Changes to the intervening natural flow above Mead due to the updated Lake Mead elevation-volume and elevation-area tables

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This document aims to summarize the differences in the intervening natural flow above Mead due to updating the Lake Mead elevation-area and elevation-volume tables.

Background

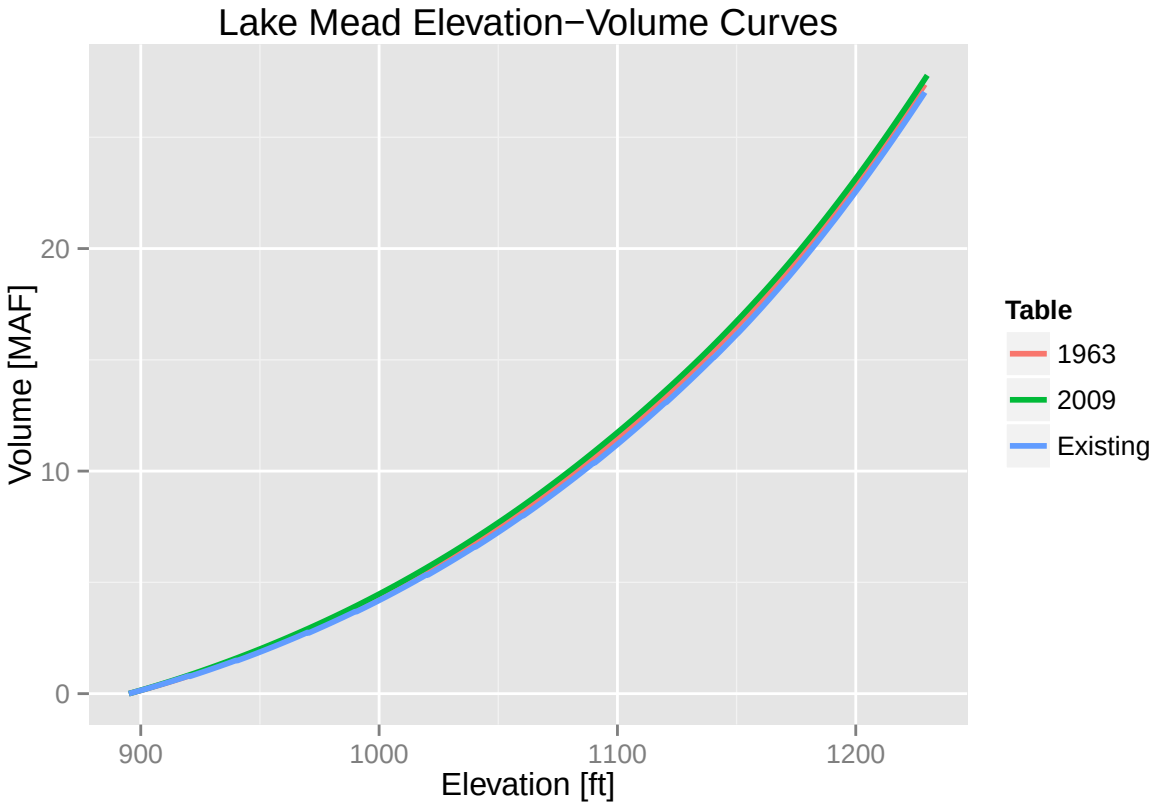
The original elevation-volume (EV) and elevation-area (EA) tables were developed using a survey from 1963-64 and documented in a 1967 report. New tables were developed in 2009 using 2001 bathymetry survey and 2009 LiDAR survey (Tighi and Callejo, 2009) and were put into use operationally in 2012. The updated EV table showed an increases of 243 KAF of capacity, largely due to "compaction of sediments at the bottom of Lake Mead, combined with a decrease in sediment inflow into Lake Mead since the closer of Glen Canyon Dam in 1963".

