Appendix A

# Feasibility Level Design, 30,000 TPD Tailings Storage Facility
# And
# Tailings Distribution and Water Reclaim Systems

Copper Flat Project

Sierra County, New Mexico

Golder Associates Inc.,

Revised, June 2016

## List of Appendices

# 7.0 TAILINGS DELIVERY AND DISTRIBUTION SYSTEM DESIGN

## 7.1 General System Description

The tailings delivery and distribution system design consists of pipeline system that delivers whole tailings from the processing plant to the tailings storage facility. Whole tailings will be separated into fine material and sand material in the cyclone plant. The sand fraction will be transported to the TSF and used for dam construction while fine material will be deposited into the TSF. The tailings surge system is designed for tailings management in case of unanticipated shutdown of any of the tailings stations or surges or overflows from station sumps. Return or reclaim water will be collected from the TSF surface pond and TSF underdrain water collection pond and transported back to the process plant. A general process flow diagram for the tailing delivery and distribution system is provided on Drawing 23.

Process equipment for the tailings delivery and distribution system will be located in four main stations as listed below:

- Cyclone Station: including the cyclone cluster, slurry pumps, slurry transfer sumps, gland seal water system, and electrical equipment;
- Surge Discharge System: including the surge pond evacuation pumps and lined secondary containment ditches;
- TSF Return Water Pond Barge Station: including a floating barge and barge mounted vertical turbine pumps and electrical equipment; and
- TSF Underdrain Collection Pond Pump Station: including vertical turbine pumps in a permanent structure and electrical equipment.

Tailings distribution will include whole tailings transport from the process area to the cyclone station and sand and fine tailings transport to the TSF. Return water will include tailing drainage water and TSF return water transported to the process plant. The major pipelines are listed below, and their interactions are shown in the overall system process flow diagram on Drawing 23.

- Cyclone Feed Line
- Cyclone Overflow Line
- Cyclone Underflow Line
- Cyclone Whole Tailings Bypass Line
- TSF Return Water Line
- TSF Underdrain Collection Return Water Line
- Main Surge Discharge Line

The major pipelines will be installed within secondary containment ditches lined with a minimum 60-mil HDPE geomembrane liner placed over six inches of liner bedding fill. The secondary containment ditches and associated pipelines will be constructed in accordance with the requirements listed in 20.6.7.23

and consolidation can occur under managed deposition is primarily a function of rate of tailings rise. It is also influenced by tailings properties, climatic conditions, surface water management, and operator effort.

## 7.4 Management of Upset Flows

Potential upset flows from the process area, cyclone plant, and TSF will be controlled through a series of secondary containment ditches, the surge pond, and the TSF underdrain collection pond (see Section 6.5). The secondary containment ditches and associated pipelines will be constructed in accordance with the requirements listed in 20.6.7.23 NMAC. The secondary containment ditches will run from the process area to the TSF (the main ditch), from the main ditch to the cyclone area, and from the cyclone area to the surge pond. The secondary containment ditches are designed to contain and transport flows via gravity that are related to potential upset conditions and direct precipitation onto the ditches associated with the 25-year 24-hour storm event (2.88 inches). Maximum upset flow conditions would be associated with overtopping of the process water reservoir (as estimated by M3, the design contractor for the process water reservoir). This maximum upset flow was assumed to be 18,000 gpm over a 30-minute period, at which point the process area pumps would be shut down. The secondary containment ditches are designed for these maximum upset flows, direct precipitation, and an additional 2 feet of freeboard. The main ditch is designed to flow to the TSF by gravity for the first six years. After year six, gravity flow to the TSF is no longer possible because of the increased height of the TSF and upset flows will then discharge to the surge pond via gravity in a lined ditch through year 11.1. The alignment of the secondary containment ditches is shown on Drawings 2, 3, 10, 11, 12, 21, and 24 through 26. Details of the secondary containment ditches are provided in Drawing 29.

Surge pond cross sections and details are shown on Drawing 22. The surge pond liner system will consist of a liner bedding fill layer overlain with a minimum 60-mil HDPE geomembrane liner. The surge pond is located at an elevation of 5,340 feet and is sized for a surge retention time of half an hour with and additional reserve capacity of over one million gallons. The pond is sized for the retention of approximately 1,610,000 gallons of slurry with an additional 2 feet of freeboard. The use of the surge pond will be intermittent and temporary and the pond will be empty under normal operating conditions. The pond will be equipped with dedicated hard-wired pumps that will automatically evacuate its contents. Emergency power for the pumps will be provided by the emergency diesel power generation system located on-site in the event of a power outage. The process facility control room will be equipped with emergency alarms that notify the operator of an upset condition allowing the operator to make necessary adjustments in the process, as needed. The pumps at the surge pond will be automatically activated upon the pond reaching a predetermined level. Water and solids collected from the surge pond will be discharged through a 12-inch HDPE DR17 pipeline to the top of the TSF. The solids handling pump is designed to evacuate the surge pond within 12 hours.

