

11.0 CONCLUSIONS

The **root cause** of the Event of December 14, 2005, specifically “*the uncontrolled, rapid release of water from the Upper Reservoir,*” was the breach of the Rockfill Dike. Our forensic investigation indicates that the breach was a stability failure of the Rockfill Dike at the northwest corner of the Reservoir brought on by a rapid increase in the pore pressure at the Dike/foundation interface, stemming from the original design and construction which was flawed.

The Breach of the Rockfill Dike, the primary Barrier to the Event, is the root cause of the “*rapid release of water from the Upper Reservoir.*” The stability failure of the Dike was caused by:

- (1) A rapid rise in the phreatic surface and the associated pore pressure at the Dike/foundation interface caused by the flow overtopping the Parapet Wall.
- (2) Weak foundation conditions attributed to the original design and construction specifications.
- (3) Inadequate shear strength of the material comprising the rockfill attributed to the original design and construction practices.
- (4) Poor construction practices and failure to meet the intended design criteria.

While the original design is considered to be consistent with the general design practice of the late 1950s and early 1960s, it is not consistent with the practice in 2006. Specifically, the rock at the Upper Reservoir was dumped and then sluiced with water to remove fine material and move the rock into a more dense state. Today, rockfill is compacted with compactors and carefully monitored to prevent the inclusion of fines with the rock. Water sluicing with monitors is an abandoned practice. In addition, the modern day designer places a great deal of emphasis on the preparation of the foundation rock, including hand cleaning and removal of soil, weathered rock and other relatively low strength material – none of which were adequately specified in the original design.

It is also RIZZO’s opinion that the construction practice followed in the field during original construction was not consistent with the intent of the design as shown on the drawings and in the specifications. Sluicing was specified by the designer for the removal of fines from the dumped rock fill. Observation of the breach slopes clearly indicates that this was not uniformly achieved during construction. The designer also called for the foundation rock to be cleaned with a bulldozer such that not more than two inches of material was left in place. Yet, our field investigation has determined that as much as 18 inches of virgin, low strength material was left in place in certain areas.

The failure of the Reservoir level monitoring instrumentation to function as intended is a primary contributing cause. As defined herein, a primary, secondary or tertiary contributing cause is a cause that may have contributed to, but would not, either singularly or in combination with other primary, secondary or tertiary causes, have caused the stability failure of the Rockfill Dike. The failure of the level control instrumentation to function as intended is due to a failure of the instrumentation support system. The failure of the level protection instrumentation to function as intended is due to a misplacement of the HI and HI-HI level protection instrumentation as a result of human error.

It is RIZZO's opinion that inadequate attention was paid to dam safety considerations as regards the design, operation, and management of the facility and that this may have been a secondary contributing cause of the Event.

The failure of the Parapet Wall, the concrete upstream face of the Rockfill Dike, the performance of several grout curtains, and the asphalt liner may have been Secondary or Tertiary Contributing Causes of the Event, as discussed in **Section 8.0**.

The performance of foundation filters was not a cause of the Event.

The synthetic liner placed on the upstream face of the Rockfill Dike was not a cause of the Event. It is Rizzo's view that the liner increased the factor of safety against stability failure.

It is our conclusion that the **root cause** of "***the uncontrolled, rapid release of water from the Upper Reservoir***" was the breach of the Rockfill Dike—a stability failure at the northwest corner of the Reservoir brought on by a rapid increase in the pore pressure at the Dike/foundation interface, stemming from the original design and construction which was flawed.

Respectfully submitted,
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