# Gold Hill Mill
# Tailings Storage Facility Evaluation

## August 2025

By:

## Colorado Milling Company

Represented by:

Lewicki & Associates

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# 1. Executive Summary

This report presents an assessment of the liner integrity at the Gold Hill Mill Tailings Storage Facility (TSF) based on recent geophysical investigations and 25-year water quality monitoring. A low-resistivity anomaly identified by Electrical Resistivity Tomography (ERT) at approximately 30 feet below ground surface has been evaluated through comprehensive temporal correlation analysis.

The ERT anomaly is located 30 feet below the TSF with no direct connection pathway to the surface. Analysis of 25 years of water quality monitoring reveals zero time-lagged chemical transfer between the TSF and downgradient wells. Manganese concentrations demonstrate a 1,270:1 ratio between TSF and groundwater with no downstream response, while multiple metal indicators show effective liner containment. Statistical analysis provides 80% confidence of no hydrogeochemical connection between the systems.

# 2. Background

The Gold Hill Mill TSF was constructed in 1998 with a composite liner system consisting of a geosynthetic clay liner (GCL) and 60-mil HDPE geomembrane, as documented in the construction completion report by McCulley, Frick & Gilman, Inc. Recent geophysical investigations were undertaken to assess liner integrity following standard monitoring protocols for tailings facilities.

# 3. Site Geology and Hydrogeology

## 3.1. Geological Setting

The TSF is situated on the Idaho Springs Formation, characterized by schist and gneiss units, with underlying Boulder Creek Granite (granodiorite). The bedrock consists of an intact block rock mass with local fracture networks and quartz vein systems (Figure 1). The rock mass is generally competent with limited permeability except along fracture zones where natural groundwater flow may occur.

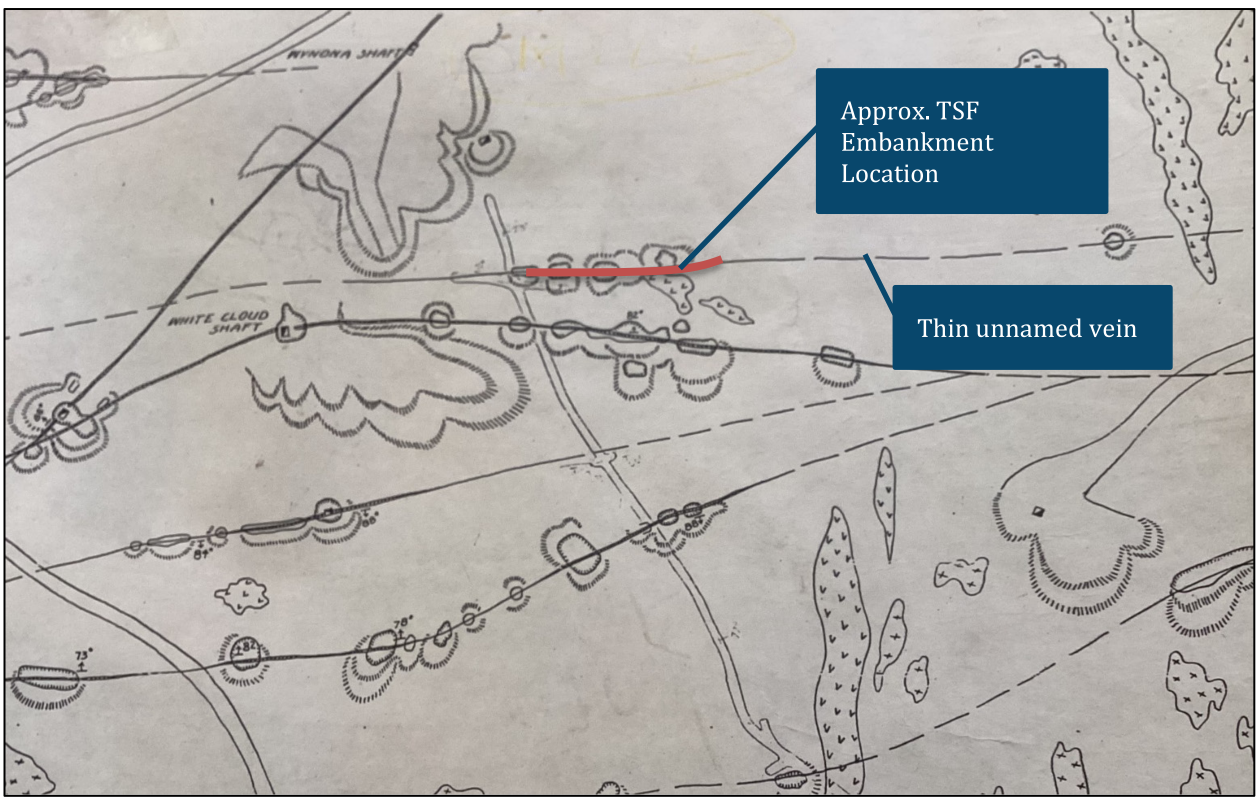



**Figure 1. Vein Mapping Near TSF**

## 3.2. Structural Features

Historical construction records indicate the presence of a 'massive quartz vein' trending approximately N 10° W on the northeast side of the facility, which limited excavation during original construction. This supports the veins mapped historically in the area (Figure 1).

# 4. Geophysical Investigation Results

## 4.1. ERT Survey Methodology

Collier Geophysics conducted an ERT investigation on July 8, 2025, using an Iris Instruments Syscal Pro 10-channel system. The survey employed two 450-foot survey lines with 5-foot electrode spacing and a Dipole-Dipole configuration designed to achieve a 50-foot investigation depth. Each line utilized 96 active electrodes to provide high-resolution subsurface imaging.

