing It", from his camping for a time along the shores of Lake Tahoe:

> So singular clear was the water, that where it was only twenty or thirty feet deep the bottom was so perfectly distinct that the boat seemed floating in the air! Yes, where it was even eighty feet deep. Every little pebble was distinct, every speckled trout, every hand's-breath of sand. Often, as we lay on our faces, a granite boulder, as large as a village church would start out of the bottom apparently, and seem climbing up rapidly to the surface, till presently it threatened to touch our faces, and we could not resist the impulse to seize an oar and avert the danger, But the boat would float on, and the boulder descend again, and then we could see that when we had been exactly above it, it must have still have been twenty or thirty feet below the surface. Down through the transparency of these great depths, the water was not merely transparent, but dazzlingly, brilliantly so. All objects seen through had bright strong vividness, not only of outline, but of every minute detail, which they would not have had when seen simply through the same depth of atmosphere. So empty and airy did all spaces seem below us, and so strong was the sense of floating high aloft in mid-nothingness, that we called these boat excursions "balloon Voyages".

The "Tahoe Water War":

There is a monument to the Water Wars in Tahoe City, CA, by the Lake Tahoe Dam that reads:

> Lake Tahoe Outlet Gates
>
> Conflicting control of these gates, first built in 1870, resulted in the "Tahoe Water War" between Lakeshore owners and downstream Truckee River Water users, which lasted two decades. The dispute was settled in 1910-11 when techniques for determining water content in snow were developed by Dr. James E. Church, Jr. and made possible accurate prediction and control of the seasonal rise in Lake and River levels"

Early skirmishes involved a plan developed in 1860 to divert Lake Tahoe water to San Francisco, selling some water to California's booming mining camps along the way. The people in Nevada were very against this scheme that would take some of the water from the Tahoe – Truckee system that they were planning to use. While the plan died in 1900, the dam at the Lake outlet had been built, ending up in the hands of the Truckee River General Electric Company. The controversy over water did continue with the passage of the Reclamation Act in 1902, which began the rapid construction of the first Bureau of Reclamation project, The Newlands Project, east of Reno, Nevada where the Bureau of Reclamation was going to "make the Desert bloom", proving that agriculture was viable in the western deserts when enough water is supplied. The Bureau of Reclamation made an initial water rights claim in 1903 for the project. The property owners around the lake became concerned about the effect of the dam operation on lake levels. The Bureau also proposed a tunnel

from the lake for additional water for the Newlands Project, but this was overcome by the lake property owners and the state of California. The controversy flared up again in 1912, when the Power Company and Bureau of Reclamation began dredging the lake outlet and cutting down the lake rim to release more water. A court order stopped this as well. Unfortunately, the Newlands Project had been designed in a wetter than average climate period, and when the dry years came in the 1920s and 1930s, suffering farmers, the Bureau of Reclamation, Lake shore owners, and both states were involved in a series of negotiations, litigations and public controversy. Several years of pumping water out of Lake Tahoe did occur in 1924, 1929, 1930 and 1934. A series of legislative Acts and Agreements now govern the Lake Tahoe water rights. Within these agreements is the language that the NRCS Seasonal Water Supply Forecast will be the basis of water management in the basin.

Water Supply Forecasts calm the war:

So, once the snow sampling measurement instruments and snow courses were developed, the question that H. H. Barter had asked Dr. Church could be addressed. The early Water Supply Forecasting at Lake Tahoe began in 1909-1910. The main focus of the water supply forecast was to better manage the water in the top 6.1 feet of Lake Tahoe from 6223 (natural rim) to elevation 6229.1 under the Truckee River Agreement. Under the agreement, the forecast helped in the decision on how the water was to be divided among competing needs. If the water supply forecast indicates that the lake will go above the 6229.1 level, then water is released from the lake. The Lake Tahoe forecast has always been for the feet of rise in the lake from April 1 to the highest level with the dam gates closed. This is a forecast of the combination of the inflow from tributaries into the lake, added in the direct precipitation, less the evaporation from the lake, and including the seepage at the outflow gates, which is reflected in the change in lake rise measurements.

Dr. Church and Horace Boardman have emphasized, even back in the early years, that the snow survey is not a complete picture of the snowpack in the watershed, and does not measure the basin total water stored as snow. Streamflow records and lake levels had been kept since the 1870s, so it was easy for Dr. Church to determine an average year streamflow and lake rise. Dr. Church started developing the first forecast using a percent of normal relationship for the snow year 1909-1910. He assumed that the precipitation was the same percent of normal as the snow survey water content. He was able to go back as far as the 1870 or 1880 precipitation records to determine what the average precipitation was in the Lake Tahoe area. The snowpack water content for that year was then determined as a percent of average from the few years of records. He used the precipitation percent of average to determine the snow percent of average. Dr. Church then compared the snow percent of average to the years of record of lake level rise since the 1870-1880s and determined that the snow and lake level should have similar percent of averages. The forecast was then determined that the 1909-1910 rise was related to the April 1, 1910 snow survey and then the forecast rise in feet was determined. The first normal used for the rise of Lake Tahoe from April 1 to the maximum high level, gates closed, was 1.66 feet. This value was used until 1927. In the early 1920s, the forecasting was put into a graphical form where the percent of normal snow would relate to the percent of average Lake Tahoe rise along a straight line relationship. The average snowpack water content at that time was 35 inches. This represented a weighted average of the snow courses in the Tahoe Basin.

The continuing saga:

Decades of fighting over available water has been settled today under very specific water rights and management agreement. Many interested groups remain vigilant over the basin water needs. The last agreement was finally hammered out in the late 1990s, where water is managed with the utmost concern to the tiniest amount measurable. The Water Supply Forecasts began by Dr. Church continue today under the USDA Natural Resources Conservation Service, as a coordinated federal forecast with the National Weather Service. These forecasts are now supplied monthly January through June and play a key role in determining the expected Lake Tahoe rise and Truckee River streamflow for the spring and summer months. This valuable information is input into reservoir management and system models that determine the daily reservoir releases to mange the expected Lake Tahoe rise and Truckee River streamflow volume. While the war may be over, the management of the scarce and precious water of Lake Tahoe will continue, and snow will continue to supply the water needs of the Tahoe-Truckee system. So, though whiskey may have been long preempted by other drinks in the West, water is still worth fighting over.

- Jolyne Lea

The Tahoe – Truckee Forecast Hydrologist.