Appendix 2A
Waste Rock Management Plan
Midway Gold US Inc.  
Waste Rock Management Plan  

Pan Project  
Nevada  

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Project No: 100013  

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ATTACHMENTS

ATTACHMENT 1 - SUPPLEMENTAL WASTE ROCK CHARACTERIZATION PROGRAM FOR NORTH PIT PAN PROJECT
# ABBREVIATIONS AND ACRONYMS

**Glossary**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABA</td>
<td>Acid Base Accounting</td>
</tr>
<tr>
<td>AE</td>
<td>Actual Evaporation</td>
</tr>
<tr>
<td>AP</td>
<td>Acid Potential</td>
</tr>
<tr>
<td>ARD</td>
<td>Acid Rock Drainage</td>
</tr>
<tr>
<td>BLM</td>
<td>Bureau of Land Management</td>
</tr>
<tr>
<td>BMP</td>
<td>Best Management Practices</td>
</tr>
<tr>
<td>ET</td>
<td>Evapotranspiration</td>
</tr>
<tr>
<td>HCT</td>
<td>Humidity Cell Test</td>
</tr>
<tr>
<td>m</td>
<td>Meter</td>
</tr>
<tr>
<td>MAP</td>
<td>Mean Annual Precipitation</td>
</tr>
<tr>
<td>mg/L</td>
<td>Milligram per Liter</td>
</tr>
<tr>
<td>ML</td>
<td>Metals Leaching</td>
</tr>
<tr>
<td>MWMP</td>
<td>Meteoric Water Mobility Procedure</td>
</tr>
<tr>
<td>NAG pH</td>
<td>Net Acid Generation pH</td>
</tr>
<tr>
<td>NDEP</td>
<td>Nevada Department of Environmental Protection</td>
</tr>
<tr>
<td>NNP</td>
<td>Net Neutralization Potential</td>
</tr>
<tr>
<td>NP</td>
<td>Neutralization Potential</td>
</tr>
<tr>
<td>PAG</td>
<td>Potentially Acid Generating</td>
</tr>
<tr>
<td>UPAG</td>
<td>Unconfirmed PAG</td>
</tr>
<tr>
<td>PE</td>
<td>Potential Evaporation</td>
</tr>
<tr>
<td>T/kton</td>
<td>Tons per Kiloton (parts per thousand)</td>
</tr>
<tr>
<td>Ton</td>
<td>Short Ton</td>
</tr>
<tr>
<td>WRDA</td>
<td>Waste Rock Disposal Areas</td>
</tr>
<tr>
<td>yr</td>
<td>Year</td>
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</table>
1 INTRODUCTION

Midway Gold US Inc.’s (Midway) proposed Pan Project, located in White Pine County, Nevada (Figure 1) includes two proposed waste rock disposal areas (WRDA); the North WRDA and South WRDA. This report describes waste placement and management concepts and is intended to be read in the context of the Pan Project Plan of Operations and the Interim Baseline Geochemistry Report (Interralogic, 2012) to meet the requirements of IM-NV-2010-014 (BLM, 2010).
The objectives of this Plan are to:

- Describe the geochemistry of waste rock that will be placed in each area
- Describe the WRDA design and adaptive management concepts
- Describe the placement strategy for North and South WRDAs

## 2 MINE PLAN

The WRDAs and other mine facilities planned for the proposed Pan Project are shown in Figure 2. The facilities in the Pan Project area include:

- North Pan Pit
- South Pan Pit
- Four smaller satellite pits
  - Black Stallion Pit
  - North Syncline Pit
  - Syncline Pit
  - South Syncline Pit
- Leach pad (1) and process ponds (2)
- Waste rock disposal areas (2)
- Growth media stockpiles
- Mine office and related facilities
- Miscellaneous facilities including roads, power lines, transformers, substations, pipelines, and storm water management structures.

The detailed mine plan is provided in the Plan of Operations and involves the following general components:

- 13 years of open pit mining in two main pits and four satellite pits; The projected mine life of 13 years uses exploration data to support the first eight years of mine planning with concomitant waste rock placement and heap leach pad development; the remaining five years of mine planning were extrapolated using professional experience to estimate pit dimensions, ore and waste rock volumes, and waste rock characterization.
- Mining of South Pan Pit first then North Pan Pit
- Truck haulage of waste and ore from the pits to WRDAs and crusher, respectively
- Crushing and heap leaching of ore.
Figure 2 - Facilities Layout Plan
Closure of WRDAs is described in detail in the Reclamation Plan (Tetra Tech, 2012) and includes surface water control, soil cover, erosion control, and revegetation consistent with or exceeding industry best practices. A summary is provided in Section 6 below.

3 WASTE ROCK DISPOSAL AREA DESIGN

The following description was extracted from Tetra Tech (2012).

Waste rock will be placed in two WRDAs - the North WRDA and the South WRDA. Both WRDAs are located along the western perimeters of their respective pits. Waste rock will be placed by trucks into the WRDAs, which are expected to contain a well-graded mixture of sized material placed in lifts. Approximately 53 and 25 Mt of waste rock will be disposed of in the North and South WRDA, respectively. The estimated volume of the North WRDA (assuming 2 tons per loose cubic yard [LCY]) is approximately 26.5 million LCY and disturbs approximately 264 acres of land. The estimated volume of the South WRDA is approximately 22.5 million LCY and disturbs approximately 216 acres of land. The WRDAs will be constructed at or near the final grade depicted on Figures 3 and 4. Cross sections and measured slope gradients for the WRDAs are provided in Table 1 and shown on Figures 3 and 4.

<table>
<thead>
<tr>
<th>Slope Range</th>
<th>Existing Ground Area (Acres)</th>
<th>Planned Reclaimed Surface (Acres)</th>
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<tbody>
<tr>
<td>North WRDA Surface Slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal to 3.00:1</td>
<td>241</td>
<td>258</td>
</tr>
<tr>
<td>2.99:1 to 2.90:1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.89:1 to 2.50:1</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>2.49:1 to 2.00:1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>1.99:1 to Vertical</td>
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<tr>
<td>Total</td>
<td>264</td>
<td>264</td>
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<table>
<thead>
<tr>
<th>Slope Range</th>
<th>Existing Ground Area (Acres)</th>
<th>Planned Reclaimed Surface (Acres)</th>
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</thead>
<tbody>
<tr>
<td>South WRDA Surface Slope</td>
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<td></td>
</tr>
<tr>
<td>Horizontal to 3.00:1</td>
<td>203</td>
<td>212</td>
</tr>
<tr>
<td>2.99:1 to 2.90:1</td>
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<td>1</td>
</tr>
<tr>
<td>2.89:1 to 2.50:1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>2.49:1 to 2.00:1</td>
<td>5</td>
<td>0.4</td>
</tr>
<tr>
<td>1.99:1 to Vertical</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>216</td>
<td>216</td>
</tr>
</tbody>
</table>
Figure 3 - North WRDA Plan and Cross Section (Tetra Tech, 2012)

Figure 4 - South WRDA Plan and Cross Section (Tetra Tech, 2012)
4 WASTE ROCK GEOCHEMISTRY

4.1 SITE WIDE GEOCHEMISTRY SUMMARY

The geochemistry of waste rock and ore from the Pan Project pits is described in detail in Interralogic (2012) including historical data, sampling frequency and locations, and complete data sets. Table 2 summarizes the historical and current data collected for the project. The following is a summary of the geochemical characteristics of the Pan Project rock types.