# 11.0 TAILINGS DAM FOUNDATION SETTLEMENT POTENTIAL

## 11.1 Analysis Approach

The TSF will consist of an earthen starter dam constructed to a height of approximately 50 feet with the remainder of the dam constructed with sand recovered from the cyclone plant. A geotechnical investigation was performed in the embankment footprint, which included standard penetration testing and sample collection from the surface to a depth of 50 feet. Drilling indicated that in general, the tailings embankment foundation consists primarily of alluvial deposits that include silt, sand and gravel, which are underlain by clay.

Representative samples of the foundation strata were analyzed in Golder's geotechnical laboratory for index properties, gradation, and Atterberg limits. Selected samples were remolded in the laboratory, and the remolded samples were subjected to one-dimensional consolidation testing.

Settlement calculations were developed for the post-construction embankment, which represents the worst-case condition. Staged settlement was not analyzed because settlement of the embankment will be adequately mitigated by continuous fill placement during ongoing embankment construction. Settlement calculations were performed using the computer model SETTLE3D v. 2.0, a computer program developed by Rocscience, Inc., for the analysis of settlement and consolidation under foundations and embankments.

A detailed description of the settlement potential investigation, settlement calculations and supporting information are contained in Appendix I.1. Drill holes and the location of cross-sections used to evaluate subsurface conditions are shown on Drawing 3. Drawings 5 and 7 present geologic cross sections B-B' and D-D', respectively, which were developed to evaluate settlement perpendicular to the dam axis. The cross-sections also include information derived from the former geotechnical study conducted on behalf of Quintana by Sergent Hauskins and Beckwith (SHB, 1980). Drill hole logs are contained in Appendix A.2.

A differential settlement and geomembrane strain analysis was subsequently conducted by Golder and is included in Appendix I.2. Cross sections were developed to intercept the various geologic materials underlying the TSF site. The engineering properties of the foundation materials were derived from the 1980 Sargent, Hauskins and Beckwith (SHB) geotechnical study, the geotechnical investigation conducted as part of the TSF design report and experience with similar foundation materials.

## 11.2 Settlement Potential Analysis Results

Laboratory consolidation testing was conducted on remolded specimens of the fine fraction of samples recovered from the embankment foundation. As such, the settlement prediction does not account for the presence of the coarse fraction in the foundation soils, and associated inter-particle contact and support of foundation loads. Settlement predictions based on the laboratory consolidation tests are therefore conservative.

Results of the settlement potential analysis are shown graphically on geologic sections B-B’ and D-D’. The maximum calculated settlement beneath the embankment is approximately 2.1 feet in the area of the maximum dam (and tailings beach) foundation loads. Settlement decreases at a relatively uniform rate as the weight of post-construction loading decreases towards the outer toe of the embankment.

Settlement prediction based on the laboratory consolidation testing of the fine fraction of foundation samples is conservative. SPT testing conducted during drilling showed the foundation strata to generally be very dense to hard. On the basis of SPT test results, actual post-construction consolidation settlement of less than 1 foot is anticipated.

Dam construction will be more or less continuous during the life of the facility. The effects of foundation settlement include the potential for the loss of dry freeboard for stormwater storage. The potential loss of freeboard can be mitigated by elevating the dam crest with managed/targeted placement of cyclone underflow sand.

The analyses did not indicate the potential for differential settlement that could impact the integrity of the TSF geomembrane liner. Sections B-B’ and D-D’ indicate predicted settlement varies uniformly across areas subject to changing foundation loads.

The impoundment underdrain will pass beneath the dam in a steel pipe placed in a ditch backfilled with concrete near section F-F’ (Drawing 9). The settlement will not adversely impact the impoundment underdrain outlet pipe. There is adequate grade and elevation change along the outlet pipe alignment to accommodate predicted settlement.

A basalt outcrop identified by SHB (SHB, 1980) may lie beneath or in the vicinity of the impoundment underdrain pipe inlet near the upstream toe of the dam. The outcrop occurred in an area that was disturbed during Quintana dam construction activities, and was not observed during the recent site exploration. If the inlet to the underdrain pipe bears on basalt, local differential settlement could occur along the pipe alignment, which could induce stress on the outlet pipe. If, during construction, a basalt outcrop is identified at the location of the inlet, an alignment change may be warranted to avoid the pipe bearing on basalt.