## 4.2. ERT Results Summary

The investigation revealed several key subsurface features: A continuous moderate resistivity layer with values between 200-400 Ohm-m was identified approximately 20 feet thick at 30 feet below ground surface across both survey lines. A distinct low-resistivity anomaly was detected on Line 1 at 30 feet depth, extending from 130 to 145 feet along the survey line with potential continuation toward Line 2. Lower resistivity measurements often indicate water saturated areas. The anomaly characteristics show resistivity values somewhat elevated for typical water-saturated conditions, suggesting limited water content or mineralized groundwater.

## 4.3. Geophysical Interpretation

The identified anomaly exhibits characteristics consistent with groundwater within fractured bedrock, possible association with the documented thin vein system, and natural hydrogeological conditions rather than anthropogenic contamination.

# 5. Liner System Assessment

## 5.1. Original Construction Standards

The 1998 construction incorporated industry-standard materials and methods throughout the installation process. The composite liner system consists of a geosynthetic clay liner (GCL) combined with a 60-mil HDPE geomembrane, providing dual containment protection. Proper anchor trench installation and backfill procedures were followed according to design specifications. Quality assurance oversight was provided by McCulley, Frick & Gilman and their qualified subcontractors, with final certification completed by Colorado Professional Engineer Jonathan P. Friedman, P.E.

## 5.2. Depth Separation Analysis

Critical observations regarding the resistivity anomaly demonstrate its separation from the liner system: The anomaly occurs at a depth of 30 feet below ground surface, representing approximately 25-28 feet of separation below the installed liner system. No geophysical evidence exists for preferential flow paths or direct connections between the TSF and the identified anomaly. The intervening geological barrier consists of intact granodiorite bedrock that provides effective isolation between the liner system and the deeper groundwater anomaly.

# 6. Water Quality Assessment

Downstream and downhill of the TSF is a set of groundwater monitoring wells: W1 through W4 (Figure 2). Each of these wells is sampled for metals every quarter as part of the DRMS permit for the mill. Each quarter, the TSF pool is also sampled. Depth to water in each well varies from 30 to 60-ft on average, as such, all well samples are below both the TSF pool and the subsurface anomaly found in the geophysical investigation. By comparing the metal values between the TSF pool sample and the wells it can be seen whether there is a correlation between the two that indicates a water connection. If there is a water connection due to a liner leak, the metals concentrations in the TSF pool sample should be similar to the well water either immediately or after a delay allowing for water movement.

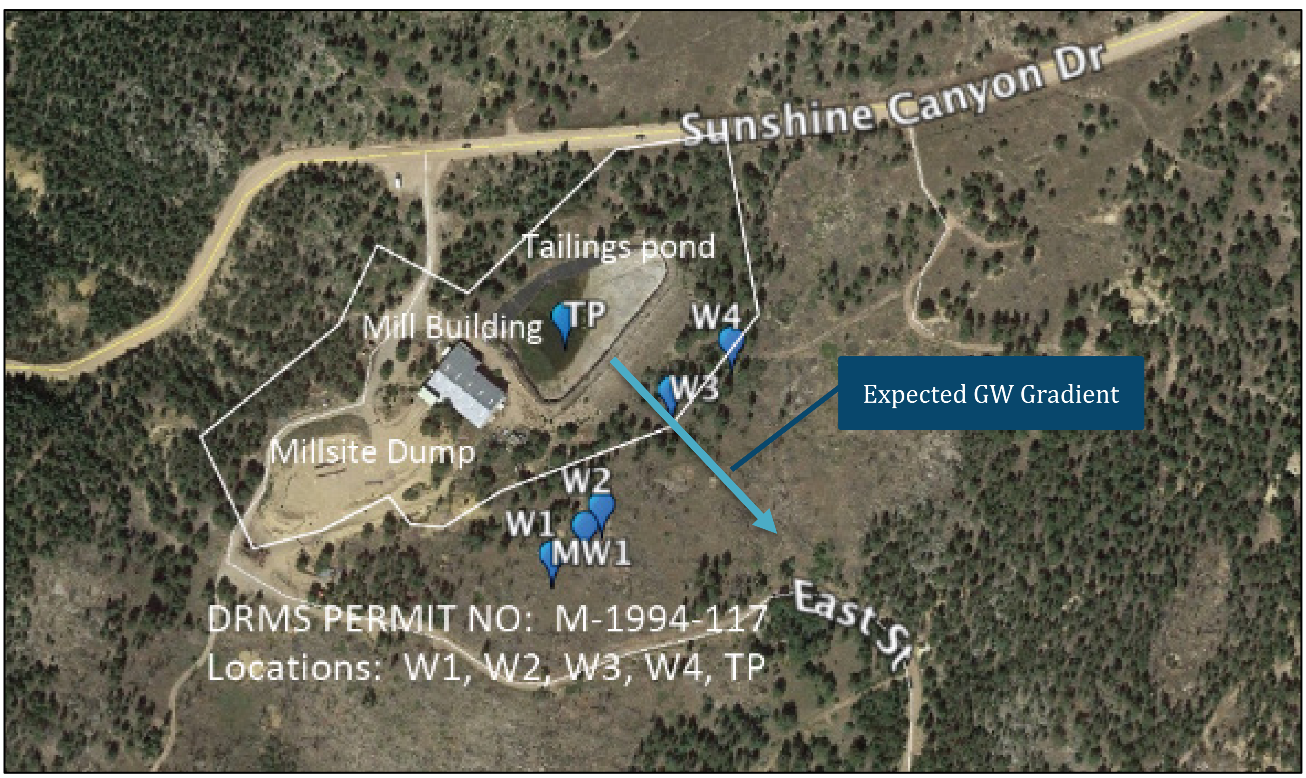



**Figure 2. Map of TSF Pool (TP) and Groundwater Monitoring Well (W1-4) Locations**

Water Data Overview

- Monitoring Period: 25 Years (1998–2023)
- TSF Samples: 57 (Quarterly to annual)
- Well Samples: 16 (W1–W4 downgradient)

# 7. Metal Indicator Analysis

Manganese, copper, lead, and zinc were compared between the TSF and the monitoring wells. While other parameters were sampled in both locations, these metals are those typically of concern at the site.