The Pan deposit is hosted in gently folded Devonian-Mississippian aged marine limestone and siltstone of the Devils Gate and Pilot Shale formations. Gold occurs as sub-microscopic particles disseminated within the limestone and siltstones (Gustavson Associates, 2010). In addition to the Pilot Shale Formation and Devils Gate Formation, other dominant rock types at the project site include Solution Breccia and Volcanic Tuff. Alteration is primarily argillic and siliceous, with decalcification of the limestones.

The dominant rock types on site have been characterized to assess their acid-generating and metals-leaching potential. Tests have included the following:

- Acid base accounting (ABA) and LECO carbon and sulfur speciation analysis of approximately 600 drill-core pulp samples collected in 2007, 2008, and 2010.
- Confirmatory/validation testing of a subset of samples from the 2010 core drilling program for ABA parameters using the Nevada hot water rinse procedure.
- Whole rock analysis of approximately 380 pulp samples collected in 2007 and 2008; and
- Metals leaching tests using the meteoric water mobility procedure (MWMP) for 16 samples collected in 2010.
- Nine humidity cell tests covering all major waste rock types were completed in 2011/2012.
Waste Rock Management Plan

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Table 2 - Geochemical Data Sources and Sample Types

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Analyses</th>
<th>Method</th>
<th>Number of Samples</th>
<th>Number of Boreholes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/2008 Drilling Program</td>
<td>Total C</td>
<td>Leco (C-IR07)</td>
<td>597</td>
<td>72</td>
</tr>
<tr>
<td>ALS in Reno, NV</td>
<td>Org C</td>
<td>Leco (C-IR06)</td>
<td>597</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Total S</td>
<td>Leco (S-IR08)</td>
<td>597</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Sulfide S</td>
<td>Leco with sodium carbonate leach (S-IR07)</td>
<td>597</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>WRA</td>
<td>Aqua Regia + ICPMS analysis</td>
<td>381</td>
<td>68</td>
</tr>
<tr>
<td>2010 Drilling Program - Completed Analyses</td>
<td>Total C</td>
<td>Leco (C-IR07)</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>ALS in Reno, NV</td>
<td>Org C</td>
<td>Leco (C-IR06)</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Total S</td>
<td>Leco (S-IR08)</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Sulfide S</td>
<td>Leco with sodium carbonate leach (S-IR07)</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Sulfate S</td>
<td>S-GRA06</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Inorg C (CO2)</td>
<td>C-GAS05</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>SVL in Kellogg, ID</td>
<td>ABA</td>
<td>NDEP Mod. Sobek with Hot water Leach, NDEP Mod. Sobek with HCl leach, and NP with siderite correction</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>paste pH</td>
<td>ASA S</td>
<td>16</td>
</tr>
<tr>
<td>McClelland Laboratories in Sparks, NV</td>
<td>Metals Leaching</td>
<td>Meteoric Water Mobility Procedure (MWMP)</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Economic Geology Consulting in Reno, NV</td>
<td>Mineralogy</td>
<td>Petrographic (optical) mineralogy, XRD/XRF</td>
<td>16</td>
</tr>
<tr>
<td>ALS in Reno, NV</td>
<td>WRA</td>
<td>aqua regia + ICP-AES</td>
<td>1154</td>
<td>14</td>
</tr>
<tr>
<td>2010 Drilling Program - Analyses Underway</td>
<td>HCT</td>
<td>Weekly analysis of redox, pH, EC, SO4, acidity, Alk, tot Fe, Fe2+, and Fe3+; Profile II dissolved on weeks 0, 4, 8, 12, 16, and 20; tot rec on weeks 0, 8, and 20</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>McClelland Laboratories in Sparks, NV</td>
<td>C &amp; S speciation</td>
<td>Leco methods used previously</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>ALS-Chemex</td>
<td>4-acid digestion + ICP</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>WETLab in Sparks, NV</td>
<td>WETLab in Sparks, NV</td>
<td>paste conductivity</td>
<td>standard methods</td>
<td>9</td>
</tr>
<tr>
<td>Tommy Thompson Mineralogy</td>
<td>WRA</td>
<td></td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>SVL in Kellogg, ID</td>
<td>NAG</td>
<td>Single additional NAG</td>
<td>9</td>
<td>9</td>
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<tr>
<td></td>
<td>ABA</td>
<td>NDEP Mod. Sobek with Hot water Leach, NDEP Mod. Sobek with HCl leach, and NP with siderite correction</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>paste pH</td>
<td>standard methods</td>
<td>9</td>
</tr>
</tbody>
</table>

NOTES:
WRA: Whole Rock Analysis; HCT: Humidity Cell Tests; NAG: Net Acid Generation; ABA: Acid Base Accounting

The Nevada BLM guidance (BLM 2010) on waste rock and tailings materials characterization suggests that materials with a neutralization to acid potential ratio (NP:AP) less than 3 or a net neutralization potential (NNP) of less than 20 T/Kton as CaCO₃, be considered PAG. NDEP guidance considers samples with an NNP less than 20 T/Kton CaCO₃ or NP:AP less than 1.2 as PAG. Results of ABA testing indicate that the majority of waste rock samples (approximately 75 percent) are considered non-acid generating according to Nevada BLM criteria (having both a net neutralization potential (NNP) greater than 20 T/Kton CaCO₃, and a neutralization to acid potential (NP:AP) of greater than 3). Using the NDEP criteria (NP:AP < 1.2) the percentage of samples considered non-acid generating increases to 90 percent. The average sulfide sulfur content of the approximately 600 samples tested is 0.2 percent. Of the primary rock and alteration types, acid generating potential is highest for siliceous Breccia and argillic Tuff; although all potentially acid generating (PAG) materials tended to have low sulfide and low NP, suggesting low overall reactivity. Limonite altered shale also had a high percentage of
potentially acid-generating samples, however this is not a primary alteration type and only two samples of this type were analyzed. The low reactivity of the “PAG” samples was verified in the HCTs (detailed below) indicating that although some samples were categorized as “PAG”, these materials are not expected to generate acid when weathered and leached.