It should be noted that the settlement potential investigation was performed for a previously completed design study, and evaluated an embankment geometry that differs from that presented in this report. The new embankment is higher and the depth of embankment fill overlying the foundation is greater for this 30,000 tons per day design; however, the original analyses assumed a higher, more conservative embankment moist unit weight of 130 pcf. Tailings testing completed after the settlement potential study was conducted indicates a post embankment fill placement moist unit weight of approximately 113 pcf. The foundation loads imposed by the higher embankment fill, when corrected for the moist unit weight determined by laboratory testing, are lower than those used in the settlement potential analysis. Therefore, the results of the settlement investigation presented above are conservative relative to the current design. As part of future detailed engineering studies, settlement calculations will be updated for final design conditions; however, the conclusions are anticipated to be consistent with those presented herein.

The results of the differential settlement and geomembrane strain analysis indicates that, in general, settlement potential across the TSF is predicted to be limited. As such, the potential for tearing of the HDPE liner due to potential differential settlement within the entire area of the TSF is considered to be low. The maximum settlement is estimated to be 0.72 feet, while the maximum tensile strain on the HDPE liner due to differential settlement is estimated to be 0.02 percent. The allowable tensile strain on an 80 mil HDPE geomembrane liner is 10 percent and the predicted tensile strain is well within acceptable conditions. Therefore, Golder does not expect tearing of the HDPE liner due to differential settlement to be an issue.

**APPENDIX I.1**
**SETTLEMENT POTENTIAL, COPPER FLAT TAILINGS EMBANKMENT FOUNDATION**

**APPENDIX I.2**
**SETTLEMENT & GEOMEMBRANE STRAIN ANALYSIS**

## SETTLEMENT & GEOMEMBRANE STRAIN ANALYSIS

Made By: JL
Checked by: GM
Reviewed by: MP

## 1.0 OBJECTIVE

Estimate the tensile strain caused by differential settlement of the in-situ subsurface materials inferred below the proposed Copper Flat tailing facility.

## 2.0 METHODOLOGY

The proposed geomembrane liner system may experience tensile strain because of differential settlement caused from the loading (tailings and embankment) of the subsurface soils.

### 2.1 Settlement Analysis

Settlement was calculated using the finite element software SigmaW from the 2012 GeoStudio package. Cross sections A and B (both shown in plan view on Figure 1 and in profile view in Figure 2) showing the proposed tailing facility and tailings embankment layout/dimensions, inferred subsurface soils and boundaries were imported into the software for analyses. Geotechnical properties for each subsurface material layer were selected from previous reports (Refs. 1 and 2) and from experience with similar soils. The geotechnical properties were incorporated into the software and used for the settlement analyses. Table 1 below provides a list of the geotechnical subsurface material layers and properties.

**Table 1: Geotechnical Subsurface Material Layers and Properties**

| Material No. | Material Name | Geotechnical Properties | | |
|---|---|---|---|---|
| | | Unit Weight ($lb/ft^3$) | Poisson's Ratio (-) | Effective Modulus ($lb/ft^2$) |
| 0 | Tailings/Embankment | 97 | 0.49 | 10,000,000 |
| 1 | Well-Graded Gravel | 110 | 0.30 | 4,000,000 |
| 2 | Well-Graded Sand with Silt and Gravel | 110 | 0.30 | 4,000,000 |
| 3 | Conglomerate | 130 | 0.30 | 5,000,000 |
| 4 | Basalt | 160 | 0.30 | 100,000,000 |
| 5 | Lean Clay, Fat Clay, Silty Clay | 104 | 0.30 | 790,600 |
| 6 | Silt | 106 | 0.30 | 671,400 |
| 7 | Caliche | 125 | 0.30 | 100,000,000 |
| 8 | Bedrock | 175 | 0.30 | 100,000,000 |

## 2.1 Tensile Strain from Differential Settlement

Settlement results from the SigmaW runs were used to calculate the induced strain in the geomembrane liner system along Cross Section A and B shown in Figure 1 and Figure 2.

