PERFORMANCE HISTORY

Zoar Levee

In 1947, Dover Dam's pool reached a then record elevation of 902.7 and under seepage and interior runoff were noted on the interior toe of Zoar Levee.

In 1948 several actions were taken to remediate the under seepage and interior drainage problems. Fourteen, 40 ft deep relief wells were added to the landward toe of the levee approximately 125 ft apart. In addition, 13 piezometers were installed between the relief wells.

Between 1950-51, a pump station was constructed to help pump flows from the Zoar Diversion Dam outside of Zoar Levee. The station was equipped with twin pumps, with 125 horsepower able to discharge 15,000 gallons per minute (gpm). At the time of construction, a space for a third pump of equal size was provided but never installed.

In 1951 the federal government, acting through the USACE, made further investments in protecting Zoar from the occurrence of a Standard Project Flood while Dover Dam's reservoir was at spillway capacity. These investments raised the levee elevation from elevation 919 ft. to elevation 928.5 ft. This increased the footprint, on average of, about 25%, and required an embankment to be placed on a portion of the Rock Knoll that had previously been "high ground". It is noteworthy, that similar efforts were not taken to protect other developments, including purchasing additional flowage easement or raising other appurtenant levees located upstream of Dover Dam.

In 1969, Zoar Levee was loaded for approximately three weeks, when Dover Dam's pool reached a then-record height of 905.0 ft. While instrumentation was read in the Ball Field reach, no report has been found of the performance in that reach. A possible seep exit was noted on the interior of the Rock Knoll reach, but later dismissed as the emergence of high groundwater.

Between 1975 and 2010, several shallow slides were noted and re-dressed in three locations: the riverward slope, the highway ramp along the pump station access road, and the landward slope.

In 1992, new manhole extensions and outlet pipes were added to existing relief wells to improve access.

Between 1994 and 1995, Relief Wells 11, 12, and 13 were replaced at Zoar Levee and five additional piezometers were added.

In 2005, Dover Dam retained a pool of record at elevation 907.35, which loaded water against Zoar Levee for approximately a month. Widespread small "pin" boils were noted on the Ball Field reach and more significant boils were found on the Rock Knoll reach of the levee. To remediate the piping of material exiting these boils, they were ringed with sand bags and a filter fabric was added to the landward toe of the levee. A Screening Portfolio Risk Analysis (SPRA) of Zoar Levee and Diversion Dam concluded after this event that Zoar Levee was a DSAC II, as boils and piping indicated that the project was progressing toward failure.

In 2008, another significant Dover Dam pool occurred loading Zoar Levee for a month and peaking three feet below the 2005 pool, at 904.6 ft. The levee's performance near the Rock Knoll reach worsened significantly, with large boils flowing along the interior of the levee.

Early during the 2008 event, each boil on the Rock Knoll reach was sand-bagged and channelized flow of seepage developed. As the pool elevation increased during the next two weeks the number of boils, the size of the boils, and the total quantity of seepage across the area increased significantly. Boils repeatedly expanded beyond and collapsed sandbag rings, and coalesced at multiple project locations into large unstable regions.

The area seepage and boils extended along a line approximately 550 ft. long, parallel with the levee centerline, for a total of around 5,000 gpm of flow at its peak. Flood fighting with sandbag rings was employed for two and a half weeks, while Dover Dam's pool rose from approximately el. 894 to 904.6. Several boils grew to 1.5 ft. in diameter and produced up to 300 gpm each moving a significant amount of foundation soils. As smaller boils began to

coalesce into larger boils capable of moving foundation material faster and large unstable regions were developing, the decision was made to install a $1.26 million seepage berm with 37,000 tons of granular material.

At the same time, widespread small boils and pervasive area seepage were again observed on the Ball Field reach of the levee, but no immediate flood fighting actions were taken. The boils were generally observed from within 150 ft. of the levee toe. This scenario was very similar to what occurred in 2005. The boils were monitored for about three and a half weeks, but did not expand to the point they were carrying large amounts of soil.

This event resulted in Zoar Levee and Diversion Dam being reclassified as a DSAC 1 project, as progression toward failure had been confirmed. The DSAC I rating was subject to an Independent External Peer Review (IEPR) and confirmed (Battelle 2010).

Zoar Diversion Dam

In 1947, after significant seepage was observed through the right abutment, the pool was drained and a sinkhole was observed about 150 feet upstream of the upstream embankment toe in the reservoir area. The 1947 remedial measures consisted of concreting the bedrock in the sinkhole and filling the remainder of the depression with clay. Also, a trench was excavated along the upstream right abutment exposing highly fragmented limestone, which was grouted and covered with a thin coat of concrete. The trench was backfilled with clay and the lake was again impounded. Clear seepage was still observed at some point after this exiting from the downstream right abutment area.

In 1970, during the first periodic inspection, clear seepage was noted exiting at the downstream toe near the outlet conduit. By 1976, the seepage exit had progressed upslope to a location 8 ft. above the toe and the toe area was described as being saturated.

In 1978, major remedial measures were undertaken which consisted of:

- Installing a toe drain system
- Lowering of the outlet channel to provide positive drainage from the outlet headwall.
- Repairing gullies on the downstream slope.
- Regrading the upstream slope and providing wave protection with large stone

In 1989, seepage of 50-100 gpm was reported 300 ft downstream of the conduit outlet on the right side, exiting at several points. By 1990, flow had increased to 150-200 gpm. During the spring and summer of 1991 the seepage caused the lake level to drop significantly before leveling off at el. 906. The flow had peaked at 500 gpm and a large vertical piping cavity had developed. Studies were begun, including a seepage tracing study that confirmed a connection between pool and seepage.

In 1993, after an Embankment Re-Analysis was conducted to study the seepage problems, repairs were implemented which included installation of an upstream impervious geomembrane along the upstream right abutment of the dam, construction of an access road to the downstream area, and installation of a seepage berm with collection system downstream of the dam extending along the right abutment to the area of seepage.

In 1997, an analysis was completed to study Zoar Diversion's flood storage capacity and potential for being overtopped. This study recommended that the impounded Goose Run Lake be drained and a permanent lake no longer retained. The gate has remained open ever since, and the only known pools retained occurred in spring 2011 (3 very flashy pools as high as el. 909). No concerns were noted during these pools, but only limited observation was possible due to the lack of warning.

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