Results of MWMP testing suggest an overall low metals-leaching potential, with arsenic and thallium having some leaching potential of the parameters tested. MWMP tests use a 1:1 rock to water ratio on crushed rock, which is not appropriate for direct application to site-scale conditions in waste rock areas; results can either over or underestimate site concentrations depending on site climate, hydrology, and particle sizes. Seven of the 16 tested samples have MWMP test results for dissolved arsenic slightly above the Nevada reference value of 0.01 mg/L; all other sample rinsates were lower than the Nevada reference value. The average dissolved arsenic concentration for the 16 samples is approximately 0.02 mg/L. Dissolved thallium concentrations from the MWMP test are also above the Nevada reference value of 0.002 mg/L for four of the 16 samples with the remaining samples below the reference value. The average dissolved thallium concentration for the 16 samples is approximately 0.03 mg/L. For other parameters, dissolved concentrations were generally below their respective Nevada reference values, with two or fewer samples above the value. By rock type, Volcanic Tuff and Solution Breccia samples had the highest leached metals concentrations. Of the Solution Breccia samples, argillic alteration samples leached the highest total recoverable arsenic concentrations.

HCT results indicate that the waste rock at the Pan site will not be acid generating and that metals leaching will be limited to an initial flush at relatively low concentrations. None of the nine HCTs went acid; all stabilized with a circumneutral pH and low sulfate concentrations, indicating that the small amount of sulfides present in the samples was not oxidizing. So while the samples were categorized as PAG according to ABA data, actual leaching test data indicate the materials are not going to generate acid in the environment when exposed to air and water.

### 4.2 WASTE ROCK GEOCHEMISTRY

Tables 3 and 4 show the estimated breakdown of waste rock for the Pan Project based on the 13-year mine plan, by pit and lithologic/alteration types. In general, the North Pan Pit waste
rock has significantly less limestone than the South Pan Pit; the North Pan Pit waste rock is dominated by argillic Breccia, argillic Pilot Shale, and siliceous Breccia. The South Pan Pit waste is mostly argillic Breccia, argillic Devil’s Gate Limestone, and unaltered Devil’s Gate and Pilot Shale. The ABA data reflect this difference in limestone content; some of the materials from the North Pan Pit have low neutralization potential (NP) and therefore fall into the PAG category while nearly all South Pan Pit materials are highly calcareous and have a high NP.

ABA results for samples from the 2007/2008 and 2010 drilling program are summarized in Tables 3 and 4 for both pits. The average sulfide content of all 601 samples is approximately 0.2 percent, with a maximum sulfide content of 3.15 percent, which is for an ore sample of carbon-altered limestone. This results in a very low average acid potential (AP) of 5.9 ppt (as CaCO₃). NP values are high, with an average of 362 ppt (as CaCO₃).

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>Total %</th>
<th>Total Tons</th>
<th>Number of ABA Samples*</th>
<th>Number of WRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argillic Breccia</td>
<td>4.7%</td>
<td>10.6%</td>
<td>13.1%</td>
<td>13.3%</td>
<td>14.4%</td>
<td>10.8%</td>
<td>2,661,212</td>
<td>62</td>
<td>100</td>
</tr>
<tr>
<td>Argillic Devil's Gate Limestone</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.1%</td>
<td>9.5%</td>
<td>12.8%</td>
<td>1.9%</td>
<td>473,125</td>
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<td>1</td>
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<tr>
<td>Argillic Pilot Shale</td>
<td>17.1%</td>
<td>22.1%</td>
<td>25.2%</td>
<td>26.1%</td>
<td>5.4%</td>
<td>22.3%</td>
<td>5,517,811</td>
<td>2</td>
<td>25</td>
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<tr>
<td>Argillic Fault Zone</td>
<td>0.3%</td>
<td>1.7%</td>
<td>2.4%</td>
<td>1.9%</td>
<td>0.0%</td>
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<td>403,895</td>
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<td>Argillic Tertiary Volcanics</td>
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<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>5.0%</td>
<td>1,235,030</td>
<td>10</td>
<td>11</td>
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<td>Argillic Diamond Peak</td>
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<td>0.0%</td>
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<td>Argillic Ely Limestone</td>
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<td>0.2%</td>
<td>55,000</td>
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<td>Siliceous Breccia</td>
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<td>31.6%</td>
<td>33.1%</td>
<td>33.4%</td>
<td>61.3%</td>
<td>32.0%</td>
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<td>8.2%</td>
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<td>6.9%</td>
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<td>0.0%</td>
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<td>4,274</td>
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<td>Siliceous Fault Zone</td>
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<td>0.0%</td>
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<td>0.0%</td>
<td>0.4%</td>
<td>106,869</td>
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<td>Siliceous Tertiary Volcanics</td>
<td>1.9%</td>
<td>0.9%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.7%</td>
<td>163,663</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Devils Gate Limestone</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.6%</td>
<td>3.9%</td>
<td>0.2%</td>
<td>47,500</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Breccia</td>
<td>0.3%</td>
<td>2.3%</td>
<td>0.1%</td>
<td>0.1%</td>
<td>1.0%</td>
<td>0.9%</td>
<td>221,588</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Pilot Shale</td>
<td>1.2%</td>
<td>3.7%</td>
<td>0.3%</td>
<td>0.1%</td>
<td>0.2%</td>
<td>1.6%</td>
<td>389,296</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Fault Zone</td>
<td>1.4%</td>
<td>2.8%</td>
<td>6.3%</td>
<td>6.4%</td>
<td>4.0%</td>
<td>4.1%</td>
<td>1,012,555</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Diamond Peak</td>
<td>12.0%</td>
<td>12.8%</td>
<td>10.2%</td>
<td>1.6%</td>
<td>0.0%</td>
<td>9.7%</td>
<td>2,398,247</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Joanna Limestone</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>3,313</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Tertiary Volcanics</td>
<td>0.1%</td>
<td>1.5%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.5%</td>
<td>122,500</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

NOTES:
- Rock/Alteration types with total percentage greater than 10% are highlighted red.
- * For North Pit waste samples only; Count for breccia samples includes samples logged as solution breccia. Count for argillic samples includes samples logged as clay.

Of the 601 samples, 84 samples are considered PAG based on NDEP guidelines of NP:AP ratio less than 1.2. According to BLM guidelines (NV BLM, 2008, 2010), materials require additional testing to confirm the acid generation potential if either the NP:AP ratio is less than 3, or the NNP is less than 20. For the purposes of this document, samples in this category are
designated as “unconfirmed PAG” or “UPAG.” Based on BLM guidelines, 189 samples are UPAG.

