Analysis of lake level history for Lake Taupo

Introduction

In 1941 control gates were installed on Lake Taupo as part of the Waikato River power scheme, and lake level control began. As part of the project, the outflow capacity was increased by ~70% from its natural state. From 1942-1945 the average lake level was raised by over 0.5m, we understand as a wartime measure, and resulted in some landowners being compensated for loss of amenity. In 1947 the Lake Taupo Compensation Claims Act introduced a maximum operating level, and from that time the lake has been managed within a range and at an average level consistent with the pre-control period. This is commonly misunderstood, and increased lake level has been cited as a contributing factor to flood susceptibility, beach erosion, and the buildup of sediment in the lower Tongariro River.

The purpose of this analysis is to compare the pre and post control lake level to determine what, if any, changes have occurred.

Methodology

Daily lake level data was obtained from Electricity Authority archives, covering the period from when records began in Jul 1905 until Dec 2008 (~38,000 data-points). While the total post-1946 period was analysed, this analysis focuses on 1984-2008 ("the post-control period") to account for any change resulting from the full commissioning of the Tongariro Power Scheme, not that it appears to have had an effect. Comparisons are made with 1906-1940 ("the pre-control period"). Thereafter graphical records until Dec 2017 show good consistency with the numerically analysed period (see appendix 1).

The analysis and findings were peer reviewed by Professor Russell Millar, University of Auckland, who is a statistician with significant experience in before-after-control-impact (BACI) assessment.

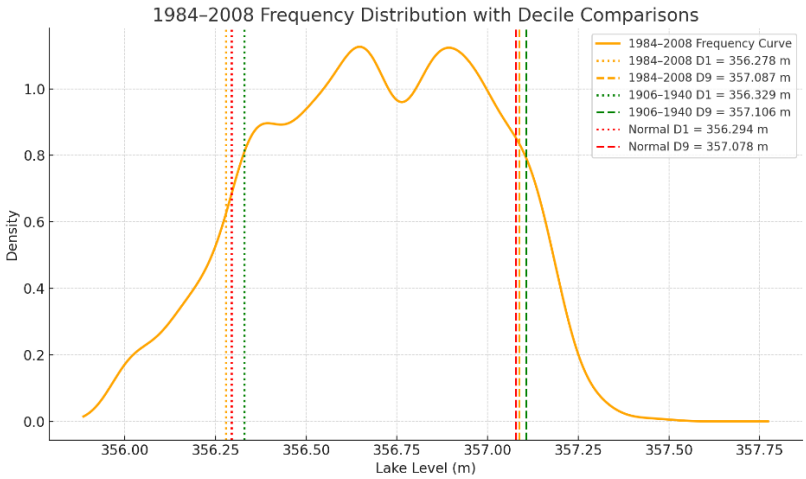
Summary of findings

In the post-control period the lake has been managed at an average level of 356.686masl, almost identical (-3mm) to the pre-control period. Even if there had been no underlying change between the two periods, statistically such a tiny difference would only be observed ~5% of the time. It is consistent with an environment which is being purposely managed.

The post-control level is fairly normally distributed about the mean. There has been no material change in the standard deviation or upper and lower quartiles and deciles, which means, for example, the level has not been skewed towards the higher and lower ends of the range under management. Figure 1 shows the frequency distribution curve for the post-control period, with the upper and lower deciles marked by the vertical orange lines. The lake spends 80% of the time between these levels. The green lines are

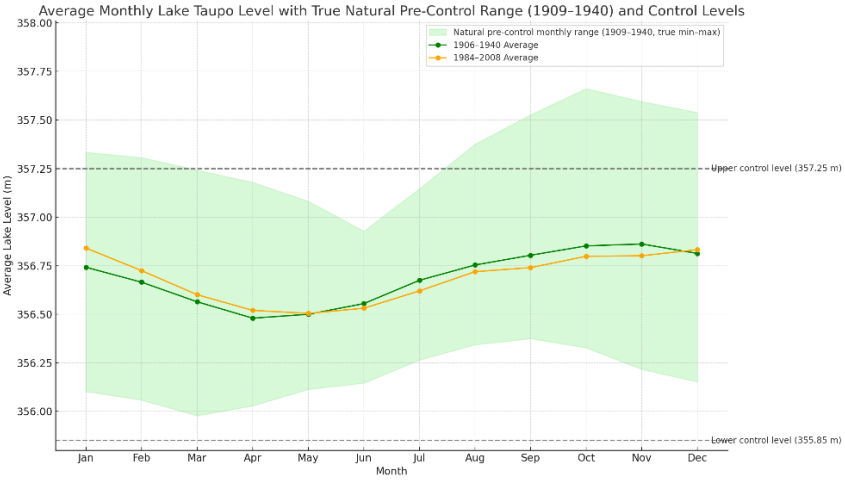
the same deciles for the pre-control period and are very marginally higher, while the red lines are for a theoretical normal distribution with the same mean and standard deviation as the post-control period and are virtually identical to the orange lines, which again is consistent with a managed environment.