Manganese (Figure 2) serves as the most sensitive indicator for mining-related contamination due to its high mobility in groundwater systems. TSF manganese concentrations range from 0.01 to 3.75 mg/L with a mean of 1.09 mg/L, while downgradient wells consistently maintain concentrations at or below 0.01 mg/L with a mean of 0.0009 mg/L. This represents a concentration ratio of 1,270:1 between TSF and groundwater. Most critically, temporal correlation analysis reveals no downstream response at 3, 6, or 12-month lag periods despite the extreme concentration gradients. The peak TSF manganese concentration of 3.75 mg/L in 2011 produced no corresponding increase in any downgradient well, providing strong evidence that TSF water is not reaching the monitoring points.

Copper (Figure 3) concentrations further support this conclusion with TSF levels ranging from 0.000 to 0.008 mg/L (mean 0.0028 mg/L) compared to well concentrations consistently at or below 0.0015 mg/L (mean 0.0003 mg/L). The resulting 11.2:1 concentration ratio demonstrates clear chemical separation between the systems. Peak copper concentrations occurred during 2008-2011 in the TSF, yet downgradient wells showed minimal response during this period, confirming effective liner containment of dissolved metals.

Lead (Figure 4) analysis provides additional confirmatory evidence with TSF concentrations ranging from 0.000 to 0.0063 mg/L (mean 0.0014 mg/L) while wells remain consistently at or below 0.001 mg/L (mean 0.0002 mg/L), producing a 7.7:1 concentration ratio. The critical test occurred in 2010 when TSF lead reached its peak concentration of 0.0063 mg/L, yet corresponding well samples showed zero response, further demonstrating liner integrity.

Zinc (Figure 5) concentrations present the most conservative assessment among the metals analyzed, with TSF levels ranging from 0.000 to 0.055 mg/L and well concentrations from 0.000 to 0.0325 mg/L, resulting in the smallest concentration ratio of 1.9:1. Again, there is no immediate or time-delayed sign that the metals are moving via a water path from the TSF to the wells.