Table 4 - Summary of Waste Rock Types and Sample Collection for the South Pan Pit

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>Total %</th>
<th>Total Tons</th>
<th>Number of ABA Samples*</th>
<th>Number of WRA Samples*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siliceous Breccia</td>
<td>0.7%</td>
<td>0.3%</td>
<td>0.5%</td>
<td>1.6%</td>
<td>0.6%</td>
<td>196,643</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Argillic Breccia</td>
<td>7.1%</td>
<td>11.3%</td>
<td>9.3%</td>
<td>14.8%</td>
<td>10.2%</td>
<td>3,352,122</td>
<td>53</td>
<td>95</td>
</tr>
<tr>
<td>Argillic Devils Gate Limestone</td>
<td>11.0%</td>
<td>18.2%</td>
<td>29.3%</td>
<td>41.8%</td>
<td>22.8%</td>
<td>7,455,625</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Argillic Pilot Shale</td>
<td>6.0%</td>
<td>8.7%</td>
<td>13.0%</td>
<td>1.8%</td>
<td>8.6%</td>
<td>2,819,316</td>
<td>23</td>
<td>39</td>
</tr>
<tr>
<td>Siliceous Devils Gate Limestone</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>5,497</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Devils Gate Limestone</td>
<td>50.5%</td>
<td>45.2%</td>
<td>41.8%</td>
<td>39.7%</td>
<td><strong>44.6%</strong></td>
<td>14,603,750</td>
<td>14</td>
<td>37</td>
</tr>
<tr>
<td>Breccia</td>
<td>3.1%</td>
<td>0.4%</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0.9%</td>
<td>282,540</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Pilot Shale</td>
<td>20.9%</td>
<td>15.8%</td>
<td>6.0%</td>
<td>0.0%</td>
<td><strong>12.1%</strong></td>
<td>3,955,494</td>
<td>4</td>
<td>38</td>
</tr>
<tr>
<td>Joanna Limestone</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>1,250</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Tertiary Volcanics</td>
<td>0.6%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.1%</td>
<td>37,870</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

NOTES:
- Rock/Alteration types with total percentage greater than 10% are highlighted red.
- * For South Pit waste samples only; Count for breccia samples includes samples logged as solution breccia and hydrothermal breccia. Count for argillic samples includes samples logged as clay.

Figure 5 presents a scatter plot of NP vs. AP for all samples broken down by waste/ore and by pit area, and Figure 6 presents a histogram of NNPs. The scatter plots show clearly the excess NP compared to AP in nearly all samples with the only PAG designated samples plotting near the origin (i.e., low NP and low AP). The histograms indicate show two peaks; one at high NNP (non acid generating) and another near zero NNP. The near-zero NNP data represent those samples with both low NP and low AP which are low-reactivity materials as shown by the HCT results. As highlighted in yellow on Figure 7, the majority of these UPAG waste rock samples have low total sulfur (less than 1.5 percent). These UPAG samples are generally relatively inert, having low AP and low NP. This is supported by the HCT results, which show these UPAG materials do not generate acid upon exposure to air and water.

As shown in Table 5 and Figure 5, the North Pan Pit area has more UPAG samples than the South Pan Pit. This result is expected, as limestone is more prevalent in the South Pan Pit area. Approximately 68 percent of the waste rock from the South Pan Pit is limestone, compared to 2 percent from the North Pan Pit.
Figure 5 - NP:AP Scatter Plots

All Samples
Waste Rock and Ore

All Samples
North Pit and South Pit

Figure 5 - NP:AP Scatter Plots
All Samples

Net Neutralization Potential

<table>
<thead>
<tr>
<th>Percentage of Samples in Range</th>
<th>Number of Samples in Range</th>
</tr>
</thead>
</table>

Waste Rock and Ore

Net Neutralization Potential

<table>
<thead>
<tr>
<th>Percentage of Samples in Range</th>
<th>Number of Samples in Range</th>
</tr>
</thead>
</table>

Figure 6 - NNP Histograms
Figure 7 - Total Sulfur, ABA Scatter Plots
The following observations regarding acid rock drainage (ARD) and metals leaching (ML) potential were derived from statistics developed on the total number of historical samples by rock type and location (North or South Pan Pit). Considering the relatively high number of ABA samples and the representative distribution of samples, this approach is considered representative of the bulk of the waste rock for this phase of the project. The sample distribution will likely be refined using the block model as it is updated with the most recent data.

South Pan Pit Waste Rock Characteristics:

- Very low sulfur content (average sulfide sulfur less than 0.1 percent)
- Only 2 out of 169 samples were categorized as PAG according to NDEP guidelines and 18 out of 169 according to BLM guidelines.
- The average NP value is very high (600 T/1000T CaCO₃) due to the high percentage of limestone present in the South Pan Pit.
- ML potential is low according to HCT and MWMP testing; about half of the waste rock consists of Devil’s Gate Limestone which showed no exceedances of Nevada reference standards in the MWMP tests.
- The remaining waste rock indicated low ML with low-level exceedances by some metals including arsenic (0.019 to 0.039 mg/L) of the Nevada reference standards in the MWMP test.
North Pan Pit Waste Rock Characteristics:

- Low sulfur content (average sulfide sulfur less than 0.3 percent) indicating low levels of potential reactivity.
- 40 out of 182 samples (22 percent) were categorized as PAG according to NDEP guidelines and 85 out of 182 (47 percent) according to BLM guidelines. The majority of the waste rock is not expected to have a high potential for acid generation and metal leaching due to low sulfide sulfur content (average of 0.44 percent) and are not expected to generate significant acidity and sulfate upon weathering. This expectation is supported by results from the humidity cell testing that indicate neutral pH conditions and low to moderate metal leaching rates.
- The overall average NP of waste rock samples is high (215 T/1000T as CaCO₃) due to the high percentage of limestone and other carbonate-rich rocks present in the North Pan Pit waste rock.
- ML potential is low according to MWMP and HCT results; the siliceous Breccia, comprising about a third of all waste rock in the North Pan Pit, showed no exceedances of Nevada references standards in the MWMP.
- The remaining waste rock indicated low ML with low-level exceedance by some metals including arsenic (0.02 to 0.034 mg/L) of the Nevada reference standards in the MWMP test.