Fig.1



There are small seasonal differences whereby the lake is held at a slightly higher level (0-10cm on average) over summer-autumn and at a slightly lower level in winter-spring, presumably to meet power generation requirements. The difference is immaterial compared to the natural variability of the average level for any given month (~1.2m in the pre-control period). Figure 2 shows a comparison of the average monthly levels pre and post control, with the shaded area depicting the natural range of the average monthly level pre-control.

Fig 2.



The biggest change between the pre and post periods is the reduction in magnitude and duration of extreme high levels. The maximum level in the post-control period was 23cm lower than pre-control. That level was exceeded on three occasions in the pre-control

period, two of them exceeding 2 months duration. The average number of consecutive days spent in the upper quartile and upper decile is markedly lower (45% and 70% respectively), and the percentage of days above the present upper control level (357.25m) has reduced from 3.5% to 0.9%. This is consistent with water being able to be released more quickly than would occur naturally.

The current resource consent stipulates that the lake must be managed with less than a 20% probability of exceeding the upper control level in any year. From 1984-2017 this occurred in 7/34 years – approximately 20%, and very similar to 7/36 in 1905-1940.

The conclusion is very clear that the lake level has not been raised.

Other relevant factors

The Taupo lakebed and surrounding land is subject to non-uniform tectonic deformation (uplift and subsidence), seismic activity, and volcanic / magmatic effects, which creates both gradual and more sudden changes to the lakebed and ground level. Such effects are well documented to have affected the south western end of the lake. Figure 3. from the 2011 OPUS flood assessment report for the Tongariro River, illustrates how subsidence of the lakebed and surrounding land can give the same appearance and effect as lake level rise. This is particularly relevant to the delta region (the area below the Turangi township), where compaction of the substrate is also a factor.

Fig 3.

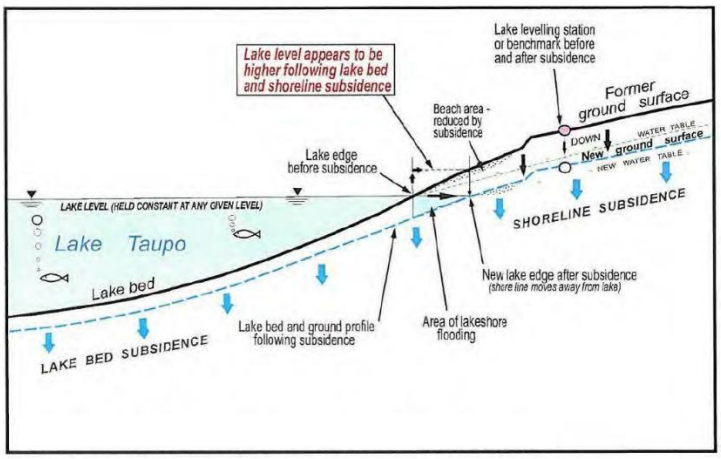


Figure 4.1: Effect of ground level subsidence on relative lake levels (Hancox, 2002).

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Appendix 1: Lake levels 2006 - 2017

23. Figure 4 shows annual lake level from 2006 (when Mercury's resource consents were granted) to the end of 2017 (only complete years are graphed). The figure shows the variability of the lake level due to climatic variations. The data includes dry, average and wet years and a combination of dry and wet years.

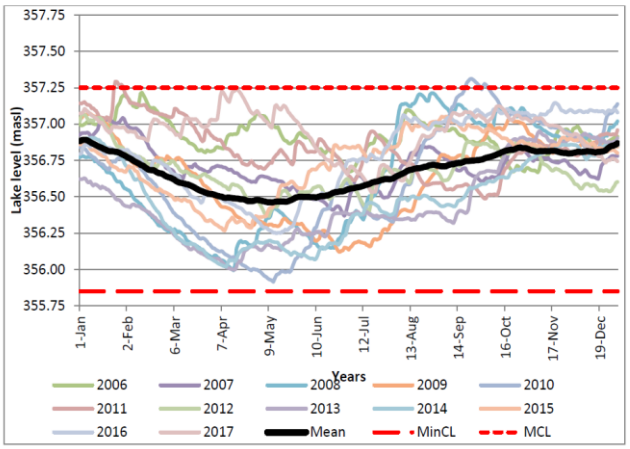

Figure 4: Annual Lake Taupo level 2006 to 2017.