Introduction

The Bureau of Reclamation has completed a study to evaluate the stability and assess the risk associated with the Leadville Mine Drainage Tunnel (LMDT) in Leadville, Colorado. The risk assessment reviewed two critical factors: the potential failure modes of the LMDT and the consequences of those failures. Throughout this risk assessment, Reclamation made conservative assumptions.

To complete the risk assessment, Reclamation utilized a similar process to that used to assess risk at its dams, a model that is a global standard for conducting risk assessments. First a group of Reclamation specialists gathered in a team setting and completed the risk assessment. Next, the draft assessment was internally peer reviewed. Finally, it was independently peer reviewed by experts not affiliated with Reclamation, including a geologic hazards specialist from the U.S. Geological Survey, a retired rock mechanics and mining engineering professor from the Colorado School of Mines, and a mining engineer from Leadville. The Independent Review Board confirmed Reclamation's conclusions that it is unlikely there would be a sudden release of water from the Leadville Mine Drainage Tunnel and that there is no imminent public safety hazard.

Findings

The risk assessment found that a blockage in the tunnel near the Pendery Fault is likely to exist due to a zone of tunnel roof collapse located downstream from the fault. The blockage is currently stable and is expected to be longer and stronger than Reclamation conservatively estimated in its stability analysis.

Even though it is highly unlikely, the study considered what would happen if the blockage near the Pendery Fault rapidly gave way. This would result in higher water pressure being transmitted to the downstream plug material and engineered bulkhead constructed by Reclamation in 1991. Based upon this conservative assumption, this is how the tunnel and surrounding area would respond:

- The higher water pressure and forces on the downstream plug material and constructed bulkhead would not be great enough to move them.

- It would take a significant period of time for the increased water pressure to migrate from the upstream end of the downstream plug near Station 5+92 to the soils around the LMDT near the timber-lattice bulkhead and tunnel liner at Station 4+61. The elevated groundwater levels would likely drain off below ground surface into the surrounding terrace gravels.

- In the remote event that groundwater levels near the timber-lattice bulkhead and tunnel liner at Station 4+61 were to rise to levels which could collapse the concrete tunnel liner, a rapid release of water is not expected. Analysis shows that the elevated water pressure would not generate enough force to push this material out of the tunnel, and erosion of the collapsed material is unlikely.

- It is highly unlikely that the hillside above the portal would become unstable. The soils are too strong for that to occur, even with elevated groundwater conditions.

Summary

Reclamation used multiple layers of conservative assumptions throughout the engineering analysis (such as low soil strengths, neglecting tunnel roughness, considering the upper blockage fails rapidly, and using extremely high groundwater levels). Therefore, conditions are actually more stable than the analyses indicate. If the blockage near the Pendery Fault were to fail, it would likely occur over a time frame of weeks or months, not hours or days. Sensors in the LMDT would provide adequate warning of the changes in the tunnel.

Engineering analysis indicates that neither a rapid release of water nor slope failure is likely to occur. Even when earthquake loadings are added to the slope above the portal, analysis shows that the slopes would remain stable. The consequences of each potential failure mode were evaluated and the residents of Leadville and The Village at East Fork are safe. There could be some seepage of contaminated water into the surrounding rock and soils that would find its way to the Arkansas River.

Recommendations

The risk assessment team recommends Reclamation enhance its activities on site to monitor water pressures in the tunnel and surrounding hillside soils. Specifically, the team recommended adding water pressure monitoring instruments to the monitoring wells at Stations 3+00, 4+70, and 6+35 and connecting them to the existing Early Warning System.

The team also recommends that the Emergency Action Plan for the facility be updated, finalized and exercised. The update to the plan should include information about the new potential failure modes, including the likely indicators of potential failure mode initiation, and establishing clear written directions of actions to be taken.

Reclamation has accepted and will be implementing these recommendations.

Next Steps

This risk assessment is in final draft form. We invite the public and government agencies to submit technical comments on this assessment to Reclamation by July 31, 2008. Reclamation will then review those comments, incorporate the relevant comments, and release the final report by the end of September 2008. The risk assessment will be available on the Internet at www.usbr.gov/gp when it is released on June 30, 2008.

Water is now being pumped from the well EPA installed in June 2008, combined with water that Reclamation has been treating at its Water Treatment Plant since 1992, it is treated and released into the Arkansas River. The successful operation of this new well will reduce the difference in the groundwater levels around the Pendery Fault, reducing an already low risk.

Reclamation will continue to work with EPA, the State of Colorado, and Lake County on issues related to the LMDT.