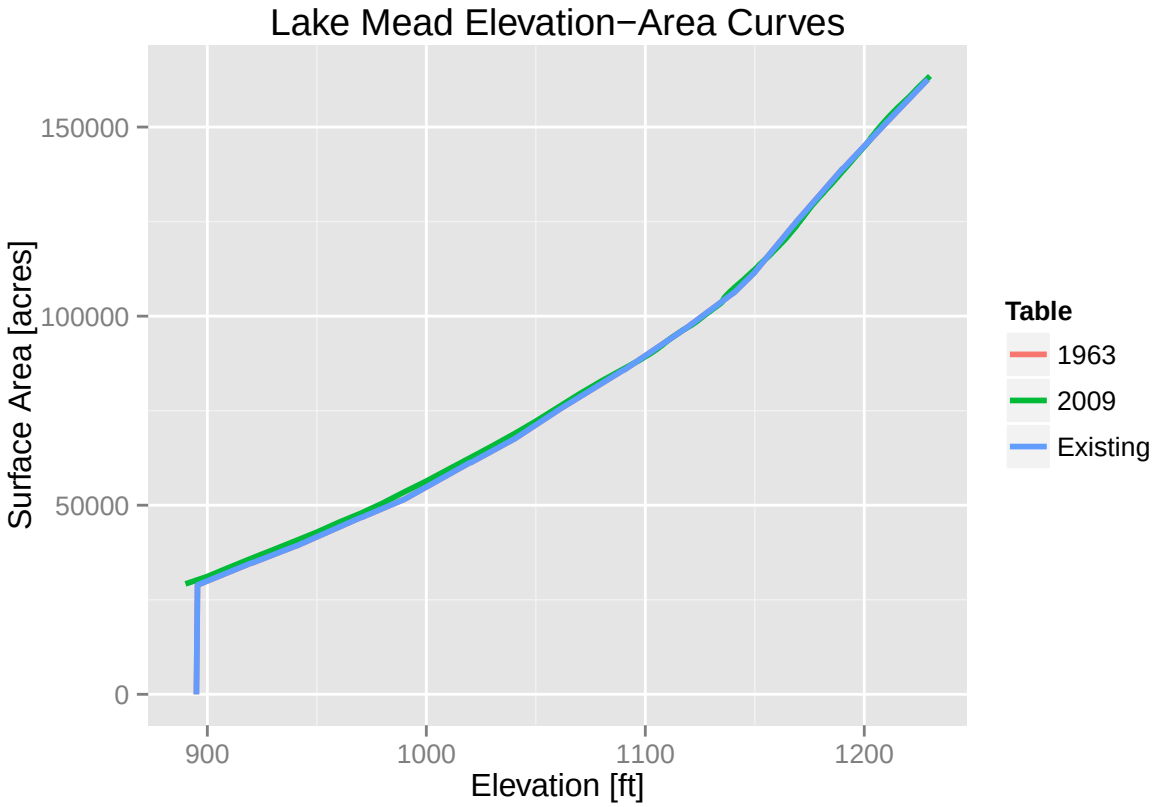
Because the natural flow computations start in 1971 and this is after the closing of Glen Canyon Dam, it was decided that the EV and EA tables should be updated in the Natural Flow and Salt Compuation Model for the entire period, i.e., 1971-present.

The intervening natural flows for the reach above Lake Mead will change if any modifications are made to the EV or EA tables in the Natural Flow and Salt Computation Model. This document presents the changes to the intervening natural flow above Lake Mead for the 1971-2012 period due to the updated EV and EA tables.

Problem

The 2010 Natural Flow and Salt model was thought to contain the 1963 EV and EA tables; however, the 2010 model contained another EV table. This EV table, defined as the "existing table" throughout this document, does not match the 1963 EV table nor the 2009 EV table. The figure below compares the three EV and EA tables.