5 PAN SITE WASTE ROCK MANAGEMENT

The following site characteristics present opportunities to manage waste rock such that potential impacts are minimized:

- very thick (> 600 ft) vadose zone beneath the site
- low reactivity and low ML potential of the waste rock
- high net evaporation climate
- presence of abundant high-carbonate material on site

The following waste rock management strategy incorporates these site-specific conditions to the extent possible to protect the environment and provide long-term storage of generated waste rock.
5.1 WASTE ROCK MANAGEMENT PLAN

Although some mining of construction materials will occur initially from the North Pan Pit, the mine plan indicates full scale mining of the South Pan Pit first, with the majority of this material being good quality rock with very high neutralizing potential and moderate to low ML potential. Full scale mining of the North Pan Pit will be mined second, approximately 4 to 8 years after the start of mining in the South Pan Pit, with the majority of the material also being good quality (low ARD and low ML potential). However, ABA data suggest some low sulfur material that also has low NP has the potential to generate low levels of sulfate, although acidic conditions were not observed based on humidity cell tests. Neutral pH leaching of arsenic and thallium does occur but at low rates and continued to decrease through time in humidity cell test results.

Waste rock management involves the following components for both the North and South WRDA:

- Run-of-mine placement of waste rock using haul trucks on prepared (cleared and grubbed) subgrade
- Concurrent reclamation of WRDAs to limit exposure of open disposal areas to the environment
- Closure of the WRDAs in a geomorphic design to enhance runoff similar to pre-mining natural conditions
- Capping the WRDAs with a growth medium layer capable of sustaining a vegetative cover.
- The growth medium layer characteristics include:
  - Good quality, local growth medium to sustain a plant community including grasses and shrubs with deep rooting depths;
  - Thickness between 12 and 14 inches to support a plant community, provide sufficient material to self-armored slopes and prevent erosion, enhance runoff and limit infiltration.

Existing data do not indicate the need for rigorous selective handling such as active blending or encapsulation other than the PAG designated areas of the North WRDA, if necessary. All geochemistry data to date (including humidity cell testing results) suggest no actual acid
generation by any samples, including those designated as PAG from acid-base accounting results; however, if future humidity cell test results indicate ARD and/or significant ML potential in localized zones of the waste rock, the block model will be refined to the extent possible to identify problematic waste rock zones. If zones are in manageable “blocks”, these zones could be targeted for operational identification (i.e., blast hole sampling and on-site analysis) and placement in PAG areas. If however, future testing indicates negligible acid generation of these North Pan Pit waste rock materials, all material would be placed in a comingled (e.g., run of mine) manner with confirmatory operational sampling and analysis.

5.2 ADAPTIVE MANAGEMENT PLAN

The existing data indicate that the North Pan Pit waste rock is not acid generating. However, before the North Pan Pit is mined, a supplemental waste rock characterization plan will be implemented with a focus on the North Pan Pit waste rock that has low NP. This supplemental plan is presented in Attachment 1 and describes generally sample selection, sampling, analysis, and interpretation. The purpose of the program is to build on, and verify, previous findings regarding the low NP waste material. Between 5 and 10 samples will be selected for rigorous testing consisting of the following:

- Static testing
  - Acid base accounting
  - Whole rock chemistry
  - Mineralogy (XRD and optical)
  - MWMP
- Humidity cell testing

Test results will be evaluated to determine the potential for acid generation and metals leaching. If present, the PAG material type will be identified in the geologic/block model for the mine and a determination will be made as to the possibility of identifying and handling that material as a discrete block (i.e., it is present in sufficient concentration and quantities to be identified and marked as part of the mining operation). This process will be conducted in communication with NDEP and BLM, as required.
If the above criteria are met and material is identified for selective handling, the following components will be added to the North WRDA:

- Designation of an area within the North WRDA for targeted placement of PAG material (i.e., PAG cell).
- Conducting an attenuation study of soils beneath and/or downgradient of the North WRDA.
- Mechanized spreading (e.g., using bulldozers) of any PAG material in the designated PAG cell(s) from the North Pan Pit to reduce vertical accumulation of this material in concentrated areas. This will limit contact by any infiltration migrating vertically through the waste rock.
- A 2.5-foot thick, good quality (e.g., non ARD, non ML), run-of-mine high-carbonate material layer under the topsoil cover layer in the designated PAG area with the following purposes:
  - To minimize seepage into the PAG area. For additional information on cover design and thickness, refer to Dwyer (2012).
  - To enhance the alkalinity of any seepage that percolates through the soil layer by dissolution of carbonate minerals
  - To provide a good quality (i.e., non-toxic) substrate for the soil layer and vegetation such that rooting depths will be enhanced (i.e., roots can grow into the high-carbonate rock below).

### 5.3 OPERATIONAL WASTE ROCK SAMPLING AND ANALYSIS

#### 5.3.1 QUARTERLY MONITORING

Grab samples of waste rock will be collected quarterly of each major rock type encountered. Samples will be submitted for MWMP and ABA testing.

#### 5.3.2 BLAST HOLE SAMPLING AND ANALYSIS

The ore production rate for the Pan Mine is planned to be 17,000 short tons (tons) per day. The average, life-of-mine waste production rate is 29,000 tons per day. For short durations, the combined ore and waste production may be as high as 64,000 tons per day.
A simple grade control system will be utilized to insure that ore and waste reach their appropriate destinations. Rock with a gold content of above economic quantities will be placed on a leach pad. All other rock being removed to access the ore will be placed in one of two WRDAs. Waste rock will be placed based upon assay analysis of drill cuttings from blast holes and geologic interpretation.

Preliminary blast design calculations utilizing 20-foot benches and 6-inch diameter blast holes indicate that each blast hole will break loose close to 400 tons of rock. Each hole will also produce about 750 pounds of drill cuttings that may be tested to represent the blasted rock from the hole. Normally only a very small, but representative, portion of the cuttings is used for testing the gold content needed for grade control.

The grade control procedure will start with surveying and marking the locations of blast holes. Wooden stakes with two identical bar code tags will be placed by a surveyor at the proposed collar locations of every planned blast hole. The associated bar code numbers will also be placed in a database with the surveyed coordinates for each hole.

During the drilling of a blast hole, cuttings will be pneumatically transported to a mechanical splitter contained on the drill. A small but representative sample of the cuttings is placed into a sample bag as the drilling progresses. After a hole is complete, one of the bar code tags is attached to the sample bag. The other bar-code tag is attached to a wooden stake which is driven into the ground next to the completed blast hole. The sample bag of cuttings may be placed next to the blast hole and collected a short time thereafter by a grade control geologist. Every blast hole will be sampled for its gold content.