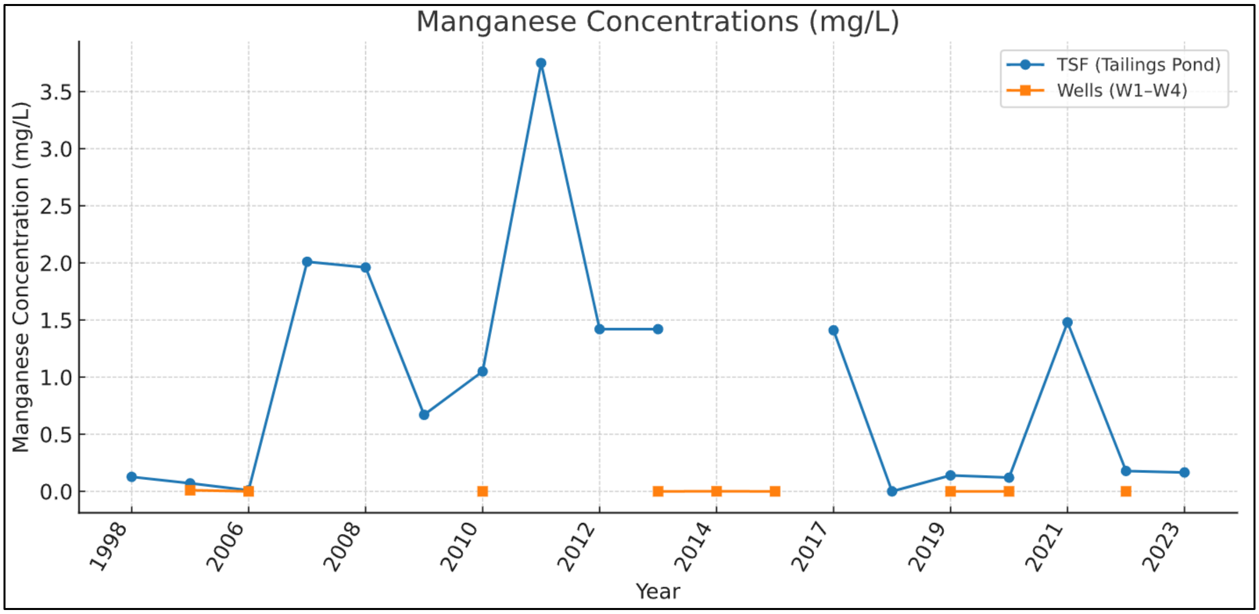



**Figure 3. Manganese Max. Concentration Comparison**

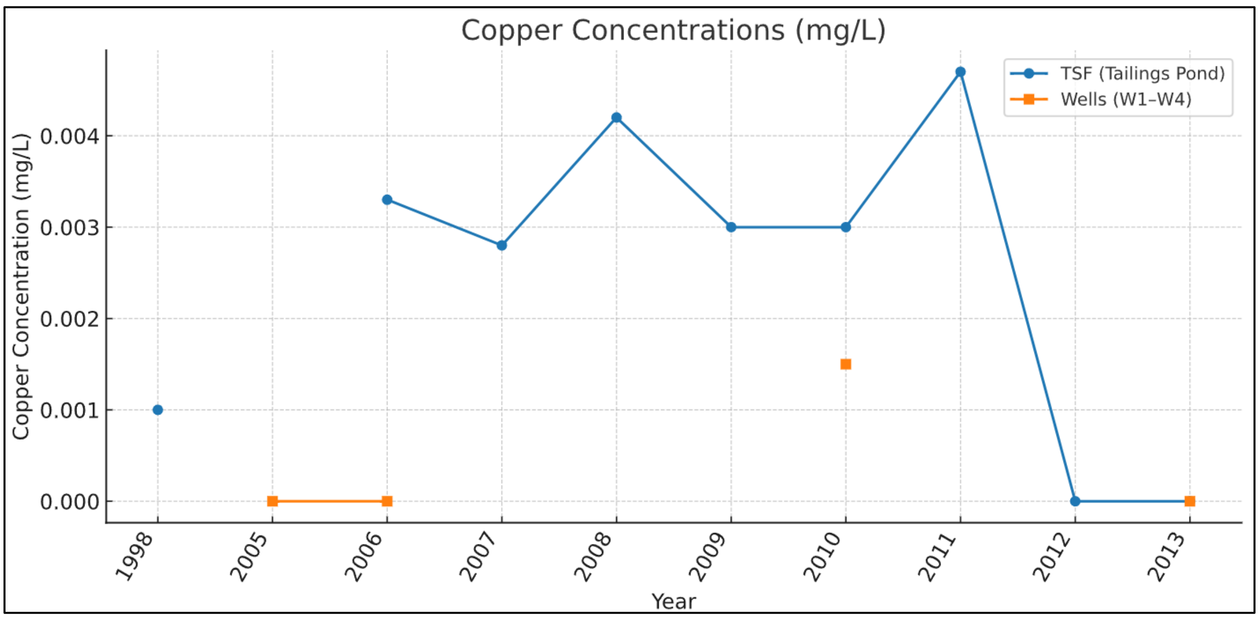



**Figure 4. Copper Max. Concentration Comparison**

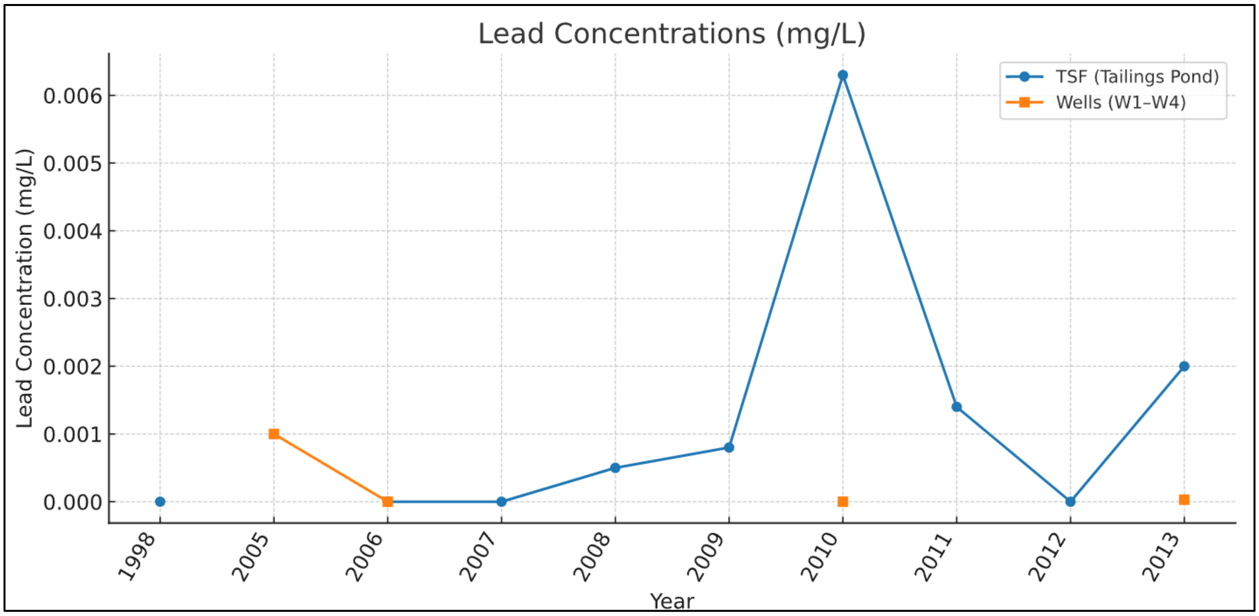



**Figure 5. Lead Max. Concentration Comparison**

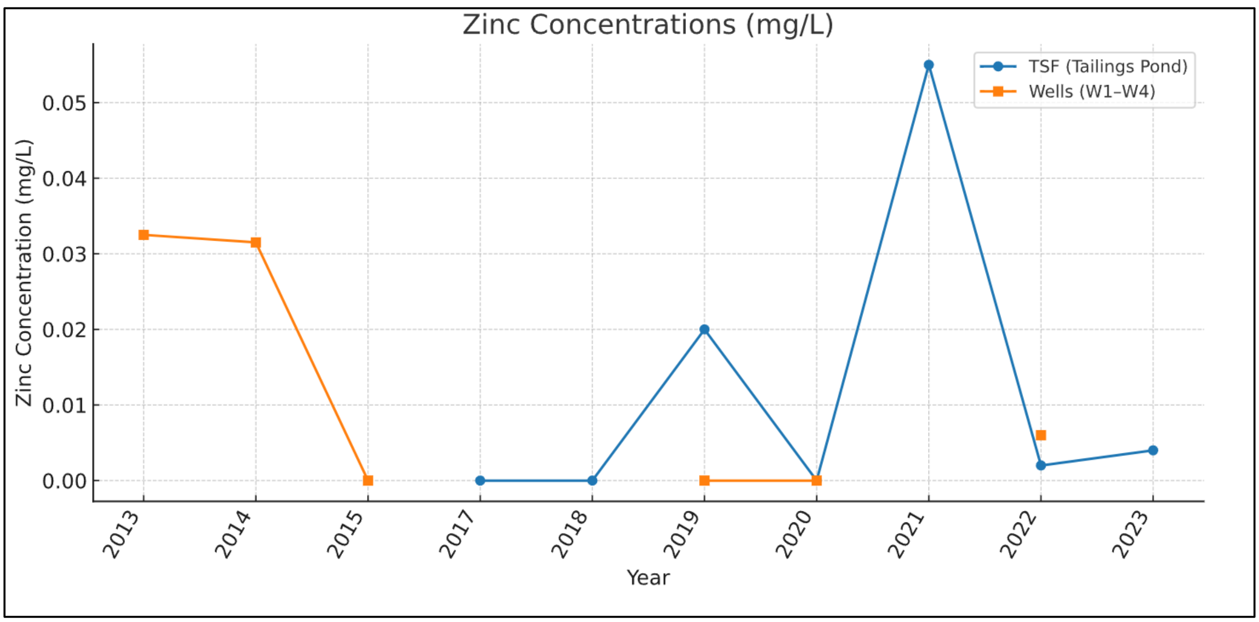



**Figure 6. Zinc Max. Concentration Comparison**

# 8. Summary & Conclusion

The ERT survey identified a low-resistivity anomaly at 30 feet depth, located within intact granodiorite bedrock and consistent with the documented White Vein location. The anomaly shows no direct pathway connection to the TSF liner system above. Water quality analysis demonstrates zero time-lagged chemical transfer between TSF and wells, with extreme concentration separations reaching up to 3,750:1 for manganese. The 25-year monitoring record shows no systematic migration patterns.

Based on these facts it can be concluded that the TSF liner is intact. The installation was done properly with nothing in the installation record indicating any issues that would lead one to doubt the liner integrity. Wear and tear on the liner is exclusively found along the sections of it exposed to the sun, when can also be easily repaired. In its current state it can continue to be used to hold the tailings currently stored in it, and with repairs to the exposed sections, can be used to contain more tailings at a further date.

## 8.1. Recommendations

Prior to additional tailings deposition: patch and repair all exposed sections of liner, survey the TSF with an aerial drone to determine remaining capacity and freeboard.