Lake Mead Elevation−Volume Curves
Volume [MAF]
20
10
0
900
1000
1100
1200
Elevation [ft]
Table
1963
2009
Existing


Lake Mead Elevation−Area Curves
Surface Area [acres]
150000
100000
50000
0
900
1000
1100
1200
Elevation [ft]
Table
1963
2009
Existing

The "existing" elevation-volume table shows a smaller volume for a given elevation as compared to the 1963 or 2009 table for all elevations. The 2009 table shows a larger volume for a given elevation as compared to the 1963 table at all elevations. For exampe, for an elevation of 1,100' the different volumes are as follows:

Table 1: Different volumes for an elevation of 1,100' based on the different EV tables.

Table	Volume [MAF]
1963	11.49
2009	11.74
Existing	11.21

The existing EA table is essentially the same as the 1963 EA table. The only difference is due to rounding—the 1963 EA table included precision to the hundredths place whereas the existing table was input into the model rounded to the nearest ones place.

More differences between the 1963 and 2009 tables are explained in Tighi and Callejo (2009).

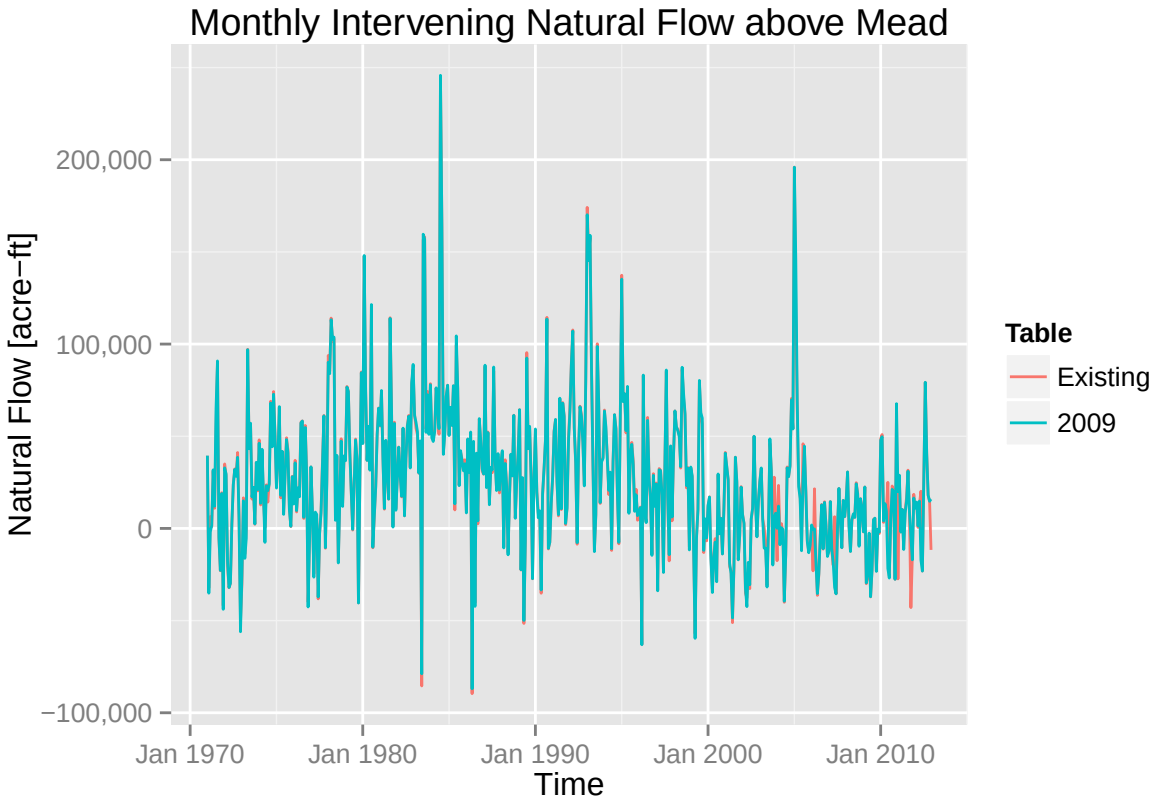
Analysis

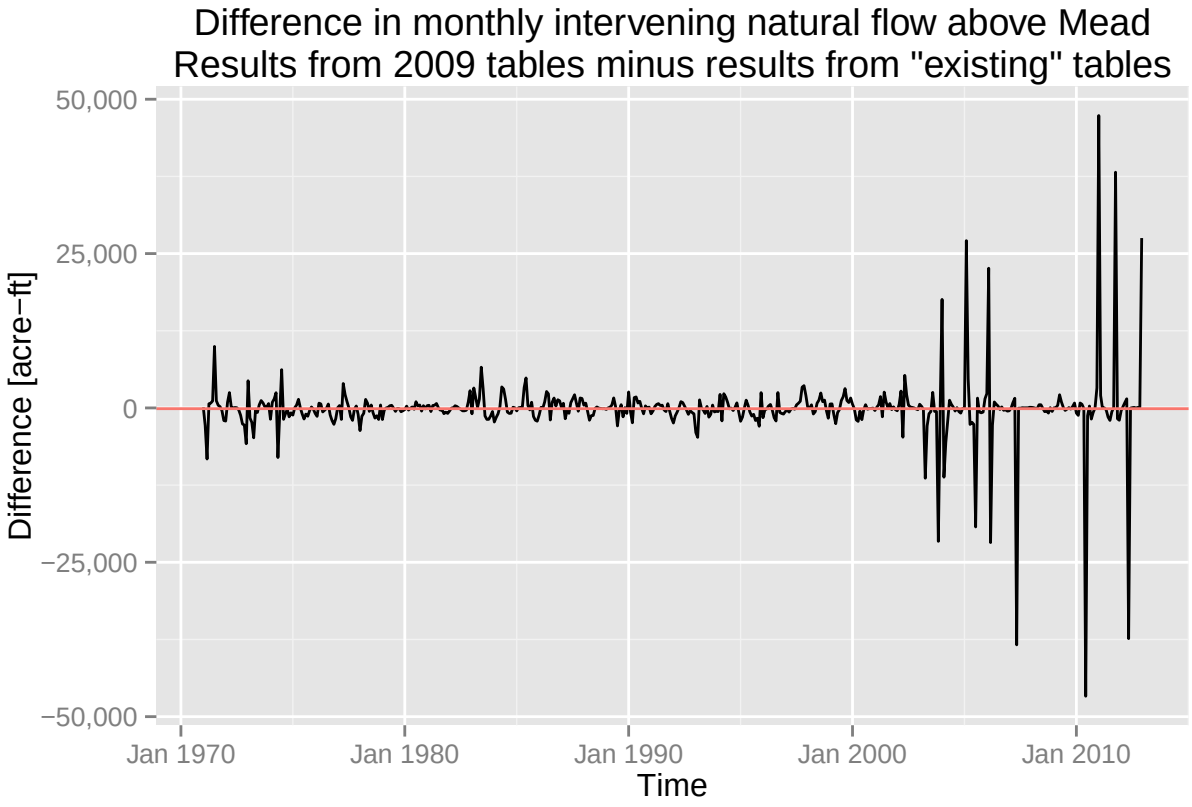
To understand how the 2009 EV and EA tables affect the intervening natural flow above Mead, the computed natural flows are compared using the 1971-2012 period for simulations computed using the "existing" EV and EA tables and the 2009 EV and EA tables. The "existing" tables were used instead of the 1963 tables because the 2010 natural flow and salt model contained the "existing" tables.

Prior to comparing the results using the 2009 tables, a simulation was completed using the "existing" tables. The results for 1971-2010 from this run were compared to the published values from the 2010 model. There were no differences in these values, indicating there were no other changes to the model or input data that had an affect on the results.