The tensile strain of a base liner system caused by differential settlement can be estimated by the following equation:

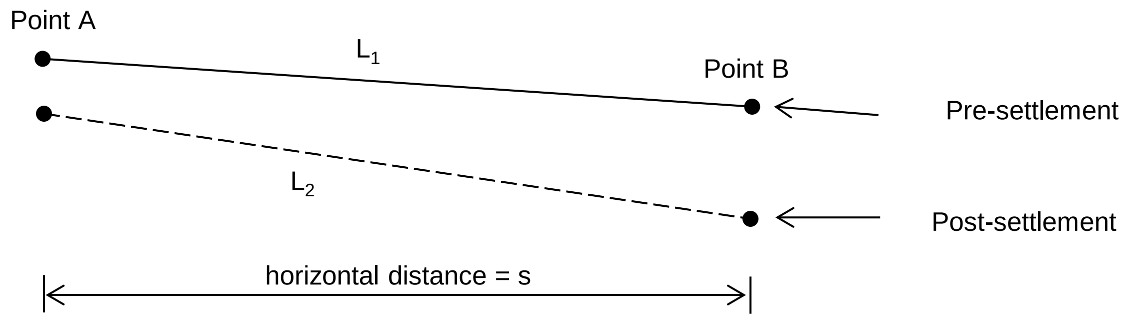



**Illustration: Liner Differential Settlement**

$$\varepsilon = \frac{L_2 - L_1}{L_1}$$

$$L = \sqrt{(Elev.A - Elev.B)^2 + s^2}$$

Where:
$\varepsilon$ = Tensile strain in liner system between Points A and B
$L_1$ = Distance between Points A and B, pre-settlement
$L_2$ = Distance between Points A and B, post-settlement
s = Horizontal distance between Points A and B

# 3.0 CALCULATIONS AND RESULTS

## 3.1 Tensile Strain from Differential Settlement

The settlement results for Cross Section A and Cross Section B are illustrated below. Points for liner strain evaluation were selected at locations where peaks or valleys were observed in the results. The liner strain evaluations due to differential settlement of the subsurface materials are summarized in Table 2 and Table 3.