# Attachments

Collier Geophysics ERT Report (July 25, 2025)

July 25, 2025

Mark A. Steen

COLORADO MILLING COMPANY, LLC
P.O. Box 1523
Longmont, CO 805027

Email:
goldtontine@gmail.com

RE: Geophysical Letter Report | Project # 250174
Gold Hill Mill Tailings Pond Liner Integrity Investigation

**EXECUTIVE SUMMARY**

At the request of Colorado Milling Company, LLC, Collier Geophysics LLC (Collier) conducted an Electrical Resistivity Tomography (ERT) survey at a Tailings Storage Facility (TSF) at the Gold Hill Mill located approximately 7.5 miles west of Boulder, Colorado (**Figure 1**). The survey's objective is to conduct a geophysical investigation into the geosynthetic liner's integrity to identify any anomalous zones that may indicate subsurface water flow from a potential liner leak. There was no observed surface seepage reported before or during the time of data acquisition. On July 8th, 2025, Collier Geophysicist Kassidy Page collected two (2) 450-foot ERT survey lines on the downgradient side of the TSF (**Figure 2**).

The ERT survey revealed a 20-foot-thick layer of moderate resistivity (200-400 Ohm-m) at 30 feet below ground surface across both lines, though more fragmented in Line 2. More importantly, a low-resistivity anomaly was found on Line 1 at 30 feet deep, extending from 130 to 145 feet, and potentially continuing southeast toward Line 2. Further investigation is needed to confirm if this anomaly is indeed related to seepage, as its resistivity values are somewhat high for typical water-saturated conditions.