All blast hole samples will be transported to an on-site assay testing facility. At the facility, the sample bar codes will be scanned. The samples will then be completely crushed, mixed and a small portion extracted. The small split will then be pulverized and subjected to a hot cyanide shake test to determine its soluble gold content. If the gold content is found to be above an appropriate cut-off grade, a portion of the sample may be additionally tested by a fire assay with an atomic absorption finish to determine its total gold content. All results will be placed in a database with assigned bar-code tracking numbers and hole collar coordinates.
The blast hole database and geologic interpretation provided by the grade control geologist will be used to define the boundaries of ore and waste. Spatial assay data from the database is used to mathematically determine the gold content of portions of a bench. Such interpolation methods as kriging or inverse distance may be applied in the determination. The boundaries of ore and waste will be further defined by incorporating observed geologic characteristics such as the rock type and alteration. The grade control geologist will provide a map with grade boundaries to surveyors. The surveyors will use the map to place wooden stakes into the broken rock after it is blasted. The staked boundaries will then be used to determine the destination of the broken rock after it is loaded into haul trucks. Ore and waste will have identifiable stakes.

The waste rock generated from the South Pan Pit has been shown to be benign from an acid generation/metal leaching standpoint. No selective handling is required for this material and therefore no additional blast hole sampling is planned for additional, on-site geochemical evaluation. Waste rock will be placed in the South WRDA as received directly from the blast area.

In the case of the North Pan Pit, the adaptive management plan may require selective handling of a subset of the material depending on the results of the confirmatory geochemical testing planned for the “inert” waste rock from the North Pan Pit. Testing is planned to verify material is inert and does not warrant selective handling and placement in PAG cells. If material is identified that is not inert, additional, waste rock blast hole sampling and analysis will be conducted to identify this material.

The additional waste rock blast hole sampling/analysis will be done on composites from a minimum of 10 percent of the blast holes identified to be within waste rock. Intra- and/or inter-hole composites may be made depending on the size and type of the waste rock zone. Samples will be tested to identify the PAG material either at the on-site assay laboratory and/or an off-site commercial laboratory. Midway will select appropriate testing methods for the PAG material, if it is identified in the confirmatory testing program. Typical tests for operational waste handling include:
6 WASTE ROCK DISPOSAL AREA MONITORING

The WRDAs will be visually inspected a minimum of once per year immediately after the spring melt/runoff period, and additionally within one to two weeks after storm events equal to or greater than the 25-year, 24-hours event. Any seeps will be identified, coordinates noted, and described in terms of flow rate estimate, and color or unusual character. If the flow rate is sufficient, a water sample will be collected and sent for Profile I analysis. If Nevada reference values are exceeded, a plan will be developed to minimize potential seepage and consequent impacts to ground water, including but not limited to the following possible actions:

- elimination of ponding on the dump surface to promote runoff and minimize infiltration and seepage,
- creating new and/or deepening existing upstream surface water diversion ditches to better intercept shallow groundwater flux and reduce seepage,
- concurrent reclamation of the source area to maximize in-situ (i.e., on dump) surface losses via runoff and/or vegetation transpiration,
- collection and pumping of seepage water into the mill circuit for make-up water use during operations, and
- longer term closure management via evaporation from an evaporation or evapotranspiration cell.

7 WASTE ROCK DISPOSAL AREA CLOSURE STRATEGY

This section summarizes the closure of the WRDAs. Additional detail can be found in Tetra Tech (2012). The following components comprise the WRDA closure at Pan:

- Diversion channels will be constructed up-gradient of the WRDAs to divert and safely pass flows from the 100-year, 24-hour storm event.
• WRDAs will be constructed at final grade, the majority of which will be reclaimed concurrently during the production period.
• Concurrent reclamation of the WRDAs will provide opportunities to improve reclamation practices over the course of the mine-life.
• As designed, the WRDAs will be constructed to achieve an overall stable hydrologic configuration over time by creating macrotopographic variability (ridges and swales) to improve the distribution of surface runoff and create “natural” channel morphology for the rapid conveyance of runoff from the surface of the WRDAs. This design approach is often referred to as “geomorphic” design.
• The final surfaces on the WRDAs are designed to:
  o Promote rapid conveyance of stormwater;
  o Prevent surface ponding;
  o Disperse rather than concentrate runoff;
  o Promote long-term stability over time and limit erosion and channel scour; and
  o Promote establishment of perennial, self-sustaining and diverse vegetation communities that contain deep rooted and drought tolerant species.
• A soil cover will be installed on the surface of the WRDAs to reduce percolation of precipitation into the waste rock. The cover includes a single-layer cover that balances the percolation of meteoric waters through the cover with the water storage necessary to establish vegetation, while avoiding exposure of mine waste due to erosion. The thickness of the soil cover will vary according to landscape and physiographic position but is expected to be 12- to 14-inches thick, subject to future refinement.
• Approximately one million cubic yards of soil will be removed and directly placed (without stockpiling) and redistributed on portions of the contoured WRDAs (live handling soil). Live handling soil is commonly recognized as a means of encouraging rapid volunteer plant growth, by minimizing the loss of seed, vegetative and microbial propagule viability.
• Soil surfaces will be roughened (surface pitting and roughening, dozer basins, discontinuous contour furrows) at the time of concurrent and final reclamation to reduce/attenuate runoff volumes, slope lengths and gradients, and provide for “intracatchment” sediment retention.
• Three different seed mixtures and sagebrush seedlings will be applied to the WRDAs following redistribution of the soil cover according to aspect, elevation and the level of long-term erosion control needed. The seed mixtures are composed of native grass,
and herbaceous and woody shrub species that are adapted to the substrate conditions and climate.

- Erosion and sediment control best management practices (BMPs) will be maintained from immediately prior to surface disturbance through final bond release.

HCT results indicate that PAG materials are not reactive and may not require special handling. The South WRDA material is not expected to contain significant quantities of PAG rock. The material will be dominated by limestone (about 70 percent) and will not require special handling. The North WRDA has non-PAG material and possibly some PAG material. An adaptive approach will be followed to determine the need for selective handling and placement of this material in a designated PAG cell within the North WRDA (described above). As this facility is not planned to be constructed until at least the 4th year of active mining, more than sufficient time is available for this approach.

The soil growth medium component of the cover on both the North and South WRDAs is designed to provide for good vegetation growth, enhanced runoff, evapotranspiration, and to reduce deep infiltration. The cover design (described fully in Tetra Tech, 2012) relied on optimizing the soil layer thickness based on evapotranspiration, self-armoring, vegetation requirements, and erosion considerations. Detailed soil surveys (Tetra Tech, 2012) indicate there is sufficient on-site material suitable for a soil cover that meets these design requirements. Detailed hydrological testing of on-site soils is underway and will form the basis of cover modeling to refine the cover design, if necessary.