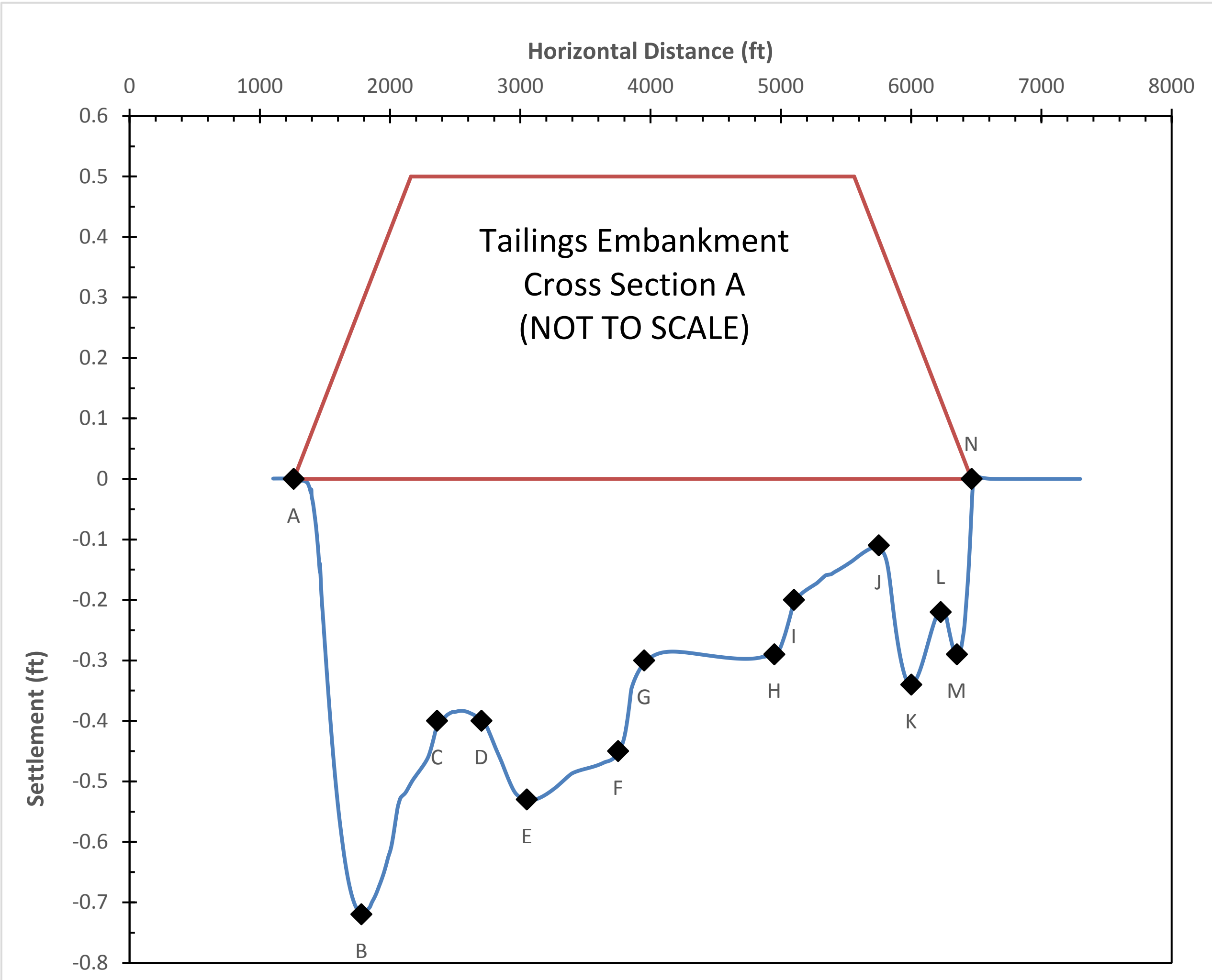



**Illustration: Settlement Profile - Cross Section A**
**(refer to Figure 2 for location along horizontal distance)**

**Table 2: Liner Integrity Analysis Results - Cross Section A**

| Points | Elevations: Pre-settlement, feet | Elevations: Post-settlement, feet | Settlement, feet | Horizontal Distance (s), feet | Pre-settlement Dist. ($L_1$), feet | Post-settlement Dist. ($L_2$), feet | Tensile Strain |
|---|---|---|---|---|---|---|---|
| A<br>B | 5383.4<br>5311.7 | 5383.4<br>5311.0 | 0.00<br>0.72 | 520.00 | 524.920 | 525.019 | 0.0188% |
| B<br>C | 5311.7<br>5275.5 | 5311.0<br>5275.1 | 0.72<br>0.40 | 580.00 | 581.129 | 581.109 | Under Compression |
| D<br>E | 5267.5<br>5251.8 | 5267.1<br>5251.3 | 0.40<br>0.53 | 350.00 | 350.352 | 350.358 | 0.0017% |
| E<br>F | 5251.8<br>5230.0 | 5251.3<br>5229.6 | 0.53<br>0.45 | 700.00 | 700.339 | 700.337 | Under Compression |
| F<br>G | 5230.0<br>5230.2 | 5229.6<br>5229.9 | 0.45<br>0.30 | 200.00 | 200.000 | 200.000 | 0.0001% |
| H<br>I | 5239.6<br>5197.3 | 5239.3<br>5197.1 | 0.29<br>0.20 | 150.00 | 155.850 | 155.826 | Under Compression |
| I<br>J | 5197.3<br>5185.2 | 5197.1<br>5185.1 | 0.20<br>0.11 | 650.00 | 650.113 | 650.111 | Under Compression |
| J<br>K | 5185.2<br>5180.4 | 5185.1<br>5180.1 | 0.11<br>0.34 | 250.00 | 250.046 | 250.051 | 0.0018% |
| K<br>L | 5180.4<br>5176.7 | 5180.1<br>5176.5 | 0.34<br>0.22 | 225.00 | 225.030 | 225.028 | Under Compression |
| L<br>M | 5176.7<br>5173.3 | 5176.5<br>5173.0 | 0.22<br>0.29 | 125.00 | 125.046 | 125.048 | 0.0015% |
| M<br>N | 5173.3<br>5168.5 | 5173.0<br>5168.5 | 0.29<br>0.00 | 113.00 | 113.102 | 113.090 | Under Compression |
| Maximum Tensile Strain due to Differential Settlement = | | | | | | | 0.0188% |