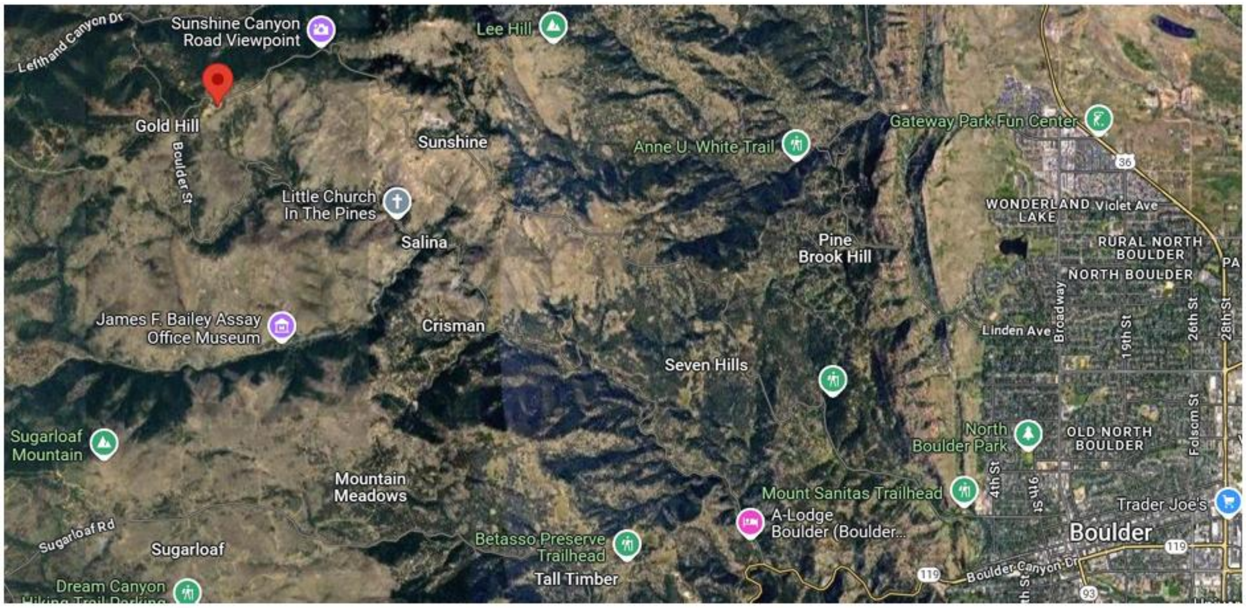



**Figure 1. The location of the Tailings Pond is shown near Gold Hill, CO. The site is approximately 7.5 miles northwest of Boulder, CO (red pin).** ***Google Earth Imagery***

## Project Site & Data Collection

The geologic setting of TSF at the Gold Hill Mill is located on the Idaho Springs Formation schist and gneiss, as well as Boulder Creek Granite. The site featured a mix of forested areas and open, grass-covered embankments (**Figure 3**). During data collection weather was sunny and partly cloudy with temperatures around 80 degrees Fahrenheit, conducive to data collection.

The ERT survey was performed using an Iris Instruments Syscal Pro 10-channel multiple electrode resistivity imaging system. The ERT line was 450 feet long with a 5-foot electrode spacing with 96 active electrodes, with a target depth of investigation of 50 feet. A Dipole-Dipole electrode configuration was used for this ERT survey along the downhill of embankment. The internal transmitter in the Syscal Pro was powered by an external 12-volt deep cycle marine LiFePO4 100-amp-hours battery.


**Figure 2. Shows the Tailings Pond at the Gold Hill Mill site with the locations of the two electrical resistivity lines collected on July 8th, 2025.**

**Figure 3. Image on the left shows the surface condition for ERT Line 1. Image on the right shows the conditions for ERT Line 2.**

## Method

The ERT method is used to characterize subsurface lithology and geologic structure. ERT incorporates the injection of an electrical current into the ground through a pair of electrodes (current electrodes) while simultaneously measuring the potential or voltage between an offset pair (potential electrodes). The subsurface apparent resistivity is then calculated from the measured voltages, according to electrode geometry. This measured apparent resistivity represents the bulk resistivity of earth materials where most injected current flows. The geometry between 2 current electrodes and 2 or more potential electrodes defines an array. The distance between the potential electrodes is related to resistivity measurements with depth. The amount of current injected and the distance between the current electrodes determines the investigation depth, i.e., larger spacing forces more available current to flow at depth. A multi-channel, multi-electrode ERT system was used for this survey to allow for a higher resolution and modeling with tomography for a two-dimensional (2D) cross-section of the subsurface.

Electrical resistivity (the reciprocal of conductivity) is a physical property which is diagnostic of the type of geologic material present. Unsaturated soils have higher resistivity (lower conductivity) than saturated soils. Coarse-grained soils with minimal fines content have higher resistivities than soil with high fines content. Sandstone, limestone, and granite typically have higher resistivity values than shale and siltstone (**Figure 6**).

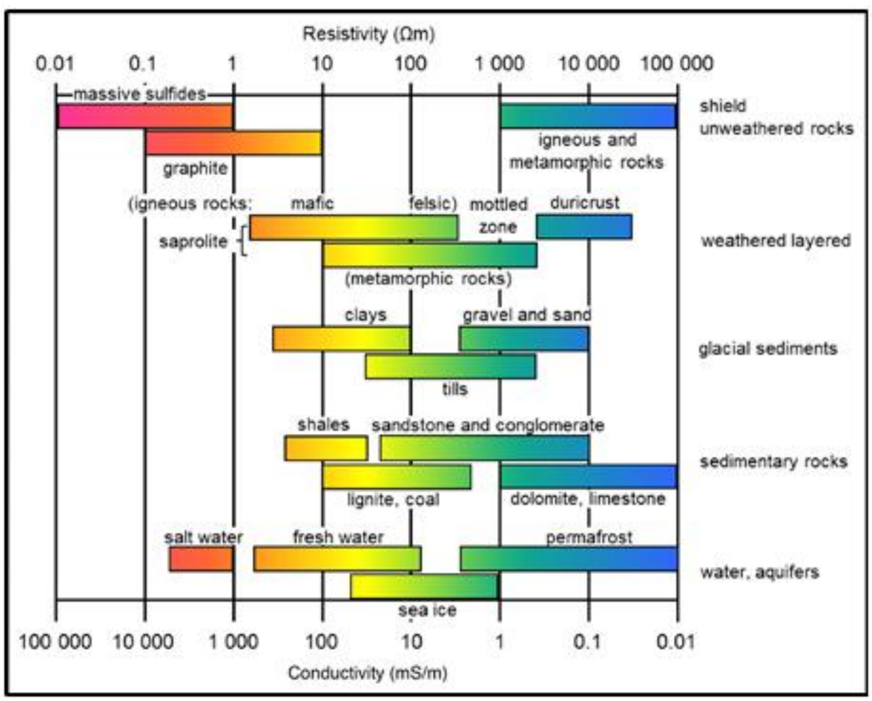



**Figure 6. The range of possible resistivity values for various earth materials.**

For this seepage investigation, water saturated areas in the subsurface should appear less resistive (more conductive). ERT data are susceptible to interference from objects that act as subsurface conductors and draw injected current away from the ERT array in ways not related to geologic structures. Poor electrode coupling was the primary source of noise in ERT measurements, creating poor resolution in the near-surface tomography model results, approximately within the first 5 feet. While common in dry resistive soils, this did not impact the results in the 10-50 ft depth range.

