Not My Fault: Oroville quakes have followed rapid lake refillings before

Lori Dengler, Times Standard News, 2-15-17

A little detour this week from Cascadia earthquakes for a foot note on current events. As I write, the evacuation order for nearly 200,000 people in Butte, Sutter, and Yuba Counties has been lifted and they can return home. But with a caveat — if any new problems develop, they need to be ready to quickly re-evacuate. I have been glued to this story since the first reports of damage to the Oroville dam spillway emerged on Feb. 7. I have read the news accounts, looked at photos and videos, and have talked to my hydrologically-adept friends as the damage grew, leading to the unprecedented use of the emergency spillway and the subsequent erosion that threatened its integrity.

I first learned of Lake Oroville and the dam in 1975 as a graduate student at UC Berkeley. All Berkeley geophysics students spent some time in the Seismological Laboratory. On Aug. 1, a magnitude 5.8 earthquake occurred near Oroville. Earthquakes of this size can occur anywhere in the state, so its size was no surprise. However, this had been a seismically quiet area and those of us working in the lab definitely noticed when seven earthquakes in the magnitude-3 range occurred in a tight cluster near the lake. On Aug. 1, the seismicity ramped up — a 4.7, a 5.8 and 35 additional earthquakes in the magnitude-3 range. Vigorous aftershocks continued with over 200 earthquakes in the magnitude-3 range recorded over the next 18 months. Then things quieted down and no earthquakes of magnitude-3 or larger have been recorded near Oroville since 1992.

It’s not unusual for an earthquake sequence to pop up out of the blue, but the difference in the Oroville case was two factors linking the earthquakes to the filling of the reservoir. The first was the proximity to the lake, the location of surface faulting and the tightly clustered epicenter locations. The second factor was that the earthquakes followed an unprecedented seasonal fluctuation in lake levels. During the winter of 1974-1975, the lake was drawn down to its lowest level since filling to repair the intakes to the power plant. It was then rapidly refilled and followed by the earthquake sequence of 1975.

At Berkeley back in 1975, there was a spirited debate about the earthquakes and its cause. Professor Bruce Bolt was the Director of the Berkeley Lab at the time and an early proponent of reservoir-induced seismicity. He believed that the rapid refilling of the lake contributed to the earthquakes. Filling a reservoir causes two changes in regional stresses. First, the additional weight of the water increases pressure on the subsurface. Pressure alone tends to make rock stronger and by itself would inhibit fault slip. But the water doesn’t just stay confined to the lake. It percolates into the ground water system increasing the fluid pore pressure in the rock beneath and nearby. This fluid exerts a pressure in the opposite direction and makes it easier for the rock to fail. There are many examples of how pore pressure can cause earthquakes — the most recent in the earthquake activity in Oklahoma and other Midwestern areas where waste fluids from drilling are pumped into deep subsurface wells and have caused earthquakes very similar in size to the 1975 Oroville sequence.

Earthquakes and dams are not a good mix. Forty-six years ago, on Feb. 9, 1971, a magnitude 6.7 earthquake struck the Southern California town of Sylmar, violently shaking the San Fernando Valley and causing major damage to the Van Norman Dam. Around 80,000 people were evacuated while a scene similar to this week at Oroville unfolded —engineers frantically assessing damage and shoring up the dam (http://seismo.berkeley.edu/blog/index.html). Fortunately the dam did hold long enough for the water levels to be lowered and people were able to safely return.

The 1975 Oroville earthquakes raised enough concern about the induced seismicity problem that construction was halted on the Auburn Dam project on the American River south of Oroville. After a number of years of additional studies and other economic factors, the books were closed on that project in 2008.

There is still a remote chance that an earthquake could be a part of the Oroville story. This week's post on the seismic hazard site Temblor (http://temblor.net/earthquake-insights/oroville-dam-is-also-at-seismic-risk-2538/) comments "An interesting question is whether after 5 years of drought, the large and rapid refilling of the Lake this winter — from 1/3 full to brim full — could set the stage for future induced earthquakes at the Lake. "