

## 6. December 14, 2005 Breach

### 6.1 General Descriptions and Observations

On December 14, 2005, an uncontrolled release of water from the upper reservoir occurred at the Taum Sauk Pumped Storage Project resulting in the damage shown in Figures 6-1 and 6-2. The time history of the reservoir transducers and the penstock transducer just before, during, and after the breach is shown in Figure 6-3. It is shown on Figure 6-3 that the full breach developed within about 25 minutes from the initial dropping of the reservoir level.

The upper reservoir of the Taum Sauk Pumped Storage Project was overtopped during the final pumping cycle the morning of December 14, 2005. Overtopping of the 10 ft high parapet wall and subsequent breach of the rockfill embankment formed a breach about 720 feet wide at the top of the rockfill dam and 430 feet at the base of the dam. Reservoir data indicate that pumping stopped at 5:15 AM December 14, 2005 with the initial breach forming at approximately the same time. Breach widening formed quickly, and complete evacuation of the 4,350 acre-ft upper reservoir occurred within about 25 minutes. The breach flow passed into the East Fork of the Black River (the river upstream of the lower Taum Sauk Dam) through a State park and campground area and into the lower reservoir as shown Figure 1-3. Upon leaving the Lower Taum Sauk Dam Spillway area, the flows proceeded downstream of the Black River to the town of Lesterville, MO, located about 3.5 miles downstream from the Lower Dam. The incremental rise in the river level was about 2 feet which remained within the banks of the river.

During IPOC inspections at the site, a good cross-section of the embankment could be observed on the north side of the breach as shown in Figure 6-4. In Figure 6-4 the dumped rockfill can be observed below the upper 20 ft of compacted rockfill. The rockfill exposed in this section is dirtier than a normal rockfill and as such would be more erodible and would be less free draining than a normal rockfill. In fact Dr. Frank Nickell (one of the original consultants during design) mentioned in one of his reports that the rockfill with the most fines could be used in the upper 20 ft of compacted rockfill for the roadway on the outside of the parapet wall.

A residual soil zone of weathered rhyolite could also be observed in the breach area; and one location is shown in Figure 6-4. The residual soil was observed to

be clayey and it was judged to have an effective shear strength almost dictated by the clay portion of the soil. Exposed rhyolite bedrock is also observed in Figure 6-4 as well as the remnants of the lower face slab and plinth.

A closer view of the exposed rhyolite bedrock and residual soil is shown in Figure 6-5. This photo is taken looking east and the rather flat looking joint surface in the rhyolite dips toward the camera in a westerly direction. This discontinuity was observed in the field to dip nearly west at a dip of about  $10^{\circ}$ . This discontinuity is described as Fracture Set 8 (FS-8) in the Rizzo Report and is reported to have a dip of  $8^{\circ}$  and a dip azimuth of  $270^{\circ}$ . As a result of the observation of the residual soil, the IPOC requested that samples of the residual soil be taken for direct shear testing.

The general geology of the breach area is given in the FERC Report and in the Rizzo Report on the Taum Sauk failure. The general geology is not repeated here but it is important to reiterate the most important engineering geology feature associated with the foundation of the Upper Dam. The low dipping joint surface shown in Figure 6-5 is important in that it serves to give a foundation discontinuity which daylight to the west side of the embankment and gives a foundation that in general dips downhill at about  $8-10^{\circ}$  in the direction of the applied water forces. In addition some of these joint surfaces appear to have clay coatings. The residual soil from weathering of the rhyolite also presents a zone of weakness as the relic rock structure present yields zones of preferential weakness along the orientation of the flat joint set described above. This can yield a situation where the residual soil left in the foundation of the dam would control the stability of the embankment rather than the shear strength of the rockfill.

Figures 6-6, 6-7, and 6-8 show three views of the area under the base of the bottom of the face slab and plinth. The most glaring issue revealed by Figure 6-6 for example is that it appears that the plinth was not taken down to the rhyolite bedrock shown at the bottom of the photo. This is not considered good practice today and it was not good practice in 1963. Figures 6-7 and 6-8 show similar construction along the plinth area. This observation makes it consistent to rationalize the blow outs and holes that had to be repaired upstream of Panels 90-95 in 1963 and 1964. It definitely appears from these inspections that the plinth was not extended to bedrock for this dam, at least in the breach area.