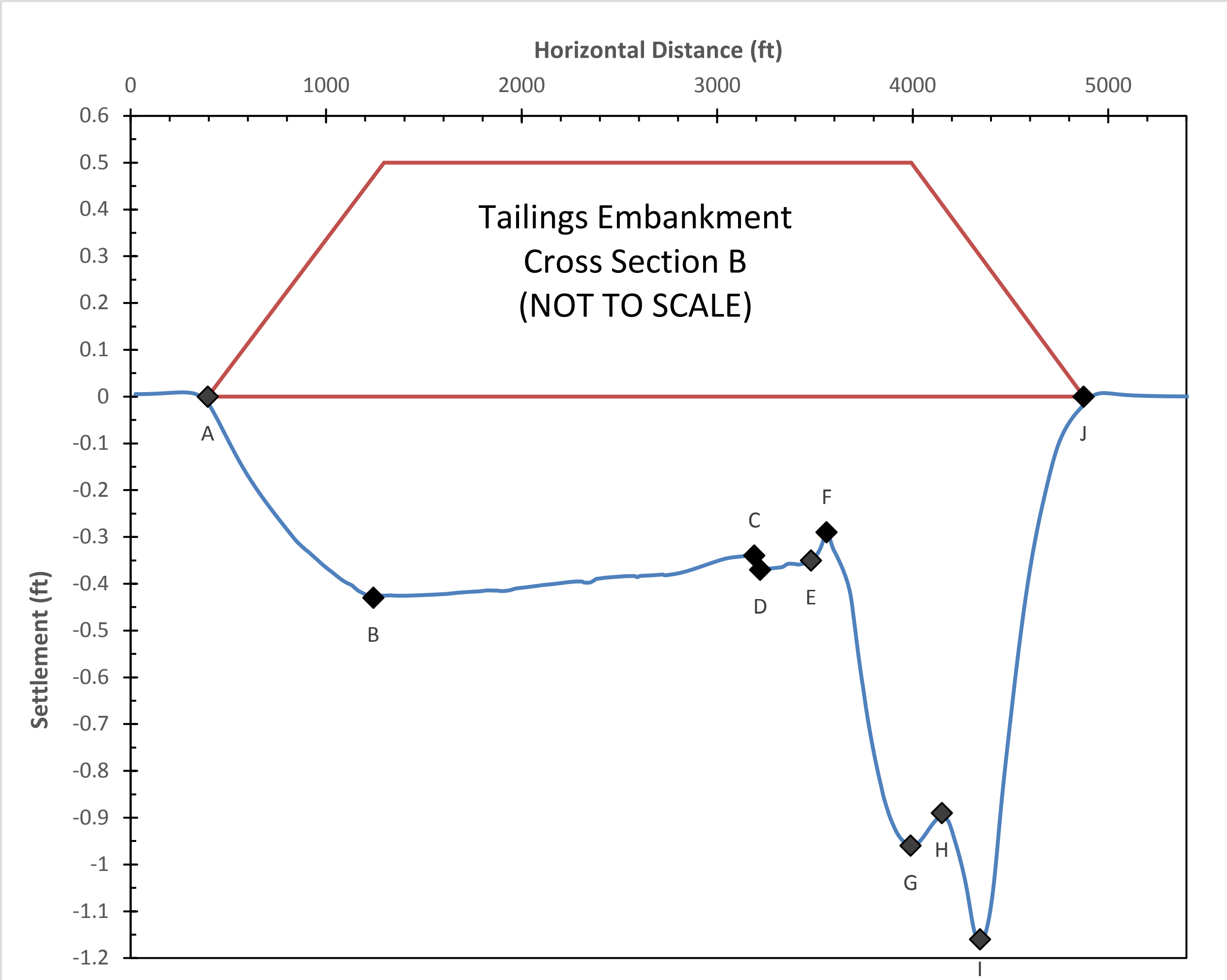



**Illustration: Settlement Profile - Cross Section B**
**(refer to Figure 2 for location along horizontal distance)**

**Table 3: Liner Integrity Analysis Results - Cross Section B**

| Points | Elevations | | Settlement, feet | Horizontal Distance (s), feet | Pre-settlement Dist. ($L_1$), feet | Post-settlement Dist. ($L_2$), feet | Tensile Strain |
|---|---|---|---|---|---|---|---|
| | Pre-settlement, feet | Post-settlement, feet | | | | | |
| A | 5280.2 | 5280.2 | 0.00 | 847.00 | 848.707 | 848.734 | 0.0032% |
| B | 5226.4 | 5226.0 | 0.43 | | | | |
| C | 5213.7 | 5213.4 | 0.34 | 30.00 | 34.000 | 33.986 | Under Compression |
| D | 5229.7 | 5229.3 | 0.37 | | | | |
| E | 5239.3 | 5239.0 | 0.35 | 79.00 | 83.716 | 83.696 | Under Compression |
| F | 5211.6 | 5211.3 | 0.29 | | | | |
| F | 52116.0 | 52115.7 | 0.29 | 430.00 | 46921.770 | 46922.440 | 0.0014% |
| G | 5196.2 | 5195.2 | 0.96 | | | | |
| G | 5196.2 | 5195.2 | 0.96 | 160.00 | 160.004 | 160.004 | 0.0003% |
| H | 5197.3 | 5196.4 | 0.89 | | | | |
| H | 5197.3 | 5196.4 | 0.89 | 195.00 | 195.004 | 195.003 | Under Compression |
| I | 5198.6 | 5197.4 | 1.16 | | | | |
| I | 5198.6 | 5197.4 | 1.16 | 530.00 | 530.000 | 530.003 | 0.0005% |
| J | 5199.3 | 5199.3 | 0.00 | | | | |
| Maximum Tensile Strain due to Differential Settlement = | | | | | | | 0.0032% |

## 4.0 DISCUSSION AND CONCLUSIONS

It is understood that the liner system will consist of HDPE 80 mil geomembrane liner between a liner bedding fill layer and tailings. The minimum allowable tensile strain for geomembrane is 10% (Refs. 3). Based on the analysis performed herein and available information at the time of this calculation, the estimated tensile strain along Cross Section A and Cross Section B are less then the allowable tensile strain. The allowable strain is presented in Table 4.