Monthly Differences

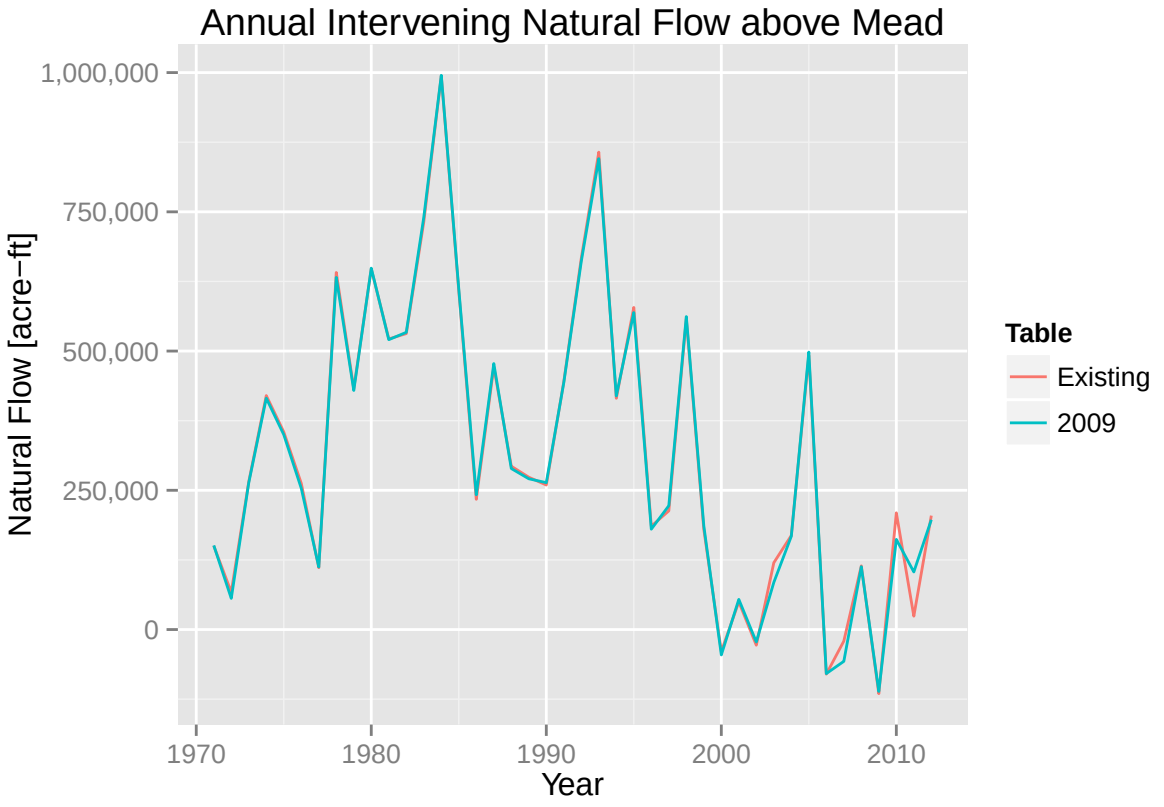
The figures below show the monthly natural flow for both sets of EV and EA tables and the monthly difference between using the two different tables. The differences range by about +/- 50 KAF in month, but the average over time is nearly 0 acre-ft.