## 6.2 Estimate of Peak Reservoir Elevation

A post breach survey by KdG is shown in Figure 3-5 and in Figure 6-9. These figures show the breach area including Panels 88 through 99. The survey indicates that there are 4 areas where there is evidence of overflow. These areas include:

Panels 10, 11, 12  
 Panels 88 to 103  
 Panels 43 to 56  
 Panels 69 to 74

Taking into account the elevations of the end panels in each overflow group from Figure 3-5 it appears as if the maximum reservoir level could range between Elev. 1597.7 and 1597.9.

Another independent estimate of the maximum reservoir elevation reached can be obtained from a comparison of the reservoir levels measured by the pressure transducers in the reservoir and by the penstock reservoir transducer on December 13 and 14, 2005. It was shown for the months of January, February, and March of 2005 that both the reservoir and penstock readings in these winter months were very close to each other and read very close to 1596 when the reservoir was full. The following readings were indicated on December 13<sup>th</sup> and 14<sup>th</sup>.

| <u>Date</u> | <u>Time</u> | <u>Level Reservoir Transducer</u> | <u>Level Penstock Transducer</u> |
|-------------|-------------|-----------------------------------|----------------------------------|
| 12/13/05    | 5:50        | 1591.68                           | 1595.88                          |
| 12/13/05    | 7:20        | 1581.52                           | 1585.71                          |
| 12/14/05    | 5:15        | 1593.70                           | -----                            |

It is noted the readings at 5:50 AM on December 13<sup>th</sup> show the penstock readings to be 4.2 ft. higher than the levels from the reservoir transducers just after the reservoir had been pumped full. At 7:20 AM on December 13, 2005 the penstock readings were also 4.2 ft. higher than the reservoir readings after the reservoir was drawn down about 10 ft. and held. On December 14<sup>th</sup> at 5:15 AM the maximum reservoir level indicated by the reservoir transducers was 1593.7 and at that time the last pump had just shut off and the penstock reading was still affected by transients. But if on the basis of past readings, if it is assumed that during the winter months that the penstock reading is near correct and that on the 13<sup>th</sup> and 14<sup>th</sup> of December that the reading of the reservoir transducers were about 4.2 ft too low, as established on the December 13<sup>th</sup> readings, then the maximum reservoir level could have been  $1593.7 + 4.2 = 1597.90$  ft.

Since the Hi-Hi Warrick Probe is set at Elev.1597.70 and did not shut the units down, it is most likely that the highest reservoir elevation did not rise greater than 1597.70.

If it is noted that the original survey pins 18 and 19 (Figure 3-4) correspond to Panels 90 and 95 within the breach area and it is shown on Figure 3-3 that the 2004 elevation of Pin 18 and Pin 19 are 1587.5 and 1587.4, respectively. Then

the top of the wall at Panels 90 and 95 were 1597.5 and 1597.4, respectively, which would give overtopping of 0.2 ft and 0.3 ft respectively at these locations. The overtopping depth of Panel 72 would have been 1597.7 minus 1597.0, or 0.7 ft for a maximum reservoir level of 1597.7 ft.

Thus it is indicated that the depth of flow over the wall at Panel 72 was about 2 to 3 times the depth of flow over Panels 90 and 95 in the breach area. The fact that the breach occurred between Panels 88 and 99 could be due to variations in rockfill. It is interesting to note a letter from Mr. M. W. Dille on May 23, 1970. In this letter he summarizes some recent erosion due to rains, by saying that: "There were several small washes noted in the fine fill area between Panels 88 through 110." He also analyzed weir gage readings and noted that: "The gage readings are generally down while the leakage is up. The "fish pond" area, say between Panels 90 and 102 is up in leakage."

These comments, in general, indicate an awareness that this area was more sensitive than other areas of the embankment. The comments also indicate that the rockfill could be finer between Panels 88 and 110 than for other areas of the embankment.