**Table 4: Summary of Allowable Liner Strains**

| Cross Section | Max. Tensile Strain from Differential Settlement | Liner Component | Allowable Tensile Strain | Tensile Strain less than Allowable? |
|---|---|---|---|---|
| A | 0.0188% | Geomembrane | 10% | Yes |
| B | 0.0032% | | | Yes |

The potential strain of the geomembrane liner system was analyzed for overall differential settlement along two cross sections (Cross Section A and B) within the proposed Copper Flat tailing facility. Based on the available information, experience with similar subsurface materials and conservative assumptions, the maximum liner strain is estimated to be 0.02%, from differential settlement which is less than the allowable strain for geomembrane liners.

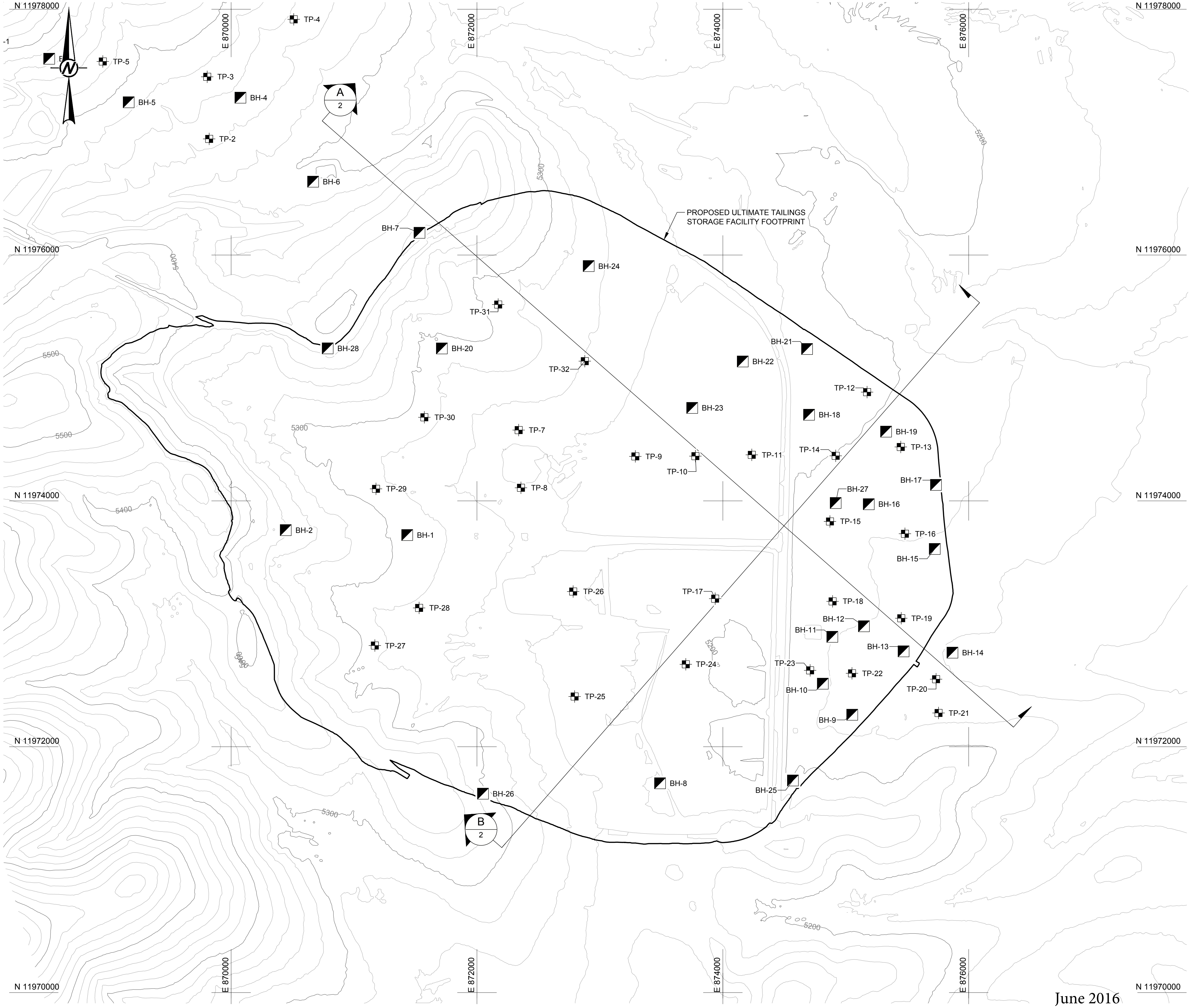
## 5.0 REFERENCES

1. - Golder 2013, Feasibility Study Copper Flat Project, Sierra County, New Mexico, Volume 1 - Tailings Storage Facility, report dated July 2013, Golder Project No. 103-92557.011
2. - SHB (Sergent, Hauskins and Beckwith), 1980. Tailings Dam and Disposal Area - Quintana Minerals Corporation - Copper Flats Project - Golddust, New Mexico. October 14, 1980
3. - Robert M. Koerner (2005) Designing with Geosynthetics, Fifth Edition, Pearson/Prentice Hall.

| **GeoStudio File Names** | **Description** |
|---|---|
| Full Cross Section A.gsz | Cross Section A Settlement Analysis |
| Full Cross Section B.gsz | Cross Section B Settlement Analysis |