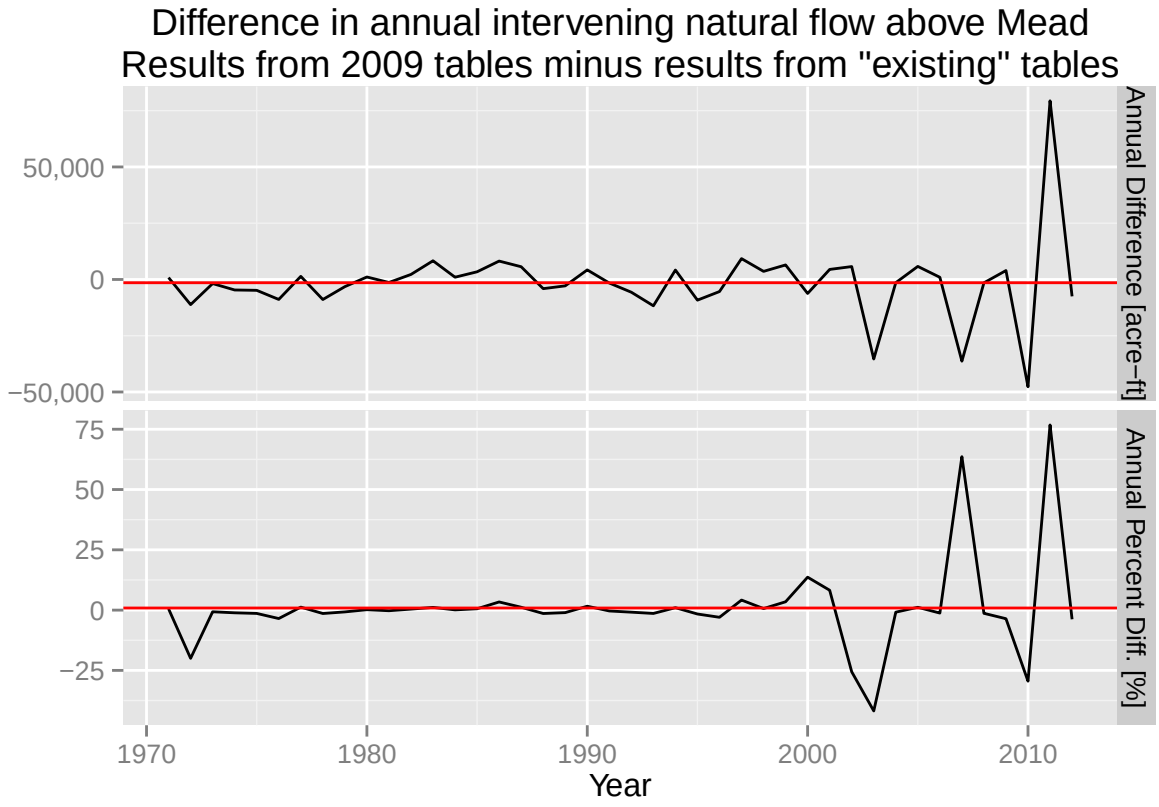

Monthly Intervening Natural Flow above Mead
Natural Flow [acre−ft]
200,000
100,000
0
−100,000
Jan 1970
Jan 1980
Jan 1990
Jan 2000
Jan 2010
Time
Table
Existing
2009


Difference in monthly intervening natural flow above Mead
Results from 2009 tables minus results from "existing" tables
Difference [acre−ft]
50,000
25,000
0
−25,000
−50,000
Jan 1970
Jan 1980
Jan 1990
Jan 2000
Jan 2010
Time

Annual Differences

The figures below show the annual intervening natural flow above Mead and the difference in the computed natural flow when using the two different EV and EA tables. At the annual scale, the differences in using the two different tables is again about +/- 50 KAF. This corresponds to roughly a maximum of 75% different. However, the aeverage difference through time is -1454 acre-ft, or 0.87%.