## Data Processing

The ERT data were processed using EarthImager, distributed by Advanced Geoscience Inc. (AGI), using a standard workflow to remove erroneous and noisy data and prepare the raw apparent resistivity values for tomographic inversion. Inversions were performed to maximize resolution, reduce noise, and provide a good fit between modeled and measured data. The resulting 2D ERT cross section is then interpreted for anomalous resistivity zones using Surfer, by Golden Software. **Table 1** below details the ERT processing and interpretation workflow.

**Table 1: ERT processing and interpretation workflow**

| Processing Step | Process | Details |
|---|---|---|
| 1 | Remove noisy data | High contact resistance results in noisy data. Noisy data points are removed to improve inversion stability |
| 2 | Georeference the data | Positional coordinates and elevation data are tied into the resistivity data to get accurate survey geometry and apparent resistivity calculations |
| 3 | Invert apparent resistivity data | Resistivity data inverted in EarthImager to acquire a 2-D resistivity cross-section |
| 4 | Identify anomalous resistivity zones | Subsurface areas modeled to have resistivity highs and/or lows are interpreted as anomalous zones |

## Results and Discussion

Results from the ERT investigation are presented as a large-format figure, appended to this report. **Figure A-1** shows the ERT Dipole-Dipole 2D models for lines 1 and 2. Blues on the models, values of 100 Ohm-m and below, are associated with resistivity values characteristic of water-saturated environments. Whereas values of 1000 and above reds are associated with resistive rocks, like that of granite.

A horizontal layer, approximately 20 feet thick, with resistivity values of 200-400 Ohm-m (appearing as green and yellows), is present about 30 feet bgs for ERT Line 1 and appears to extend to portions of ERT Line 2 at a similar depth, but is more fragmented in ERT Line 2 which could be related to the construction of the embankment.

A low-resistivity anomaly has been identified on ERT Line 1 at a depth of 30 feet bgs, spanning from 130 to 145 feet along the line. This anomaly appears to extend southeastward, with a limited observation around the 100-foot mark of ERT Line 2. The observed direction of this low-resistivity anomaly aligns with the surface topography, suggesting it may follow a path consistent with subsurface water flow. While low resistivity can suggest water-saturated soils, this anomaly falls on the higher end of typical water-saturated readings, requiring further investigation to confirm water saturation as the sole cause.

## Closure

Collier conducted an ERT survey for Colorado Milling Company, at the Gold Hill Mill's Tailings Storage Facility to check for liner leaks. Using an Iris Instruments Syscal Pro, two 450-foot ERT lines were acquired on July 8th, 2025, targeting a 50-foot depth. Results show low resistivity (≤ 100 Ohm-m) indicates water saturation and high resistivity (≥ 1000 Ohm-m) indicates resistive rock. A 20-foot-thick layer (200-400 Ohm-m, green/yellow) was found around 30 feet bgs on Line 1, extending to Line 2 but more fragmented. A low-resistivity anomaly on Line 1 (30 feet bgs, 130-145 feet) extends southeast towards Line 2, aligning with potential saturated subsurface, though further investigation is needed as its resistivity values are on the higher end for water-saturated conditions.

The geophysical methods used in this investigation, like any remote sensing technique, require the subjective interpretation of indirect methods of measurement. As such, there is an inherent margin of error, which is unavoidable. Our methods of data acquisition and interpretation for this project are complete as is reasonably possible and have been successfully applied by Collier geophysicists to investigations of similar size and nature. We believe the results presented herein to be a reasonable representation of the subsurface conditions as they relate to the subsurface of the embankment of the tailing pond. Due to the subjective nature of any type of interpretation, we cannot guarantee that our results are accurate in all areas. In addition, all subsurface seepage paths present at the site may not have been detected or identified.

If you have any questions regarding the field procedures, data analysis, or the interpreted results presented herein, please do not hesitate to contact us. We appreciate working with you and look forward to providing RJH with geophysical services in the future.