### Attachments

Figure 1: Cross Section Location Plan
Figure 2: Geologic Cross Sections




**LEGEND**

| | |
|---|---|
| 3600 | EXISTING GROUND CONTOUR (ft -MSL) |
| BH-11 | HOLLOW STEM AUGER (HSA) BOREHOLE |
| TP-8 | TEST PIT |
| A / 2 | CROSS-SECTION CALLOUT<br>SECTION ID<br>DRAWING SHEET LOCATION |

0 250 500
1" = 500' FEET

June 2016

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PROJECT
COPPER FLAT

SIERRA COUNTY, NEW MEXICO

TITLE
**CROSS-SECTION LOCATION PLAN**

CONSULTANT
Golder Associates

| | |
|---|---|
| YYYY-MM-DD | 2016-05-11 |
| DESIGNED | JS |
| PREPARED | JHR |
| REVIEWED | JL |
| APPROVED | GM |

| PROJECT NO. | CONTROL | REV. | FIGURE |
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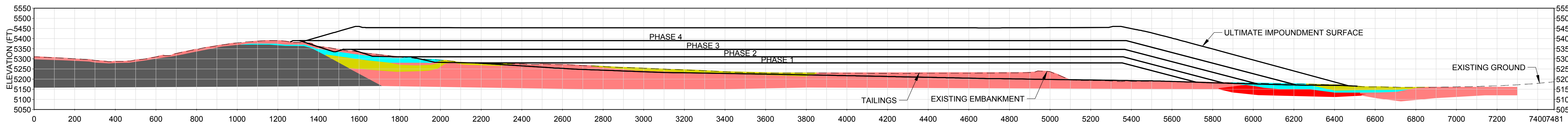
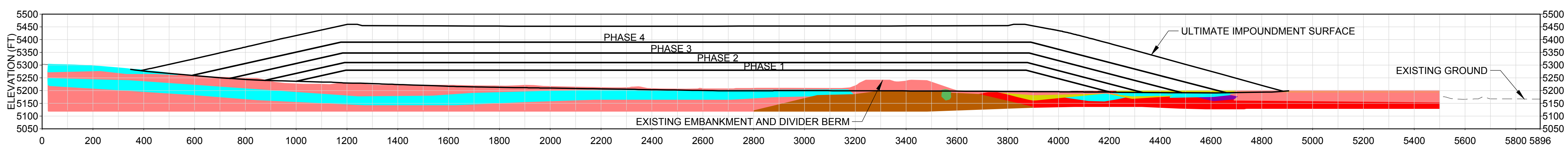



SCALE 1" = 500' (A / 2) CROSS-SECTION A




SCALE 1" = 500' (B / 2) CROSS-SECTION B

0 250 500
1" = 500' FEET

**LEGEND**

- WELL-GRADED GRAVEL
- WELL-GRADED SAND WITH SILT AND GRAVEL
- CONGLOMERATE
- BASALT
- LEAN CLAY, FAT CLAY, SILTY CLAY
- SILT
- CALICHE
- BEDROCK

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PROJECT
COPPER FLAT

SIERRA COUNTY, NEW MEXICO

TITLE
**GEOLOGIC CROSS-SECTIONS**

CONSULTANT
Golder Associates

| | |
|---|---|
| YYYY-MM-DD | 2016-05-11 |
| DESIGNED | JS |
| PREPARED | JHR |
| REVIEWED | JL |
| APPROVED | GM |

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 1531453 | 0001 | A | 2 |

June 2016

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