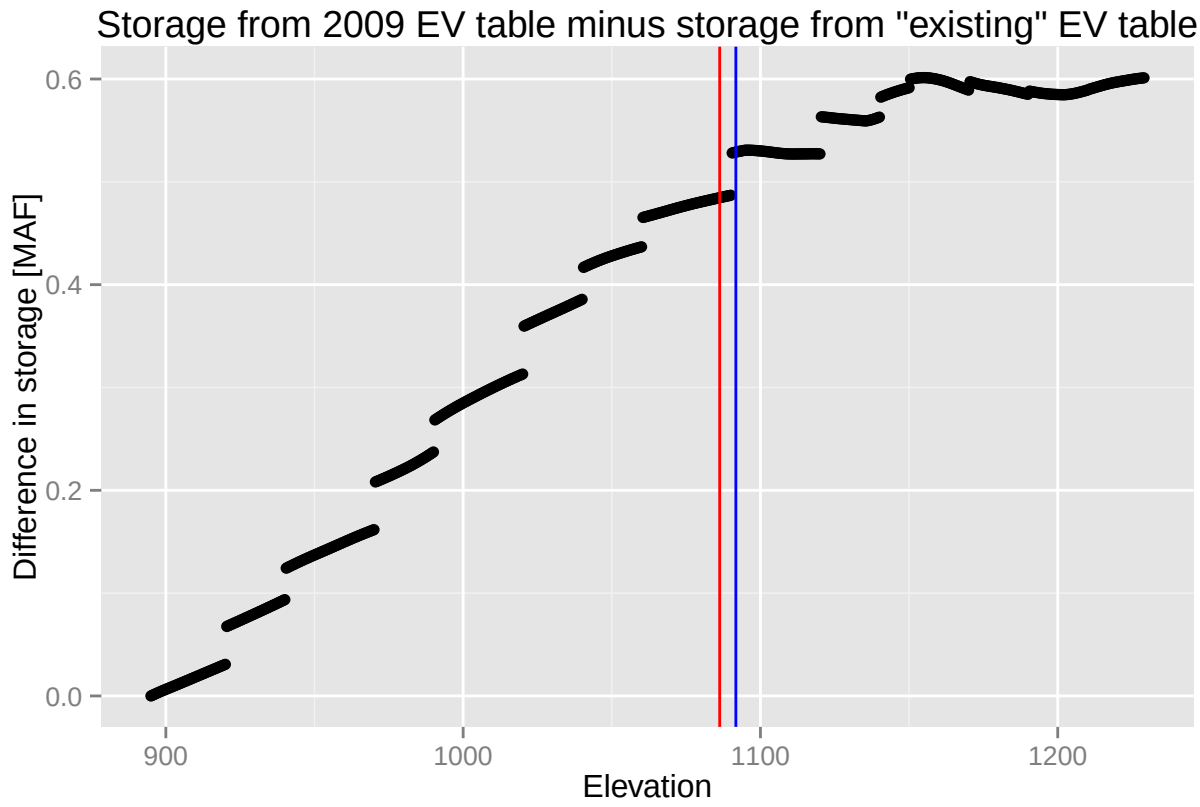

Annual Intervening Natural Flow above Mead
Natural Flow [acre−ft]
1,000,000
750,000
500,000
250,000
0
1970
1980
1990
2000
2010
Year
Table
Existing
2009


Difference in annual intervening natural flow above Mead
Results from 2009 tables minus results from "existing" tables
50,000
0
−50,000
Annual Difference [acre−ft]
75
50
25
0
−25
Annual Percent Diff. [%]
1970
1980
1990
2000
2010
Year