Respectfully Submitted,

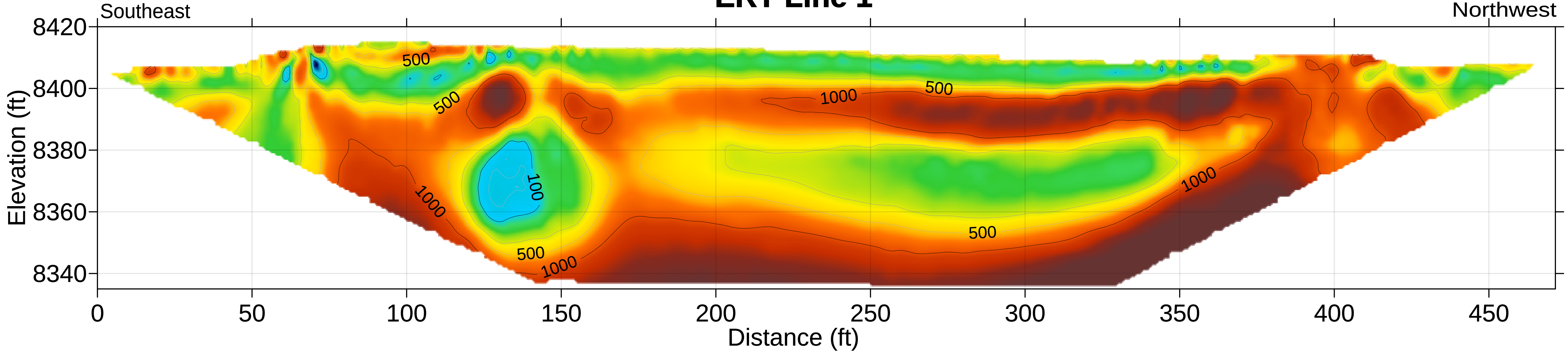
Collier Geophysics, LLC

Stan Smith
Senior Geophysicist

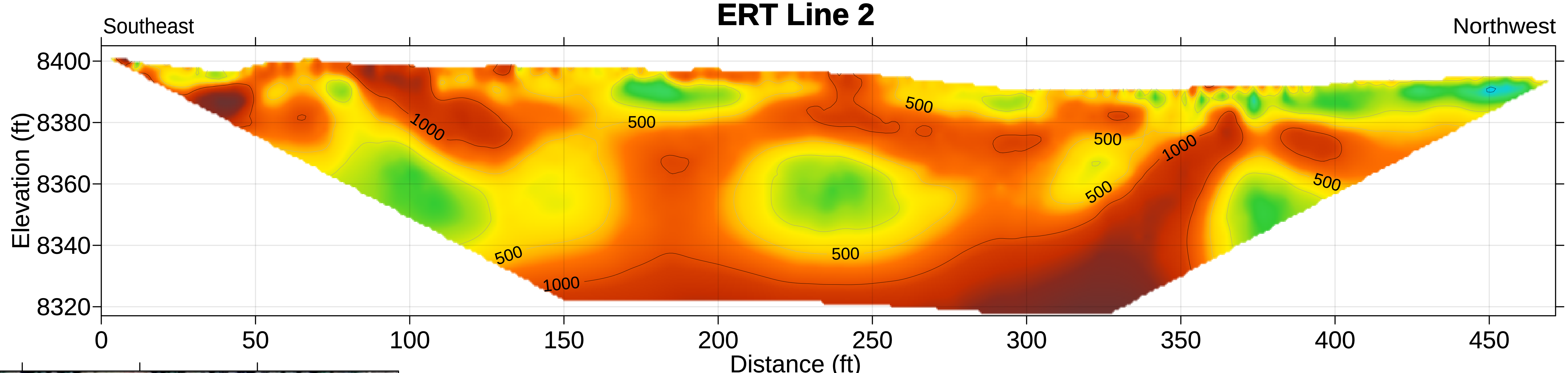
Dawn Lipfert
Geophysicist

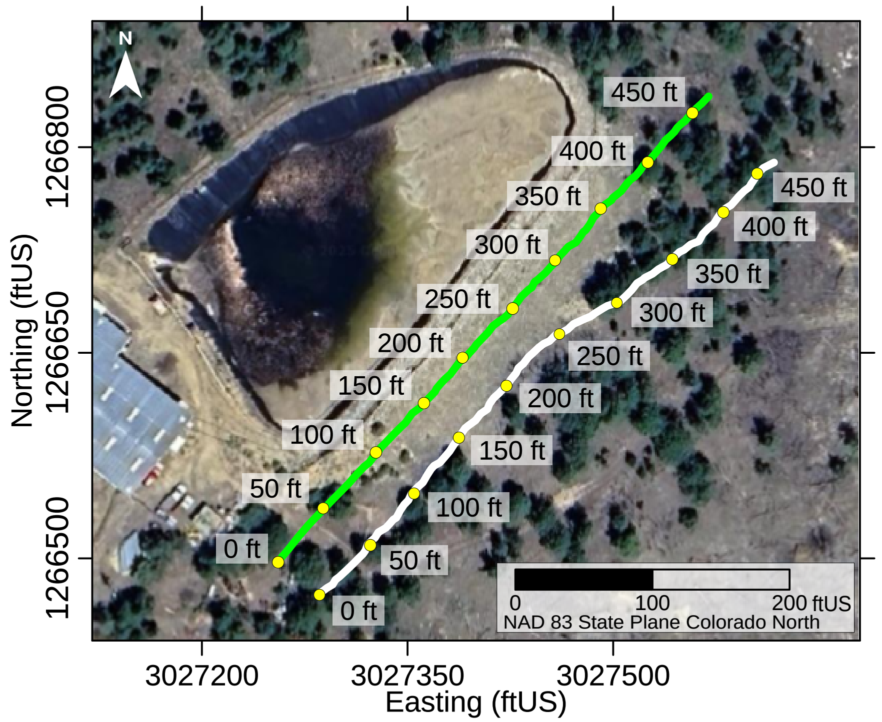
# APPENDIX FIGURES

## ERT Line 1




## ERT Line 2



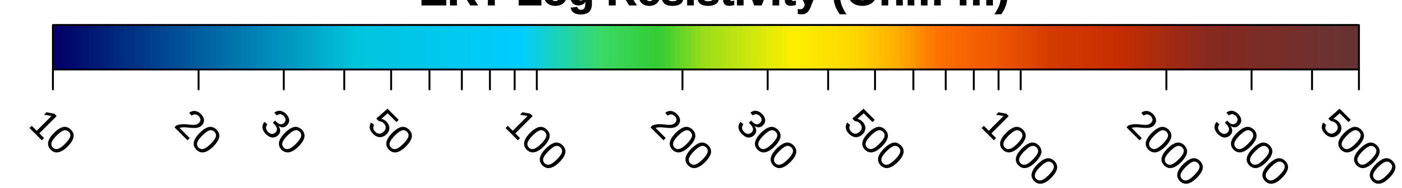




**Map Key:**

ERT Line 1

ERT Line 2

**ERT Log Resistivity (Ohm-m)**




Gold Hill Mill Tailings Pond Liner
Integrity Investigation: ERT 2D Models
*Gold Hill, CO*

COLLIER GEOPHYSICS

Colorado Milling Company, LLC

Project #: 250174

**Figure A-1**

Drafted by: D. Lipert

Reviewed by: R. Bowling

**July 2025**