Observations at Copper Basin (Pers. Comm., Sauer, 2011) indicate that roots readily extend into the waste rock below if waste rock does not contain toxic levels of metals thereby enhancing evapotranspiration. In the case of Pan, run-of-mine waste rock is generally good quality with relatively low metals content and will be suitable for a base for the soil cover. These materials will allow roots to develop below the soil layer into underlying materials thereby enhancing evapotranspiration and maintaining a healthy and sustainable plant community.
8 REFERENCES


ATTACHMENT
Attachment 1

Supplemental Waste Rock Characterization Program for the North Pit Phase of the Pan Mine Project

The objective of the supplemental waste rock characterization program is to gather additional information about the waste rock to be generated from the North Pan Pit of the Pan Project. It is expected that additional mine plan, drill hole data, geologic model information and block model development will be available by the time this plan is to be finalized. This preliminary plan lays out the general strategy and testing to be conducted and it is anticipated that it will be adjusted for additional data gathered in the interim to best characterize the unconfirmed potentially acid generating (PAG) material.

Data will be used to identify unconfirmed PAG waste rock in that pit area with the goal of informing the adaptive management plan for waste rock management. The initial phase of baseline geochemical characterization indicated that the North Pan Pit was not acid generating in humidity cell tests (HCTs) despite acid-base accounting (ABA) data that suggested there may be some PAG material present. Samples will be targeted and selected from core archives that are considered to be unconfirmed PAG or marginally PAG material according to standard acid base accounting static test result.

1 SAMPLING AND ANALYSIS STRATEGY

Samples will be collected from the North Pan Pit with focus on materials that have exhibited low neutralization potential (NP) and with an NP to acid generation potential (AP) of less than 3:1. The goal would be to define which, if any, materials generate acidic drainage upon weathering in HCTs. If any materials are found to generate acidic drainage, the secondary objective would include identifying a simple (e.g., static) test protocol that can be used operationally to identify this material during mining such that it can be selectively handled, as appropriate.

Analytical work will comply with Nevada BLM IM guidelines (2010) and will include, at a minimum the following tests:
• Whole rock elemental analysis
• ABA including NAG and paste pH
• HCT
• Optical mineralogy and x-ray diffraction (XRD) mineralogy

In some cases, these tests may have already been conducted and are available in the existing database.

2 SAMPLE COLLECTION AND PREPARATION

Five to 10 samples will be selected primarily based on ABA characteristics to target those materials that were identified in the baseline geochemistry program as PAG according to static test interpretative cutoff values. That is, those materials with an NP:AP of less than 3:1 and/or a net neutralizing potential (NNP) of less than 20. As appropriate, lithology, alteration, geochemistry, spatial position (laterally and with depth), and mining phase will also be considered and sampled.

Standard QA/QC for the chemical analysis will be conducted by the laboratory. Compositing of samples is to be avoided whenever possible. Because these samples are to be tested in humidity cells, core samples are preferable for these analyses.

Samples will be assigned specific identifiers in addition to the unique sample identification number which will be labeled on each sample. The minimum amount of sample will be 2 kg to be crushed and split at the laboratory using standard crushing and splitting protocols. It is important that samples are not contaminated by other material during crushing and splitting. All crushing, sieving and splitting equipment must be air or water cleaned between samples, as necessary to avoid cross-contamination.

3 GEOCHEMICAL TESTS

Geochemical testing involves paste and NAG pH, ABA (including siderite correction, as necessary), multi-element chemistry, humidity cell testing, and mineralogy. These are described briefly in the following sub-sections.
3.1 PASTE PH

Paste pH data provide a qualitative estimate of the pH of a lixiviant, such as rainwater, on initial contact with reactive rock material or weathered detritus. Because of the short solid-solution reaction time accommodated by the test, paste-pH data reflect the net acid-generation/consumption potential of readily hydrolyzed mineral phases only. Typically, these include carbonates and sulfate salt weathering products.

3.2 ACID-BASE ACCOUNTING

Acid-base accounting is an industry-standard procedure for appraising the acid generation (or acid consumption) potential of rock and soils. The procedure involves the assessment of two parameters:

- neutralization potential (NP), and
- acid generation potential (AP).

These parameters are subsequently used to calculate interpretive indices, including NNP as the difference between the values, and NP:AP ratios.

Neutralizing potential (NP)

Values of NP indicate the capacity of rock materials to buffer acidity produced by sulfide oxidation or other proton generating reactions. The determination of NP values for all samples will follow the modified EPA Sobek protocol (Sobek, et al., 1978). A volume of 1:3 HCl will be applied to a 2 gram sample of crushed rock and agitated until any ‘fizzing’ reaction ceases. Approximately 125 ml of H₂O will be added and the sample allowed to rest for 24 hours to degas any dissolved CO₂. The resultant solution will be subsequently back-titrated with NaOH to a pH of 8.3. An NP value will then be calculated based upon the normality of the acid and base applied, and the mass of sample. All results will be normalized to CaCO₃ (equivalent) per 1,000 tons of rock.
Additionally, a correction will be employed to correct for the presence of siderite in the sample which artificially increases the NP value if not corrected. The correction is based on Skousen et al. (1997). This method involves boiling a 2 gram sample in HCl for 5 minutes, and then filtering the material. The filtrate is then added to a 30 percent peroxide solution and boiled for 5 minutes to drive the oxidation of ferrous to ferric iron. The solution is then titrated to determine the calcium carbonate equivalent for the acid consumed during the test, and the results will be normalized to the conventional unit of tons CaCO$_3$ (equivalent) per 1,000 tons of rock, as with the Sobek test.

The NP of the material may also be calculated based on the total inorganic carbon (TIC) content of the sample. TIC content is determined in the laboratory as the difference between the total carbon content and the total organic carbon (TOC) content. Total carbon is measured using the standard LECO furnace method (ASTM 2011). For TOC determination, inorganic carbon must be removed from the samples by bathing the samples in 2N HCl for 24 hours, followed by rinsing and centrifuging. The sample is then analyzed for TOC using the LECO furnace method. The difference between total carbon and TOC is the TIC content of the material. The NP is calculated based on the TIC, and converted to standard units of tons CaCO$_3$ per 1,000 tons of rock.

**Acid generation potential (AP)**

Numerous procedures exist for the determination of AP. All include the derivation of a sulfur value, which can be assigned to sulfide within the sample matrix. The potential acid yield is calculated in accordance with the stoichiometry of pyrite oxidation. Options for the derivation of an appropriate sulfur value include:

- the assignment of all sulfur within a sample to stoichiometric pyrite;
- the analytical differentiation of sulfide sulfur from other sulfur species, and assignment of the former to stoichiometric pyrite; and
- the mineralogical determination of pyrite sulfur.