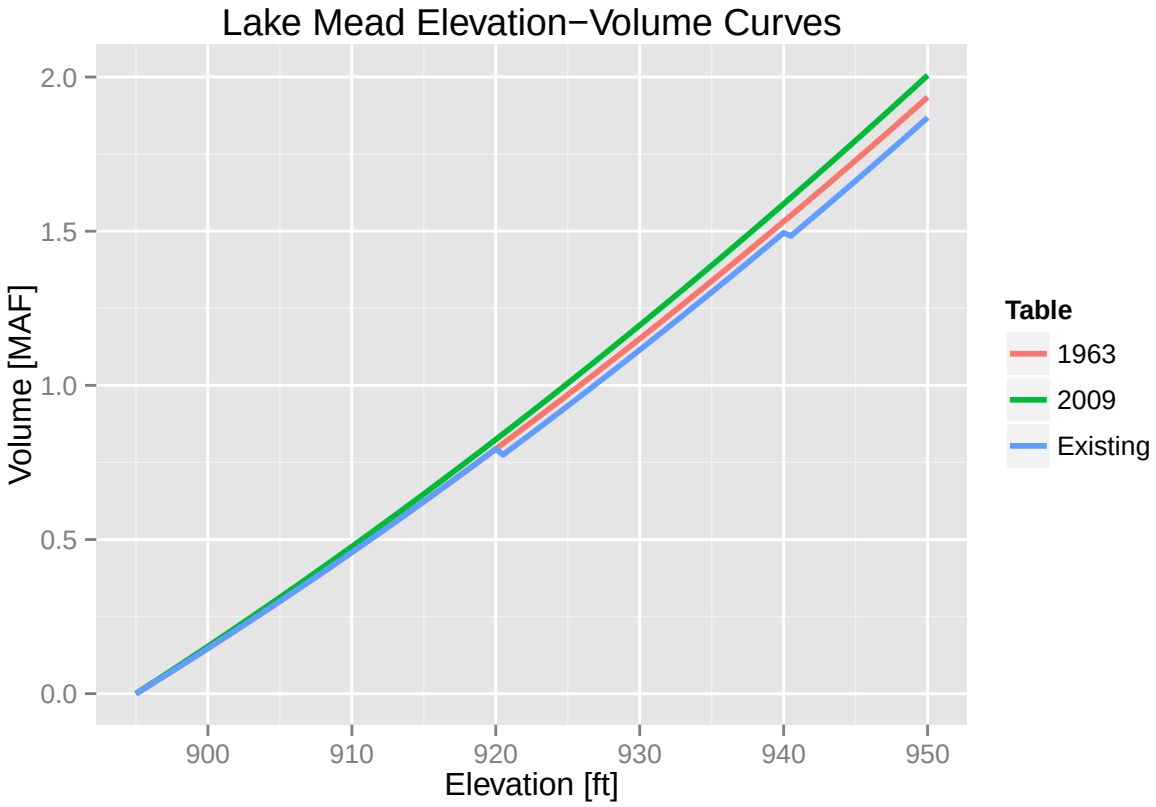
Reasons for the Largest Differences

In the monthly differences in natural flow, the differences appear to be "noise" around 0, until several cases in the 2003-2012 time range that are abnormally large. Because the larger differences only appear in the later period, this seemed suspect so these differences were investigated further.

The differences are due to "step changes" in the difference between the 2009 EV table and the "existing" EV table. The figure below shows the difference between the two tables. The largest differences in the natural flows occur when the elevation crosses one of the step changes from one month to the next. For example, the largest difference in natural flow occurs in January 2011. In December 2010, the elevation is marked by the red line. In January 2011, the elevation is marked by the blue line. The larger difference in natural flow is due to crossing the step change of storage differences from one month to the next.



The reason for the step changes in the differences between the storage from the 2009 EV table and the "existing" EV table is due to some unexplained drops in the storage in the "existing" EV table. The figure below shows the EV curves for a narrow elevation band. The "existing" EV curve decreases in storage from elevation 920' to 920.5' and again from 940' to 940.5'. The reasoning for this is unknown. The 1963 table does not have these jumps, so the changes in the invervening natural flow when using the 1963 EV table as compared to the 2009 EV table would not include the large changes depcited in the differences between the 2009 and "existing" tables.



Summary

The "existing" EV table, i.e., the EV table included in the 2010 natural flow and salt computation model, does not match the 2009 nor the 1963 EV table. It is unclear where this "existing" table originated and it includes some weird changes in storage, i.e., decrease in storage for an increase in elevation, from one elevation to the next that are unexplainable.

Because of the oddities in the "existing" EV table, there are some larger differences in the intervening natural flow above Mead when computed using the 2009 EV table as compared to using the "existing" EV table. The differences can be large in a given year or month, the average difference from 1971-2012 in nearly 0. While some differences in the natural flows are an artifact of updating the EV table, it is important to represent the EV table as accurately as possible.

For the 2012 natural flow and salt model, the 2009 EV and EA tables will be used, and as such there will be changes in the 1971-2010 intervening natural flow above Mead as compared to the data published in 2013.