A modification of the Sobek et al. (1978) method, involving the use of sulfide sulfur for AP calculation, is most commonly used industry wide. This procedure can, however, be considered
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conservative with respect to samples which hold a significant component of sulfide sulfur in non-pyrite phases and insoluble sulfate phases such as barite.

For all samples, total sulfur will be determined using a LECO induction furnace (EPA method 600). If sulfur is detected, then sulfur speciation will be conducted following the US-EPA method 600, hot water leach, and sodium carbonate leach.

Method 600 is a sequential leach in which sulfate and sulfide sulfur are differentiated on the basis of their respective solubilities in HCl and HNO₃. The hot water leach includes a parallel extraction using hot water, HCl, and HNO₃ (Schafer and Associates, 1987).

The carbonate leach procedure dissolves sulfate more completely than the HCl leach to include barite and alunite. With this procedure, a prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and calculated as %S (of total sulfate) in the original sample.

Values of AP will be calculated for samples using (a) total sulfur and (b) sulfide sulfur data. All results will be converted to ton equivalents of CaCO₃ per 1,000 tons, using a conversion of 31.25 (e.g., moles of calcite required to neutralize acid liberated by 1 mole of oxidized pyrite).

Analysis will also include the single addition NAG pH procedure. This test is intended to predict if a sample will generate acid and resolve uncertainties in ABA approaches (Miller, et al. 1995). The single addition NAG test involves a single addition of 250 ml of 15% H₂O₂ to a 2.5 g of pulverised (less than 75 μm) sample. The sample is allowed to react overnight. The entire sample is heated until gently bubbling for approximately 1-2 hours to remove excess H₂O₂ and encourage release of inherent neutralising capacity. Once the sample has cooled to room temperature, the pH and titrated acidity to pH 4.5 and 7.0 (in kg H₂SO₄/tonne of sample) of the solution are measured. A NAG pH less than 4.5 indicates the sample is likely acid producing. A temperature rise is commonly observed in NAG testing of sulfidic samples as a result of catalytic decomposition of peroxide by metal ions released during sulfide oxidation. Complete
decomposition of the peroxide may occur before all the reactive sulfides have oxidised. Thus the single addition NAG test may not account for the total acid potential of a given sample (Miller, et al. 1995).

### 3.3 MULTI-ELEMENT ANALYSIS

Multi-element chemical analyses are used to determine the chemistry of the materials for numerous purposes, including mine operations and environmental testing. Results indicate the key elements that comprise the materials and provide an indication of potential metals of concern in each rock/alteration type material. Multi-element analysis provides an indication of potential constituents of concern although it does not provide any direct information on the environmental behavior (e.g., leaching) of the materials.

Sample digestion and chemical analysis is recommended for all samples but because many of the samples have undergone this test, this analysis will be done only on any samples which have not already undergone this test. For each sample which needs analysis, roughly 33 elements are recommended for inductively coupled plasma/mass spectrometry or atomic emission spectrometry (ICP/MS, ICP/AES) or graphite furnace or flame atomic adsorption (GFAA/FLAA) analysis using EPA Method 3050B (EPA 1996).

Method 3050B is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment (EPA 1996).

### 3.4 MINERALOGICAL ANALYSIS

Mineralogy will be conducted on at least one sample split from each of those selected for HCTs, and will include X-ray diffraction (XRD) and optical mineralogy. The XRD evaluation will be qualitative mineral identification upon pulverized rock samples. The mineralogical analysis will be used in conjunction with the bulk-rock chemistry and other geochemical testing to evaluate each rock’s propensity to undergo chemical weathering. The results will also be used to
constrain the geochemical modeling. Optical mineralogy will be conducted on samples to identify and characterize specific mineral phases. SEM analysis may be conducted if necessary. Of particular interest are those mineral phases that contribute to acid generation or acid neutralization and those mineral phases that contain high concentrations of mobile metals.

### 3.5 HUMIDITY CELL TESTING

Humidity cell tests (HCTs) will be conducted on 9 samples. HCT is a kinetic test in which samples are subjected to accelerated weathering conditions (ASTM D5744-96, 2001). A 1.2 kg sample, crushed to minus 1/4-inch, is subjected to weekly cycles of dry air, humidified air, and a de-ionized water flush. The water samples are analyzed and the time-series chemistry data are generated on a weekly and monthly basis. Monitoring of the weekly water sample includes redox potential, pH, electrical conductivity, temperature, sulfate, acidity, alkalinity, and iron (ferrous and ferric if possible). Periodically (e.g., weeks 0, 1, 2, 4, 8, 12…), effluent samples will be chemically analyzed for general inorganic chemistry and metals composition using EPA Methods (ICP/MS and ICP/AES) on Nevada Profile II analytes.

Data are used to estimate the short- and long-term weathering rates of the sample, and to estimate the chemistry of water that would contact similar materials on the mine site. These estimates are used to predict the water chemistry of waste rock seepage, pit wall runoff or other contact water type by applying scaling calculations and site-specific climate data. HCTs will be run for a minimum of 20 weeks and in some cases longer if samples have not reached equilibrium (i.e., stable or decreasing) production rates for key indicators (e.g., pH, sulfate, alkalinity/acidity, major metals).

### 4 DATA INTERPRETATION

ABA data alone are not always reliable indicators of how material will weather in the environment. This is the case for the North Pan Pit waste rock material; existing data indicate that the “PAG” waste rock does not actually generate acidity when weathered in HCTs. The focus of data interpretation for the purpose of waste handling at the North Pan Pit will be to compare the results of additional HCTs with the ABA, NAG pH, mineralogy, and multi-element analysis to develop an understanding of how the “uncertain PAG” material will weather when
placed on waste rock disposal areas (WRDAs). If additional HCTs indicate no acid generation, and/or a buffered leachate, then no special handling will be required for the North Pan Pit waste rock. However, if samples are tested that do generate a consistent trend of un-buffered leachate with significant titrateable acidity, criteria will be developed from the data set to identify and separate these materials during mining operations to the extent possible given mining constraints such as the ability of the material to be extracted as a mineable unit. Specific criteria could include four consecutive weeks of consistent PAG leachate that includes all the following:

- pH below 5.5
- titrateable acidity greater than 10 mg/L as CaCO₃
- no measurable alkalinity

Confirmed PAG materials will be placed in PAG cells (as described in the Waste Rock Management Plan).

5 SCHEDULE

This program will be initiated no later than 2 years before mining at the North Pan Pit is planned to begin. This will provide sufficient time for any static and kinetic testing to be completed prior to mining of that area. Static testing generally takes 3 to 6 months to complete, including sampling, shipping, and data interpretation. Kinetic tests will be run a minimum of 20 weeks with the potential to be extended depending on stability of results.
6 REFERENCES


